PHYSICAL ACTIVITY PERCEPTIONS AND ASSOCIATIONS WITH MARKERS OF HEALTH IN CANCER SURVIVORS: A MATCH- FUNDED PHD PROJECT BY LIVERPOOL JOHN MOORES UNIVERSITY AND THE UNDERGROUND TRAINING STATION FOUNDATION.

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A thesis submitted in partial fulfilment of the requirements of Liverpool John Moores University for the degree of Doctor of Philosophy.

This research programme was carried out in collaboration with the Underground Training Station Foundation.

September 2022.

CANDIDATE DECLARATION

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Degree for which thesis is submitted: Doctor of Philosophy (PhD)

1. Statement of related studies undertaken in connection with the programme of research.

I have undertaken a programme of related studies that aimed to develop my research skills and competence in understanding a research project.

2. Concurrent registration for two or more academic awards

I declare that while registered as a candidate for the University's research degree, I have not been a registered candidate or enrolled student for another award of Liverpool John Moores University or other academic or professional institution.

3. Material submitted for another award

I declare that no material contained in the thesis has been used in any other submission for an academic award.

BACKGROUND STATEMENT

The purpose of this statement is to set the scene as to how this PhD project originated between Liverpool John Moores (LJMU) the match-funders, the Underground Training Station (UTS) Foundation and the PhD candidate.

Th PhD programme was a match-funded project with LJMU and a charity-based organisation (Charity No. 1169421), the UTS Foundation, based in Hoylake, Wirral. During my undergraduate degree and MPhil research project at LJMU, I worked as a Personal Trainer at the sister facility of UTS and with the Foundation delivering 1-to-1 personal training sessions to individuals living with cancer. In February 2017, I was awarded my Level 4 Cancer Rehabilitation Certification from the Wright Foundation, a brand leader in exercise referral and specialist populations exercise qualifications, as part of the Foundation's professional development pathway, https://www.wrightfoundation.com/course/level-4-cancer-rehabilitation/.

My first client consultation was with a female diagnosed with pancreatic neuroendocrine cancer who was 6 weeks post total gastrectomy, splenectomy, pancreatomy, partial colectomy with stoma surgery. The client arrived at the gym facility with her parents who were visiting from America and her husband. Following the consultation there were many aspects to consider, firstly, I had to think about how to introduce the client to exercise again following their surgery. Secondly, I had to ensure their training programme was adapted and tailored individually to allow for progression with exercise. Initially, the sessions consisted of mobility exercises and were progressed, symptom dependent, to include bodyweight exercises that addressed the key fundamental movement patterns including squat, hinge, lunge, push, pull, and carry. Once the client was moving well in each of these movement patterns and with frequent symptom check-ins, the sessions were then progressed to included exercises with bodyweight, free weights, and resistance bands. Over the initial 8-week period of working with the client it was very clear to see the positive impact the exercise training was having, she was looking and feeling stronger, this was evident from her programme template, and she was also slowly gaining weight-both of which she also reported. This experience strongly facilitated my personal interest in exploring the impact of exercise, specifically resistance training, in cancer survivors and I began working more with individuals living with cancer.

As the Foundation began to grow, the delivery of group-based exercise sessions became part of the service delivery model https://utsfoundation.com, and as a result, the number of service users started to increase. Dependent on clinical status and current level of fitness at the time of screening, individuals were allocated to either 1-to-1 personal training sessions or the group-based sessions. By 2018, the Foundation was operating on a larger scale than when I initially began working with them, as more cancer survivors were registering for consultations, and the positive verbal feedback from the service users reported to the Foundation coaches was outstanding. As a result, the Foundation's team of Directors approached LJMU to discuss the idea of a research project. While operating as a UTS coach, I was also in the final stages of my MPhil research project, therefore fortunate to have been assigned as the candidate for the PhD project. In the lead up to enrolment, the supervisory team was assembled which also consisted of those individuals I had previously worked with during my MPhil. In September 2018 I enrolled on this PhD project and during this time I delivered the group-based exercise sessions at the Foundation. Within the supervisory team, cardiovascular and exercise physiology, and PA and qualitative expertise were the main specialisms and among this, qualitative expertise. Initially the qualitative dimension was to facilitate the research process, but due to the cohort, cancer survivors, and the COVID-19 pandemic (see chapter 2), the project reverted to that of a largely qualitative stance. Dr Colin Robertson, Director and Foundation Trustee, was also appointed as an additional PhD project advisory personnel alongside the supervisory team. This professional relationship facilitated the development of the PhD programme and was most beneficial when initial plans had to be adapted for the remaining two studies due to the COVID-19 pandemic.

ABSTRACT

Evidence suggests that regular physical activity (PA) and exercise can improve health and wellbeing following a cancer diagnosis and may help reduce cancer recurrence and mortality and prolong disease-free survival in cancer survivors. However, few cancer survivors are regularly active and many fail to meet the recommended PA guidelines. This is a major area of concern as for survivors to achieve the long-term health benefits associated with PA and exercise, they must be habitually active. The overall aim of this thesis was to explore PA and exercise participation in adult cancer survivors, with a specific focus on group-based PA and exercise. Study 1 explored cancer survivors' perceptions of general PA and identified specific barriers and facilitators they experience specifically related to group-based activity. Qualitative methodology was employed and underpinned by the PRECEDE component of the PRECEDE-PROCEDE model. A unique finding from Study 1 was the group-based format of the exercise program being a key facilitator for PA and exercise participation. Study 2 evaluated the feasibility of a virtual home-based exercise intervention utilising the RE-AIM evaluation framework and explored participant experiences transitioning from a gym-based to home-based setting to exercise during the COVID-19 pandemic. A mixed-methods approach was employed to evaluate each dimension of the RE-AIM framework and additional qualitative methods were employed to explore participant experiences. High levels of acceptability and satisfaction (feasibility) were reported by participants, significant improvements in physical fitness and mental health were observed, and the group-based format and coach were reported as key facilitators for adherence to the intervention. Study 3 identified and critically reviewed the literature exploring the effect of home-based PA and exercise interventions on PA, physical fitness (PF), and quality of life (QoL) in cancer survivors. The effect of home-based PA and exercise interventions on PA, PF and QoL appeared complex. There was some evidence for the positive effects of home-based PA and exercise interventions on PA, PF and QoL in this population, particularly those with aerobic exercise components and additional support. Assessment tools used, and outcomes reported were variable, specifically for PA. Overall, there is a need for standardisation across studies in terms of assessment methods that will facilitate future reviews in this area.

ACKNOWLEDGEMENTS

For Yvonne – the most wonderful lady.

Firstly, I would like to thank my director of studies, Dr Ellen Dawson. I am so fortunate to have had you on this journey with me. I wouldn't be submitting this thesis if it weren't for the unconditional support and encouragement you have given to me throughout my studies. I will miss our twice weekly catch ups.

Another big thank you also goes out to the rest of my supervisory team: Dr Lynne Boddy for guiding me with your expert opinion but letting me figure it out for myself. Prof Zoe Knowles for your expertise and valuable input, I never thought I would submit this thesis from a largely qualitative stance, and I am extremely grateful for having had you shape me into the qualitative researcher I am today. Prof Claire Stewart and Dr Dominic Doran for your ongoing support and encouragement throughout the PhD project process.

A special mention and thank you goes to my colleague, James. You have been my academic rock from day 1.

Thank you to the UTS Foundation, the match-funders, who selected me as candidate for this PhD project. Coaching the members on a weekly basis has been some of my most rewarding work to date - it has been an honour and privilege to have known some of this life's most wonderful people.

To my future husband, Dan. Thank you for believing in me and encouraging me to keep going, especially when I didn't believe in myself - I owe this to you. A special thanks goes to my colleague Anthony, your words "just get it done" have echoed in my head each day, and here I am. GOOD. I am forever grateful to have the both of you in my life. An extended thanks goes to my wonderful family and friends for their ongoing support, and to another wonderful human, Nikki. Thank you for teaching me that thriving makes all things possible, and that there is gold to be won from failure.

Lastly, to myself. You did it.

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1. PHD PROJECT PROCESS

The process of the PhD project from enrolment to thesis submission is presented in the Gannt chart below to demonstrate the impact of the COVID-19 pandemic and the decisions made during the research process to successfully complete the project.

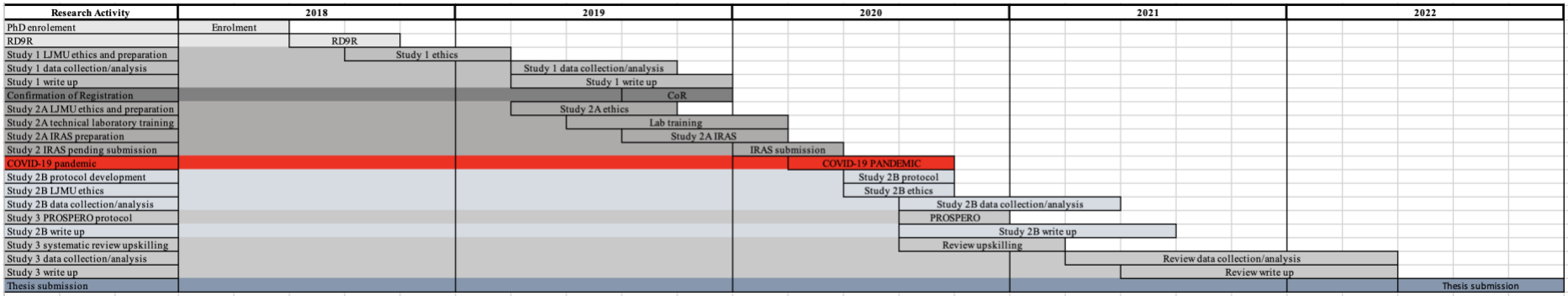

Figure 1- Gannt detailing the PhD project research process.

2. INTRODUCTION

The following chapter will introduce the 3 empirical study chapters and how they evolved during the PhD project process. These 3 empirical chapters include a formative study (chapter 7), an exercise intervention study (chapter 8), and a systematic review (chapter 9). The methodological processes utilised throughout the thesis are covered in more detail in the relevant chapters including the literature review (chapter 5), general methods (chapter 6), and 3 empirical study chapters. This chapter will also provide an explanation for the development of study procedures throughout the research process pre and in response to the COVID-19 pandemic and the role of the PhD researcher as both an academic candidate for the project and coach for the organisation.

2.1 Overview of empirical chapters

2.1.1. Study 1

The main aim of study 1 was to explore PA and exercise participation in a group of cancer survivors. The objectives were 1) to explore perceptions of general PA and 2) to identify barriers and facilitators for group-based PA participation in cancer survivors, with a secondary aim to provide formative information to inform the design of group-based activity interventions. Study 1 adopted a constructivist approach to achieve the study aims and objectives, (see chapter 4 and 6 for further detail).

Study 1 was completed as intended, prior to the COVID-19 pandemic, in October 2019 (See Gannt chart). The findings were to provide formative information that would support a cross-sectional study as the next step of the research process. It was initially planned that both study 1 and study 2, would facilitate the design and implementation of a gym-based exercise intervention for cancer survivors (Study 3).

Originally, Study 2 aimed to explore levels of PA, relationships between physiological and psychological markers of health including vascular function, inflammatory markers, and quality of life as well as the feasibility and acceptability of the included measures. An ethics application for the study was submitted to the LJMU Research Ethics Committee however, after extensive review from the committee it was suggested that the study protocol and procedures be submitted as an NHS IRAS application. On completion of study 1 and during the preparation for study 2, whilst undergoing technical laboratory training (~15 hours per week over ~6 months) and preparing

to submit the IRAS application, the COVID-19 pandemic halted all research with human participants in the UK in March 2020. The COVID-19 restrictions also closed gym and leisure centre facilities and mandated a 'lockdown' where people were required to stay at home with exceptions for medical appointments, shopping for essential items and 60 minutes of physical activity per day outside. The UK and other national governments also advised cancer survivors to shield for several months as they were classed as a serious risk group and being more susceptible to manifest complications of the viral infection. As a result, the Foundation's exercise sessions were moved to an online group-based format using the Zoom platform. The PhD researcher produced a step-by-step guide detailing how to set up and utilise Zoom for the Foundation's members.

Following the first lockdown period in March 2020, the PhD researcher, supervisory team, and Foundation Director (Stakeholder) met virtually via Zoom in April 2020 to discuss how the project could be evolved to allow for continuation during the pandemic. Given the qualitative expertise within the supervisory team regarding research evaluation work, the PhD researcher's role as candidate and coach, and the need for the continued delivery of the group-based exercise sessions of the Foundation and being the match-funders of this PhD project, the idea of evaluating a virtual home-based exercise intervention became evident. Following this meeting, the PhD researcher developed a protocol for the evaluation of a virtual home-based exercise intervention using the RE-AIM framework. This protocol was presented to the supervisory team and Director (Stakeholder) of the Foundation. Following agreement of the protocol, a minimal risk ethics application was registered and approved by the University's research ethics committee (UREC). Substantial changes were therefore made to the research programme, where Study 2 and Study 3 were completed revised as outlined below.

2.1.2 Study 2

Utilising the RE-AIM framework, this study aimed to; 1) evaluate intervention feasibility by exploring acceptability and satisfaction of a virtual home-based exercise intervention for cancer survivors 2) explore the effectiveness of the intervention on a variety of participant outcomes including PA behaviour, motivation and competence for PA, quality of life and physical fitness 3) retrospectively explore participant experiences moving from a gym to home-based exercise setting during the COVID-19 pandemic using focus groups. This rich, qualitative data was also used to elaborate on the quantitative data and methods utilised. Therefore, Study 2 adopted a pragmatic approach to achieve the study aims, a mixed-methods approach was employed to address the 5 dimensions of the RE-AIM Evaluation Framework [1] (see chapter 4 for further detail). This pragmatic

approach was largely facilitated by the incorporation of a constructivist approach (see chapter 4 for further detail). The participant outcomes explored including PA, physical fitness (PF), and quality of life (QoL) to inform the Effectiveness dimension of the RE-AIM framework, further informed the development of the protocol for a systematic review (Study 3).

2.1.3 Study 3

Due to the COVID-19 restrictions and changes in exercise delivery, Study 3 was designed to complement Study 2 by conducting a systematic review of home-based PA and exercise interventions to explore the evidence of such interventions on outcomes of PA, PF and QoL, those of which were evaluated in Study 2 in a small cohort of cancer survivors. Systematic reviews are the reference standard for synthesising evidence in health care because of their methodological rigor [2]. An essential part of the systematic review planning process is the development of a protocol, this ensures that the review is thoroughly planned before the review starts. The protocol for Study 3 (systematic review) was registered with PROSPERO (CRD42020214759). The key characteristics of a systematic review are, clearly stated objectives with reproducible methodology, a systematic search that attempts to identify all evidence that meets pre-set eligibility criteria, an assessment of the validity of the findings from included evidence such as assessment of risk of bias, and systematic presentation and synthesis of the characteristics and findings of the included evidence [2]. The aim of the systematic review was to critically review the literature on the PA and associations with health outcomes from home-based PA and exercise interventions in individuals living with and beyond cancer adopting a positivist approach. The key objectives of the review were too 1) establish if home-based exercise interventions improve PA levels and behaviours in adults living with and beyond cancer 2) establish if home-based exercise interventions improve PF in adults living with and beyond cancer 3) establish if home-based exercise interventions improve clinical outcomes such as QoL in individuals living with and beyond cancer. The Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) guidelines were utilised to inform the review process [2].

2.2 Role as practitioner-researcher

2.2.1 Practitioner-researcher

Crotty [3] suggests that an interrelationship exists between the theoretical stance adopted by the researcher, the methodology and methods used, and the researcher's view of epistemology (see further detail in chapter 4).

Therefore, it is important to note in this chapter the academic and applied role of the PhD researcher and their involvement in the research process (more detail is previously provided in the background statement at the beginning of this thesis and below in the next chapter, Positionality) as this largely facilitated the generic methods utilised. As well as being the PhD candidate and undertaking the research procedures in this PhD project, the PhD researcher was also working professionally with the Foundation. Following enrolment into the PhD project the PhD researcher was appointed lead coach of the group-based exercise sessions delivered to the members of the Foundation. Therefore, throughout the PhD project process they embodied the role as practitioner-researcher.

As mentioned in the background statement earlier in this thesis, the PhD researcher had also previously delivered 1-to-1 personal training sessions to individual cancer survivors who were members of the Foundation. Some of these individuals later went on to join the group-based exercise sessions that the practitioner-researcher delivered. Prior to any recruitment and data collection procedures of the PhD project, the practitioner-researcher had been delivering the group-based exercise sessions to the Foundation's members for over 6 months at the gym facility and had been a UTS coach for 5 years previously. This role facilitated direct access to individuals living with cancer and allowed thorough engagement between the practitioner-researcher and members of the Foundation on a weekly basis. This professional work in an applied setting helped to foster a genuine understanding and improve knowledge of this unique population for the practitioner-researcher. This had imperative value in the formative stages of designing studies 1 and 2 of this PhD project. In turn, this also led to the development of relationships between the practitioner-researcher and members. This created a level of rapport between the practitioner-researcher and members of the Foundation. Given the practitioner-researcher's role in this this applied setting, it was vital that all research procedures were conducted in a rigorous and ethical manner, as the practitioner-researcher may have influenced the studies designs, procedures and findings, to minimise any potential biases and produce good quality data, particularly as all of the members attending the group-based exercise sessions also became participants in studies 1 and 2. The qualitative materials and methods used in studies 1 and 2 were developed between the practitioner-researcher and a HCPC practitioner psychologist who was also a member of the supervisory team. Throughout the data analysis and reporting stages, the practitioner-researcher was facilitated by the HCPC practitioner psychologist to allow for a robust and rigorous interpretation of the data. In addition, when the practitioner-researcher developed the protocol for Study 2, the protocol was discussed amongst the practitioner-researcher, supervisory team, and the directors of the Foundation. Given that the practitioner-researcher had been a UTS coach for 5 years before the PhD project, a level of rapport had been well established

between them and the directors of the Foundation, and in their professional role as the lead coach the practitioner-researcher also developed and delivered the training programmes for 1-to-1 and the group-based exercise sessions at the Foundation. This was of particular benefit when discussing the protocol for Study 2 and the directors had confidence in the practitioner-researcher's ability to develop and conduct the online feasibility study. Acquiring this practitioner-researcher position within the PhD project was particularly beneficial when designing and implementing the virtual home-based exercise intervention and for the application of the RE-AIM framework [1] in study 2. This framework and its application are discussed in more detail in the literature review (see chapter 5) and study 2 (see chapter 8) of the thesis. Aside to the design procedures of studies 1 and 2, all data collected and interpreted were discussed between the practitioner-researcher and supervisory team to ensure reporting of the findings in a rigorous and accurate manner, reducing any potential biases from the practitioner-researcher. Overall, the established relationships between the practitioner-researcher and members/participants thoroughly facilitated uptake and engagement throughout studies 1 and 2, this may not have been achieved if the practitioner-researcher had not been working in this applied role. Throughout the thesis, the implications of these relationships are considered and in the final chapter (see synthesis chapter 10) the practitioner-researcher provides justification for why ultimately, they regard it as a strength of this research project.

It is also important to recognise the potential impact of working with this population may have had on the practitioner-researcher from a personal point of view because of the closeness in nature with members/participants through the relationships developed over the course of the PhD project. The practitioner-researcher spent time each week with the members when conducting the exercise sessions and got to know the individuals well. Most members were very open and frequently talked about their own cancer journey and stage they were at whether that be during or post-treatment and the impact the disease had on their livelihood. At the beginning of the research project, the supervisory team set up support for the practitioner-researcher with a health psychologist based at the university and separate to the supervisory team. The practitioner-researcher could go and speak with the psychologist if they felt the need too during any stage of the project.

2.3 Behaviour change and the Self-Determination Theory

Behaviour plays an important role in individual's health, and changing individual's health-related behaviour can have a profound impact on some of the world's largest causes of mortality and morbidity [4]. In general, it is well

established that regular PA and exercise can reduce the risk of comorbid disease and delays declines in physical and mental functioning associated aging. More specifically, mounting evidence highlights that regular PA and exercise can improve health and wellbeing following a cancer diagnosis and may help to reduce cancer recurrence and mortality [5]. However, as outlined in this thesis, few cancer survivors meet the recommended PA and exercise guidelines (see chapter 5, section 5.2) and uptake and adherence to PA and exercise programmes/interventions is low [6]. Changing behaviour from a mainly sedentary to a physically active lifestyle poses a challenge to most people but particularly to those with diseases such as cancer [7]. A variety of interventions have been developed over the last decade aimed at promoting PA in this unique population [7]. Increasing evidence suggests that public health and health-promotion interventions that are based on social and behavioural science theories are more effective to facilitate behaviour change than those lacking a theoretical base [8,9]. Theories most commonly used as a basis of behaviour change interventions have been the Transtheoretical Model (TTM), Social Cognitive Theory (SCT), and Theory of planned behaviour (TPB) [7]. An understanding of 'why' only few survivors meet the current PA and exercise recommendations is essential and these findings may help to largely facilitate interventions aimed at promoting behaviour change in this population.

In addition, there is a need for facilitating ways in which health-promoting behaviour such as engaging in regular PA and exercise can be fostered in the cancer population and to support motivations for these kinds of health promoting behaviours. Although the studies in this thesis were not underpinned by specific behaviour change theories, from an applied perspective, the practitioner-researcher utilised need-supportive techniques to foster the basic psychological needs of the Self-Determination Theory (SDT) to inform their professional working practice concerning the group-based exercise sessions throughout the course of the PhD project (see general methods chapter). SDT is a theory of human motivation [4] and assumes that individuals are inherently prone toward psychological growth and integration, and consequently toward learning, mastery and connection with others. However, these proactive human tendencies do not occur automatically, they require supportive conditions to be robust. For healthy development to unfold individuals require support for basic psychological needs [10]. SDT introduces the concept of basic psychological needs as central to understanding both satisfactions and supports necessary for high quality, autonomous forms of motivation and in turn engagement in activities including PA and exercise [11].

Intrinsic motivation is defined as doing an activity because of its inherent satisfactions [11]. However, not all motivation is inherent, extrinsic motivation refers to doing an activity for instrumental reasons, or to obtain some outcome separable from the activity per se. These varying levels of motivation are based on a continuum (see figure below) and SDT distinguishes between intrinsic and extrinsic types of motivation regulating an individual's behaviour and motivation to engage in any behaviour [11,12]. Extrinsically motivated behaviours cover the continuum between amotivation, the state of lacking intention to act, and intrinsic motivation, varying in the extent to which their regulation is autonomous [13]. A more autonomous, or self-determined form of extrinsic motivation is regulation through identification which considers a conscious valuing of a behavioural goal or regulation that the action is accepted as personally important. The most autonomous form of motivation is integrated regulation which occurs when regulations are fully integrated to oneself, which means they have been evaluated and brought into congruence with one's other values and needs. Actions characterised by integrated motivation share similarities with intrinsic motivation [13]. SDT argues that there are basic psychological needs for competence, relatedness, and autonomy, all of which are essential in the development of intrinsic motivation [10].

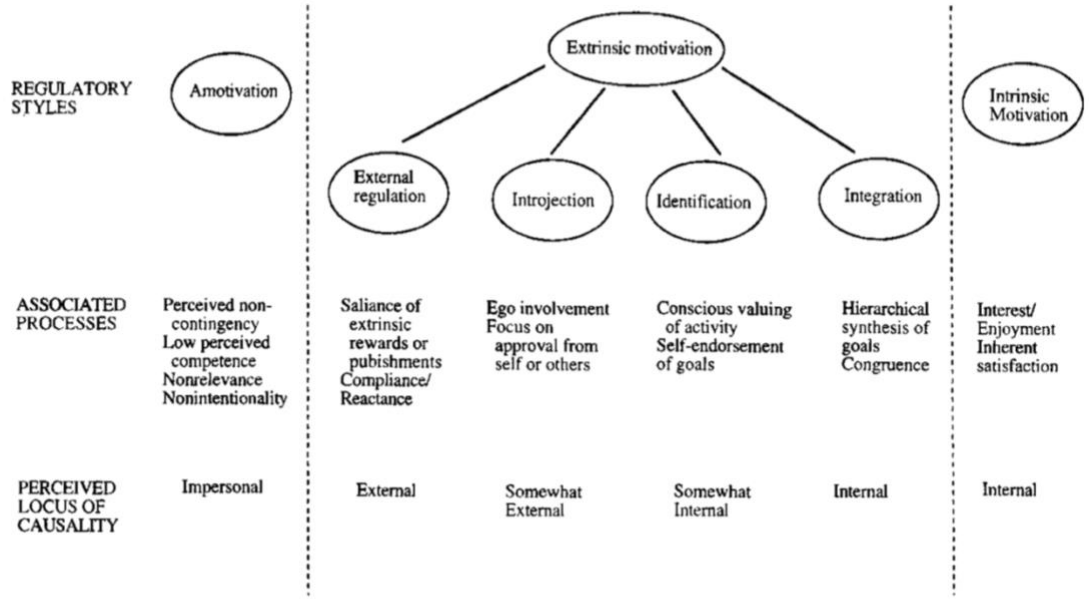

FIG. 1. A taxonomy of human motivation.

Figure 2 - Reprinted from Ryan and Deci (2000) demonstrating the taxonomy of human motivation.

Autonomy concerns a sense of initiative and ownership in one's actions. It is supported by experiences of interest and value and undermined by experiences of being externally controlled, whether by rewards or punishments. Relatedness concerns a sense of belonging and connection, and it is facilitated by conveyance of respect and caring. Competence concerns the feelings of mastery, a sense that one can succeed and grow. The need for competence is best satisfied within well-structured environments that afford optimal challenges, positive feedback, and opportunities for growth [10]. Overall, SDT is therefore based on the premise that the motivation of an individual to engage in behaviour is based on the satisfaction and experiences of their basic human needs of competence, relatedness, and autonomy. A detailed overview of how the practitioner-researcher used SDT to inform their professional working practice with the members of the Foundation is provided in the general methods chapter (see chapter 6, section 6.4).

3. POSITIONALITY

The purpose of this chapter is to highlight the positionality of the PhD researcher and their influence on the PhD project process.

Positionality is viewed as an important research tool [14]. The term positionality both describes an individual's world view, 'where the researcher is coming from', and the position they adopt about a research task and its social and political context. Positionality influences both how research is conducted, its outcomes, and results [15]. Therefore, knowing what we as researchers are bringing to the research critically helps us see our data in productive, insightful ways and greatly furthers our capacity to do creative analysis and theorisation [14]. In relation to the philosophical positioning (see further detail in chapter 4) of the PhD researcher, all research and analysis were conducted by the PhD researcher who had prior experience and understanding of cancer, cancer survivors, and physical activity and exercise as well as an established academic Sport and Exercise Science background. As previously stated, and explained in more detail in chapter 4, the positionality of the researcher may have largely influenced the PhD project research process and it is important that researchers recognise how that of their own experiences and perceptions may facilitate interpretations of others world views. It is also important to note that all planning procedures and decisions were discussed amongst the supervisory team before any research procedures were conducted.

Growing up in the Northern Irish countryside meant that there was no time for doing nothing. From scrapping up pig poop on my parent's farm at the age of three, to ploughing over the endless, emerald carpet on horseback, being active was and is a way of life me. I was a very active child, and always enjoyed being physically active, particularly outdoors. It wasn't until I moved to high school that I really discovered exercise and physical activity as my passion. On reflection, I guess this passion was largely influenced from an early age by my up bringing and farming background. Throughout my high school years, I excelled in sport, particularly athletics. Each year I was crowned winner of the one-hundred and two-hundred metre sprint races and further went on to represent my school at local championships. It was obvious that I would choose to study Physical Education at GCSE level. During this time the school had just been kitted out with a fitness suite and this is where I first discovered resistance training. After completion of my A levels, I took a year out. This was a great year; I worked in a hairdressers and

dog groomers, both of which meant I was on my feet all day, attended the gym on a regular basis and taught children and adults with a variety of disabilities to horse ride. This was my first experience of working with individuals with a health condition and one I found extremely rewarding.

Fast forward a few years and I found myself enrolled as an undergraduate Sport and Exercise Science student. It was here that I became fascinated with the gym and exercise, particularly resistance training, I thoroughly enjoyed the Physical Activity and Exercise Physiology and Nutrition modules. I wasn't very interested in the social side of university life regarding going out most evenings, instead any free time alongside studying was prioritised for the gym. I could be found training at either the university gym or a gym facility on the Wirral. As I finished the first year of my degree, I completed an 8-week voluntary placement throughout the summer at this facility and was fortunate to be offered a coaching position at the end of the 8 weeks. I was based at this facility from 2014 to March 2020 and delivered one-to-one personal training sessions and group-based sessions to the general population, both children and adults alongside completing my undergraduate and MPhil research degree. This facility was part of a franchise and had a sister gym in Hoylake, Wirral, and this is where the Foundation is located as previously mentioned in the background statement at the beginning of this thesis.

As noted in the background statement at the beginning of this thesis, I began working with a small number of cancer survivors on a one-to-one basis from this sister facility, the Foundation. This meant I had the privilege of first-hand experience of delivering exercise training to this population. During the initial screening sessions for potential members to begin using the service, many voiced their lack of experience with and understanding of exercise. However, following their first few exercise sessions, their feedback was extremely positive, and it was very clear to see their perceptions and attitudes towards exercise evolve. Many also reported the positive effect that the exercise was having on their day-to-day lives, such as giving them more energy to complete tasks of daily living. Alongside this and from my own personal experience in working with them on a weekly basis and observing their progressions across the exercise training programmes, it became evident to me just how beneficial exercise appeared to be for this population, specifically resistance training.

Providing this information to the Foundation and establishing the positive outcomes the service was having on these individuals, the questions arose as to how we could possibly objectively and rigorously explore these phenomena. This led to the development of a qualitative protocol guided by a model of health promotion, outlined

in the relevant chapters, for study 1. To ensure all potential biases were minimised, this protocol was developed by myself and a Health and Care Professions Council Registered Practitioner Psychologist (HCPC). During the global pandemic, the goal was to keep the members engaged with the service and exercising on a regular basis. Therefore, the service was adapted and delivered in a virtual format and immediately the success and positivity of this delivery soared. Again, the questions arose as to how beneficial it could be to evaluate the feasibility of a virtual home-based exercise intervention at the individual and organisational level. To do so rigorously, a mixed-methods protocol was underpinned by an evaluation framework, outlined in the relevant chapters. All the above has largely facilitated my pathway to this match-funded PhD which has been a huge challenge, particularly by how the global pandemic influenced the research programme, but my biggest academic achievement to date.

4. PHILOSOPHICAL POSITIONING

The following chapter identifies, explains, and justifies the epistemological and theoretical perspectives underpinning the research methods utilised in this thesis.

Ontology is the study of being, and is concerned with the nature of existence, the structure of reality and 'what is'. Epistemology is concerned with what knowledge is and what kinds of knowledge are possible. Epistemology tries to understand 'what it means to know', providing a philosophical background for deciding what kinds of knowledge are legitimate and adequate [16]. Crotty [3] suggests that an interrelationship exists between the theoretical stance adopted by the researcher, the methodology and methods used, and the researcher's view of epistemology. Therefore, theoretical perspectives embody a certain way of understanding 'what is' (ontology) and a certain way of understanding what it means to 'know' (epistemology).

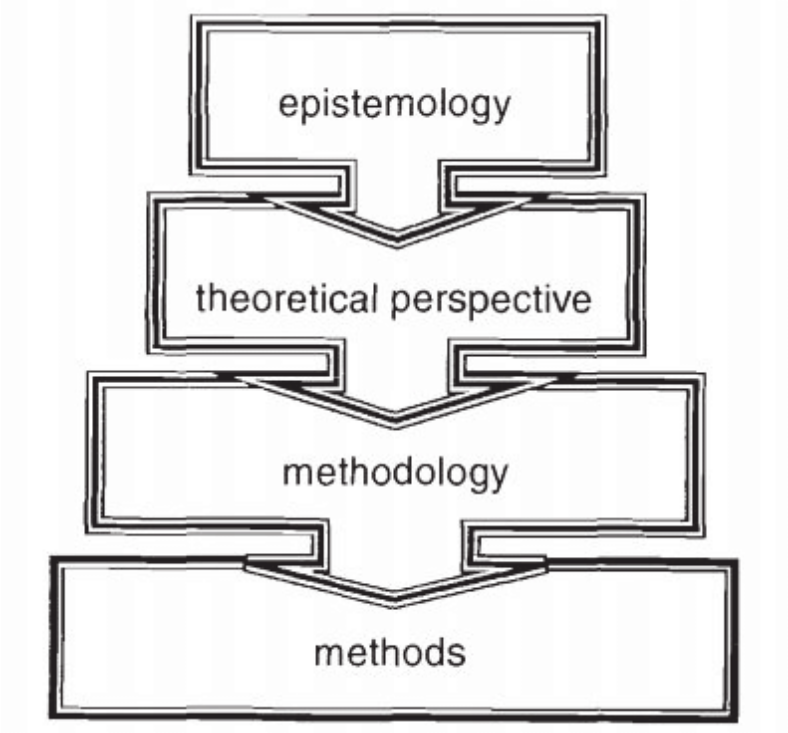

Figure 3- Reprinted from Crotty (1998) illustrating the process by which epistemology informs theoretical perspectives, methodology and methods [3].

Within the fundamentals of epistemology there are two opposing philosophical schools of thought, rationalism and empiricism, which are an ongoing historical debate [17]. Both attempts to establish the source of human knowledge claims and to determine how we as individuals form concepts and ideas or in simple terms, to establish where human knowledge ultimately originates from. Rationalism argues that knowledge is based on reason absent of empirical testing, therefore innate ideas and empiricism argues that knowledge is based on experience and that suitable scientific method should be applied such as hypothesis testing as there are no innate ideas [17]. Throughout this history of debate three major theoretical perspectives have emerged, pragmatism, positivism, and constructivism. This thesis drew largely upon elements of constructivism and pragmatism.

4.1 Constructivism

The core assumption of a constructivist paradigm is that truth and meaning do not exist in an external world but are constructed by the subject's interaction with the world, meaning is constructed not discovered [16] such as prior experiences and knowledge that shape subjects views. A theoretical perspective linked to constructivism is interpretivism, which looks for culturally derived and historically situated interpretations of the social life world. Therefore, subjects and researchers construct their own meaning in different ways, even in relation to the same phenomena, and multiple contradictory but equally valid accounts of the world can exist [16], such as the participants included in this thesis being cancer survivors and engaging in PA and exercise at the same organisation. As a result, the purpose of the research is to explore multiple participants' experiences within the context of their environments [1,18]. It is also important for researchers to recognise how their *own* experiences and perceptions may influence their attempts to make sense of or interpret the meanings others have constructed about the world [16]. A constructivist approach incorporates an inductive approach to developing theory and is therefore viewed as a qualitative approach to research. It is important to note that constructivism differs to that of subjectivism whereby meaning does not emerge from the interaction between the subject and outside world, but subjects impose meaning on objects through unconsciousness dependent on embodied perceptions, understandings, feelings, and experiences [16]. A constructivist approach underlies study 1, the research methodology adopted utilised semi-structured focus groups to explore perceived barriers, facilitators and reinforcing factors for PA and exercise engagement reported in a narrative format. Furthermore, the research was conducted by the PhD researcher with a prior understanding and experience of cancer survivors and exercise, as such the analysis was constructed from the perspective of the researcher and a Health and Care Professions Council Registered Practitioner Psychologist (HCPC).

4.2 Pragmatism

The key assumptions of pragmatism are that at every stage of the research process from data collection to analysis and reporting, researchers inject a host of assumptions [3]. Therefore, it is suggested that these assumptions about knowledge and reality shape the meaning of research, the purposiveness of the methodologies, and the interpretability of the findings [3]. Although there are many forms of pragmatism, a common characteristic is the emphasis on using the approaches best suited to understanding a particular problem. Furthermore, pragmatism is not committed to any single epistemology, but adopts a positivist perspective, a theoretical perspective closely linked to objectivism, of the physical world, and a constructionist perspective of social interaction. Therefore seen by some to provide an epistemological justification for mixing approaches and methods [16,19]. A pragmatic approach encompasses abduction, intersubjectivity and transferability [20]. An abductive process is employed which allows researchers to work back and forth between qualitative and quantitative data, providing opportunity to search for connection between the two types of data. Therefore, the transferability of the research is strengthened by both the breadth and depth of the data provided by the connection of qualitative and quantitative approaches. In relation to subjectivity and objectivity, a pragmatist approach argues that there is impossibility of complete subjectivity and objectivity when conducting research, but intersubjectivity representing the emphasis on processes of communication and shared meaning that are central to any pragmatic approach [20].

For more than a decade, mixed-methods research has been increasingly articulated, attached to research practice, and recognised as the third major research paradigm along with qualitative research and quantitative research [21]. Mixed-methods research combines elements of qualitative and quantitative research approaches for the broad purposes of breadth and depth of understanding and corroboration of a research problem than either a qualitative or quantitative approach alone [21,22]. Therefore, mixed-method research can be seen as the chair that sits in the middle, pragmatism, with qualitative and quantitative research approaches either side. Pragmatism has relevance to the current thesis. By adopting a pragmatic approach specifically (albeit unplanned at the start of the thesis) for study 2, this enabled a qualitative and quantitative exploration of the feasibility of a virtual home-based exercise intervention. Furthermore, by adopting both a constructivist and positivist approach this allowed for a more in-depth exploration of the data in relation to the action of the intervention and changes in behaviour and

outcomes measured. This approach also provided a more comprehensive understanding of PA and exercise in a small group of cancer survivors generalisable to the wider cancer population during the global pandemic.

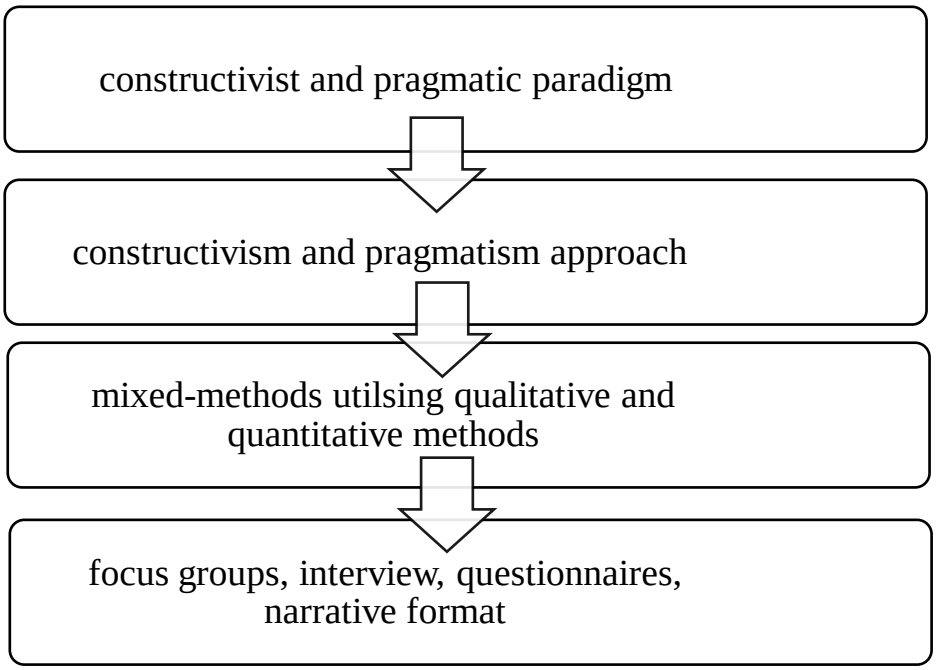

Figure 4- Adapted from Crotty (1998) illustrating the epistemological, theoretical perspectives research methodology, and methods underpinning the research process.

4.3 Positivism

Originally Study 2, the cross-sectional study, was going to be underpinned by a positivist theoretical approach. The plan was to utilise objective methods to measure PA and clinical outcome measures such as vascular ultrasound and venous blood sampling to determine the effects of PA behaviour on measures of health, using statistical analysis. As outlined in the introduction section of this thesis (chapter 2), it was not possible to conduct this cross-sectional study because of the COVID-19 pandemic. However, as Study 2 later developed into a mixed-methods feasibility study, and following the outcomes obtained, this information largely facilitated in the design of Study 3, the systematic, review. Objectivism or empiricism as an epistemology gave rise to positivism as a theoretical perspective, which has been the prominent paradigm for scientific enquiry. The core assumption of a positivist paradigm is that reality exists external to the researcher and can be investigated through scientific enquiry to determine how causes (probably) determine effects or outcomes [16]. Overall, research is concerned with identifying and assessing the causes influencing an outcome through experiments

[16]. Therefore, this paradigm lends itself to quantitative methods in which values, numbers, and data are used to test a hypothesis. Therefore, a positivist approach underlies Study 3 (chapter 9) in this thesis whereby the methodology included a review of experimental research and the methods included statistics within each study reviewed.

5. LITERATURE REVIEW

The purpose of this chapter is to provide a review of the relevant literature and key topics discussed throughout this thesis, including an introduction of two key frameworks that underpinned studies 1 and 2.

5.1 Cancer

5.1.1 Pathophysiology

Human cells multiply in a highly regulated process called the 'cell cycle' which involves a mixture of signals to determine whether a cell will grow, divide, differentiate or die [23]. Normally, human cells grow and multiply through a process called 'cell division' to form new cells and when these cells grow old or become damaged, they perish to allow new cells to replace them. However, sometimes this cellular process is impaired and abnormal or damaged cells grow uncontrollably and divide to form tumours, either malignant (cancerous) or benign (non-cancerous) [23]. Cancer is termed a 'genetic disease' because it is caused by changes to genes, often referred to as mutations, that control the way cells function, especially how they grow and divide [23]. The Hallmarks of Cancer were proposed as a set of functional capabilities acquired by human cells as they make their way from normalcy to neoplastic growth states, more specifically capabilities that are crucial for their ability to form malignant tumours [24]. The Hallmarks of Cancer currently comprise eight parameters, the acquired capabilities for sustaining proliferative signalling, evading growth suppressors, resisting cell death, enabling replicative immortality, inducing/accessing vasculature, activating invasion and metastasis, reprogramming cellular metabolism, and avoiding immune destruction. Deregulating cellular metabolism and avoiding immune destruction were segregated as 'emerging hallmarks' but now it is evident that they can be considered core Hallmarks of Cancer along with the original six [24]. The genetic changes that contribute to cancer generally affect three main types of genes, oncogenes, tumour suppressor genes, and DNA repair genes. Oncogenes are involved in normal cell growth and division. However, when these genes are altered in certain ways or are more activated than normal, they become cancer causing genes, allowing cells to grown and survive when they should not. Tumour suppressor genes are also involved in controlling cell growth and division. Cells with certain alterations in tumour suppressor genes may divide in an uncontrolled manner. DNA repair genes are involved in fixing damaged DNA. Cells with mutations in these genes tend to develop additional mutations in other genes and changes in their chromosomes, such as duplications and deletions of chromosome parts. Together, these

mutations may cause cells to become cancerous [23]. Overall, the fundamental abnormality resulting in the development of cancer is the continual upregulated proliferation of cancer cells [25]. Some ways in which these genetic changes occur are due to errors in cell division, damage to DNA caused by harmful substances (carcinogens) in the environment such as chemicals in tobacco smoke and ultraviolet rays from sunlight, or an individual's genetic predisposition [23].

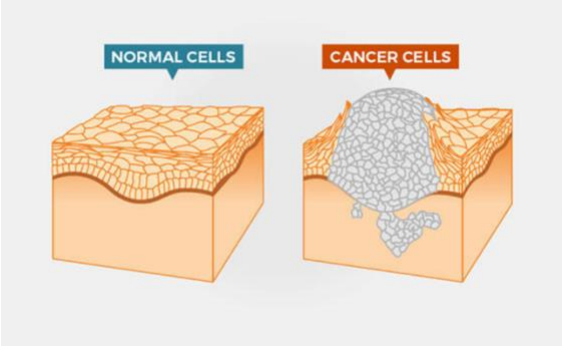

Figure 5- Reprinted from the National Cancer Institute website (2021) illustrating normal cells and abnormal cells with uncontrollable cell division and spread into surrounding tissues.

In normal cell cycling, our body's generally eliminate cells with damaged DNA before they turn cancerous through the process of apoptosis, but as we age, our body's ability to do so reduces, therefore cancer is a disease largely associated aging [23]. The most-studied known or suspected risk factors for cancer include age, alcohol, cancer-causing substances in the environment (carcinogens), chronic inflammation, diet, hormones, immunosuppression, infectious agents including viruses, bacteria and parasites, obesity, radiation, sunlight and tobacco [23]. Although the ageing process cannot be prevented, many of these risk factors are modifiable. It is estimated that one third to one half of cancers could be prevented by healthy lifestyle choices such as eliminating tobacco use, maintaining a healthy body mass index (BMI), moderating alcohol consumption, and maintaining an active lifestyle [26]. There is strong evidence to suggest that physical inactivity increases the risk of many adverse health conditions including the world's major non-communicable diseases (NCDs) of coronary heart disease (CHD), type 2 diabetes, and breast and colon cancers and shortens life expectancy. Given that much of the world's population are inactive, this creates a major public health problem [27]. Physical inactivity is defined as an activity level insufficient to meet current recommendations [27]. Furthermore, physical inactivity has been recognised as a global pandemic, that causes an estimated 10% of colon and breast cancers and 9% of premature mortality overall [27]. Consequently, the health burden from physical inactivity has been compared to that of smoking and obesity [26,27].

Malignant tumours have the ability to spread into or invade nearby tissues via the circulatory and lymphatic systems, referred to as metastasis, to form new tumours [23,25]. This can make treatments of cancers extremely difficult and can make some tumours resistant to treatments. These malignant tumours can be classified into four types of cancers including carcinomas, sarcomas, non-solid tumours and brain and CNS (central nervous system) tumours and are further classified according to their tissue of origin such as breast carcinomas and the type of cell involved including epithelia cells [25,28]. Carcinomas, which include ~90% of human cancers are malignancies of epithelial cells (skin or surface layers inside and outside of the body) [25]. There are four different types of epithelial cells: 1) squamous cells, flat covering surface cells that line the mouth and oesophagus; 2) adenomatous cells, forming the lining of glands and found in organs such as the stomach, ovaries, kidneys, and the prostate gland; 3) transitional cells, layers of stretchy cells only found in parts of the bladder and urinary system; 4) basal cells, which are found in the skin. Sarcomas, which are rare in humans (~1% of all cancers), refer to a group of cancers that develop in connective tissues of the body such as muscle, bone, cartilage, and fibrous (fatty) tissues. Non-solid tumours refer to cancers of the blood and immune system, respectively. Leukaemia's are cancers of the blood and arise when the bone marrow makes too many abnormal white blood cells (Leukaemia cells and leukemic blast cells) and these cells build up in the blood and bone marrow, crowding out normal blood cells. The low level of normal cells can make it extremely difficult for the body to get oxygen to tissues, control bleeding or fight infections [23]. Although relatively rare (~3% of all cancers), leukaemia's are the most common cancers to affect children. Lymphomas and myelomas are cancers of the lymphatic system (immune). Lymphomas are cancers of lymphocytes (T cells or B cells) and ~5% of all cancers, and myelomas are cancers of plasma cells and ~1% of all cancers. Brain and CNS tumours make up ~3% of all cancers and most develop from the cells that support the nerve cells of the brain called glial cells, a tumour formed here is called a glioma [25].

Following diagnosis, staging to describe the cancer size and how far it has grown is important for the best decisions to be made regarding treatment plans [28]. There are two main types of staging systems, and they include the TNM system and number system. The TNM system illustrates Tumour, Node and Metastasis; T describes the size of the tumour, N describes whether there are any cancer cells in the lymph nodes, and M describes whether the cancer has spread to other parts of the body. Number staging systems use the TNM system to divide cancers into stages, and most types of cancers have four stages. Stages I, II and III indicate cancer is present and the higher the number, the larger the cancer tumour and the more it has spread into nearby tissues and lymph nodes. Stage IV

indicates the cancer has spread to distant parts of the body/other organs, also referred to secondary or metastatic cancer. Stage 0 or sometimes referred to as 'carcinoma in situ', is when abnormal cells are present but have not spread to nearby tissues and may develop into cancer in the future. An example of this is the cervical screening test for human papillomavirus (HPV) which is used to identify if any abnormal cells present and treat them before turning cancerous [28].

5.1.2 Treatment

Over the course of recent decades, cancer has been transformed from a fatal disease to one in which many people diagnosed with cancer receive highly effective treatments that result in either cure or long-term survivorship [29]. Early detection and improvements in a variety of treatment modalities, including surgery, chemotherapy and radiotherapy for cancer has resulted in the increase in the number of cancer survivors alive today [30]. In 2015 the National Institute for Health and Care Excellence (NICE) published updated guidance on suspected cancer underpinned by epidemiological evidence from primary care, https://www.nice.org.uk/guidance/ng12. The NICE guidelines are evidence-based recommendations for health and care in England to help health and social care professionals to prevent ill health, promote and protect good health, improve the quality of care and services, and adapt and provide health and social care services [31]. These new guidelines represent the first national approach to reduce 'diagnostic delay' by systematically applying evidence on how cancer presents in primary care [32].

The new guidance has established the following: cancer risk thresholds, explicit risk thresholds to recommend urgent investigation within 2 weeks when a combination of symptoms predicting cancer risk are presented, and a risk threshold of 3% set for adult cancers; improving direct access to investigations, by extending direct access for general practitioners (GPs) to a range of diagnostic tests helping to support the pivotal role of general practice in raising the suspicion of cancer, potentially helping reduce diagnostic intervals; non-specific symptoms of cancer, recognising that certain symptoms are associated with more than one cancer, and non-specific features of cancer such as appetite loss, weight loss and fatigue; and patient communication, highlighting two specific areas including safety netting as an approach to manage low-risk symptoms which may be early symptoms of cancer by providing clear time frames to patients if symptoms persist, and information and support at the point of referral from the GP [32]. However, this new guidance does not come without its challenges, how to implement them successfully across the health service comes as a major challenge as GP's are now faced with more complex rules in determining cancer risk.

To reduce this burden for GP's, Macmillan Cancer Support has developed a cancer decision support tool (CDS) which is now integrated into GP clinical software throughout England. If these NICE guidelines are implemented successfully this could accelerate the rate at which a cancer diagnosis is made and reduce disparities in cancer survival between England and other developed nations [32,33]. In addition, more recently community pharmacists and their teams have also been recognised to play a key role in raising awareness and helping with the early detection of cancer [34,35]. It is also important to note the impact that the COVID-19 pandemic has had on oncology care regarding screening and treatment for cancer patients/survivors and oncology clinical trials [36]. During the pandemic there was a reduction in screening procedures and treatments which may result in advanced-stage diagnoses soon, and oncology clinical were either withdrawn or postponed. However, the pandemic has accelerated the implementation of new operational approaches and innovative clinical trials which could lead to faster patient access to new diagnosis and treatments. Furthermore, there has been a shift in the way clinical trials are executed, towards remote management models [36]. These new approaches may largely facilitate new ways for oncology practice and clinical trials, improving global oncology care and support services. Overall, the implementation of such strategies and initiatives may help to increase the number of cancers in England found at an early and more treatable stage, which will hopefully facilitate greater longevity of anyone diagnosed with cancer.

Following diagnosis, it is important the individuals are provided with the most facilitative treatment plan to aid them on their road to a hopefully, long-term recovery. There are many different types of procedures and medicines used to treat cancer such as surgery, chemotherapy and radiotherapy, and many more are being studied [37]. However, treatment can also bring about many side effects, which can be different for types of treatments, the individual, and gender [38]. The type of treatment provided will be dependent on the type and stage of cancer and some individuals will require a combination of treatments such as surgery followed by chemotherapy, adjuvant treatment [37]. Treatments can be classified into two types, local or systemic. Surgery and radiation therapy are local treatments which are used to treat a specific tumour or area of the body. Generally, surgery is one of the main treatments for cancer and is often performed if the tumour is localised to a specific area of the body. However, surgery for certain types of cancers is not always possible due to location and those cancers of the blood and lymphatic system including leukaemia's and lymphoma's. Following surgery, ways to minimise pain and risk of infection are usually administered to facilitate the recovery process [39,40]. Different to surgery, radiotherapy

uses ionising radiation eradicates cancer cells by damaging the DNA present in these cells which leads to cell death (apoptosis). Unfortunately, radiotherapy can also affect surrounding healthy cells and a common side effect of radiotherapy is fatigue [41–43]. Fatigue occurs most often after surgery, radiotherapy, and chemotherapy (see section below). Fatigue in cancer patients has been reported in 90% of patients treated with radiation and the severity of fatigue varies dependent on several factors such as age, gender, stage of disease, and functional ability [44]. In a cross-sectional study, 10% of patients reported mild fatigue, 45% reported moderate fatigue and 45% reported severe fatigue following radiotherapy [45].

Chemotherapy, hormone therapy, immunotherapy, targeted therapy, stem cell or bone marrow transplant are referred to as systemic treatments as these work throughout the whole body [46]. Chemotherapy is an anti-cancer drug treatment and works by stopping or slowing the growth of cancer cells. Although a powerful form of treatment, chemotherapy also kills or slows the growth of healthy cells which is why some individuals experience hair loss when receiving this form of treatment. Fatigue is one of the most prevalent side effects during chemotherapy usually persisting for more than two weeks and it has also been shown to have the greatest and most long-lasting impact after chemotherapy (see Survivorship section ahead for more detail). Fatigue in cancer patients has been reported in 80% of patients treated with chemotherapy and similar to that of radiotherapy, the severity of fatigue also varies dependent on several factors such as age, gender, stage of disease, and functional ability [45,47,48]. In addition, in a cross-sectional study, 98% of patients reported severe fatigue following chemotherapy [45], and 85% of patients reported fatigue following chemotherapy in another prospective cohort study [49]. Hormone therapy is a form of treatment that uses medicines to block or lower the number of hormones in the body to stop or slow down the growth of cancer as some cancers are hormone sensitive/dependent. Hot flashes, nausea, fatigue, and muscle and bone changes are common side effects associated with this form of treatment in males and females. Hormone therapy can also cause more specific menopausal symptoms in females due to low levels of sex hormone [50]. These symptoms may present as fatigue, vaginal dryness, sweating and night sweats, lowered sex drive, anxiety and low mood, cognitive problems including issues with concentrating and thinking clearly, headaches, joint pains and muscle aches, and overtime the possible development of osteoporosis (thinning and weakening of the bones) [50–53]. Some breast cancer treatments including hormone therapy, can also induce early menopause in females which may either be temporary or permanent depending on age, individuals who are closer to the natural age of menopause occurrence ~45-55 years, are more likely to experience permanent menopause [50]. In a previous study, 95% of breast cancer patients reported menopausal

symptoms when receiving hormone therapy [54]. Among the menopause symptoms, fatigue was the most prevalent side effect reported by 97% of breast cancer patients. Other side effects including hot sweats and flushes were reported by 81% patients, sleeping disorders were reported by 79% of patients, joint and muscle complaints were reported by 91% and psychological symptoms including depression and anxiety were reported by 86% and 85% of patients. In addition, sexual problems and vaginal dryness were reported by 84% and 79% of participants [54]. Coping with a cancer diagnosis and the subsequent side effects of treatments may be overwhelming for survivors and may severely affect their QoL.

Immunotherapy uses the body's immune system to fight cancer, it aids the immune system in recognising cancer cells and attacking them. In general, the immune system helps our bodies to fight infections by identifying and terminating abnormal cells. Some individuals may have immunotherapy on its own or with other treatments necessary to treat their cancer [55,56]. As with any of the treatments discussed so far, individuals may experience side effects from immunotherapy such as flu-like symptoms, skin changes/reactions at the needle site, increased risk of infections and may experience adverse effects in the following systems, cardiovascular, dermatologic, endocrine, gastrointestinal, neurologic and pulmonary [57,58]. Approximately 1 in 5 patients receiving immunotherapy will have an immune-related adverse event [59]. Targeted therapy targets the proteins that control how cancer cells grow, divide, and spread. The changes in genes that cause one type of cancer such as breast cancer are different to that of another cancer such as lung cancer. Therefore, targeted medicines target those differences that facilitate cancer growth. Diarrhoea and liver problems are the most common side effects of this form of therapy [60,61]. Although the side effects of targeted therapies are lower than that on other treatments such as chemotherapy, targeted drugs need to be used for extended periods of time or even indefinitely which can produce a high incidence (80%) for side effects in the process of targeted therapy [62]. In a previous study, 61% of patients reported side effects including skin, damage, fatigue, mucosal damage, hypertension, and gastrointestinal discomfort as the top 5 side effects during targeted therapy [62]. Stem cell and bone marrow transplants are used to help the body recover following high doses of radiotherapy or chemotherapy. Despite these treatments eradicating cancer cells, they also eradicate the stem cells in bone marrow, therefore stem cells are collected prior to chemotherapy (autologous) or provided by a donor (allogeneic). Following treatment these stem cells are fed back into the body, gravitating to the bone marrow to begin making new blood cells. These blood-forming stem cells are extremely important as they grow into the different blood cells our bodies need to for our natural defences to survive including erythrocytes (red blood cell), which contain haemoglobin to carry oxygen

around the body to working tissues and muscle; leucocytes (white blood cells), which make up the immune system to help fight infections; and platelets which prevent bleeding by helping blood to clot [63,64]. In some cases when individuals have an allogeneic transplant, they may develop graft-versus-host disease (GvHD) which can cause damage to many organs. This disease is caused by the white blood cells from the donor recognising the receivers (patient) cells as foreign and attacks the cells. Acute GvHD can occur in up to 50% of patients and the prevalence of chronic GvHD ranges from 6% to 80%. GvHD is considered one of the main causes of morbidity and mortality after stem cell transplants, and more than 10% of patients will die from this complication [64]. The side-effects mentioned above are only some of the side effects experienced by these individuals. Many survivors go on to live with long-term side effects as a result of the disease and its treatment [65]. Therefore, supporting survivors following diagnosis and treatment in managing and improving these side effects is of crucial importance.

5.1.3 Public health and prevalence

Cancer poses a significant mortality, morbidity, economic and humanistic burden to patients and healthcare systems [66]. In the United Kingdom (UK), the total economic burden of cancer was reported as £7.6 billion in 2019 and this figure was the result of multi-faceted costs associated with the disease [67]. Over recent years spending has increased due in part to advances in treatment, including targeted therapies, immunotherapies, advanced imaging, and supportive care; longer treatment durations; and more treatment combinations. Many survivors also receive additional medical care because of the late and lasting effects of the disease and its treatments. Furthermore, survivors and their families increasingly face high out-of-pocket costs following their diagnosis. Financial hardship is increasingly common with many survivors reporting high levels of financial distress, the most common additional cost in this 'cancer premium' is connected to transport and hospital visits as well as additional day-to-day living costs such as fuel costs and help around the home and garden [67,68]. In turn, this may add to the already heightened levels of stress incurred from an individual's diagnosis. However, cancer's full cost is much more than that of financial strain, living with it, surviving it, recovering from it, or caring and supporting someone with it is tough physically, financially, and emotionally. The 'ripple effects' of its cost can be felt in families, firms and communities everywhere in England [67]. Therefore, the impact of cancer may be more than economic and financial, but social and emotional too.

In 2017, data from the Office for National Statistics reported more than 300,000 cancer registrations, with 1,953,645 people living with and beyond cancer in England [69]. Worldwide, an estimated 19.3 million new cases

and almost 10.0 million cancer deaths occurred in 2020, and the global cancer burden is expected to be 28.4 million cases by 2040, almost 50% higher than in 2020 [70,71]. The increase in cancer incidence and mortality is largely attributed to population growth, and ageing population and increased exposure to risk factors, resulting in a high unmet need for effective and well-tolerated treatments as well as earlier disease detection [66]. Although the number of cancer survivors is increasing worldwide, this places substantial pressure on survivorship recovery services [67]. As a result, globally, cancer is a major public health problem [72]. In the UK, over half (53%) in 2016-2018 [73] and in the United States (US) almost half (50%) of all new cancer cases were breast, prostate, lung, and colorectal cancers [74]. Furthermore, breast, prostate, lung, and colorectal cancers accounted for almost half of cancer deaths in 2018 in the UK [75] and lung, colorectal, pancreatic, and breast cancers accounted for almost half of cancer deaths in the US [74]. Globally, breast and lung cancers were the most common cancers, contributing to 12.5% and 12.2% of the total number of new cases diagnosed in 2020 and colorectal cancer was the third most common cancer with 1.9 million new cases in 2020, contributing to 10.7% of new cases [76]. In terms of age, incidence rates for all cancers combined in the UK from 2016-2018 were highest in people aged 85-89 years. However, incidence rates for all cancers combined have increased across all age groups in the UK from 2016-2018, with the largest increase in people aged 25-49 years where rates have increased by more than 22% [73]. Despite cancer being a disease largely associated with aging, this increase in younger adult age groups may be because of a variety of unhealthy lifestyle behaviours such as poor diet, alcohol consumption and inactivity.

In terms of sex differences, prostate cancer is the most common cancer in men in the UK [77]. Globally, lung cancer was the most common cancer reported in men, contributing to 15.4% of new cases diagnosed in 2020. Overall lung, prostate and colorectal cancers contributed to 41.9% of all cancers in 2020 in men. Breast cancer is the most common cancer in women in the UK [78]. Globally, breast cancer was the most common cancer reported in women, contributing to 25.8% of new cases diagnosed in 2020. Overall, breast, colorectal and lung cancers contributed to 44.5% of all cancers in 2020 in women [76]. The incidence and mortality of various cancers have been associated with sex-specific disparities with the incidence and mortality rates being higher in males compared to females [79,80]. Sexual differentiation begins with fertilisation and continues beyond menopause and it affects virtually every body system, resulting in marked sex differences in such areas as growth, lifespan, metabolism and immunity, all of which can impact cancer progression, treatment response and survival [80]. Sex difference in cancer incidence is attributed to regulation at the genetic/molecular level and sex hormones such as oestrogen, with circulating sex hormones positively or negatively affecting the development of various cancers

through modulating gene expression [79]. Sex hormones may contribute to the differences in the incidence of cancer between males and females. Given these organismal level differences and correlates at the cellular level, males, and females can fundamentally differ in their protections and vulnerabilities to cancer, from cellular transformation through all stages of progression, spread, and response to treatment [80].

5.1.4 Survivorship

The National Cancer Institute considers an individual a cancer survivor from the time of diagnosis, through the balance of their life [81]. Although it is exceptional that survival rates have increased over recent decades with advances in early diagnosis and treatments [5], the disease and its treatment can have a long-term impact on a survivor's physical and psychological health that does not recede with time including, declines in physical function, cancer-related fatigue and many more leading to an overall reduction in the individual's quality of life (QoL) [82]. This has given rise to a new concept, chronic cancer, as cancer survivors face living with the long-term consequences of their diagnosis and its treatment long after the completion of primary treatment [83,84]. Two major categories of health concerns are cancer recurrence and mortality, and the persistent adverse effects of cancer treatment [85]. PA has been associated with a lower risk of systemic recurrence and mortality in individuals diagnosed with cancer. For example in women diagnosed with breast cancer, participation in PA post diagnosis seen a 24% reduction in disease recurrence, and 45% reduction in mortality [85,86]. Despite this, the biological mechanisms through which PA and exercise reduces the risk of systemic recurrence and mortality are not yet known. However, existing hypotheses contend that the benefits of PA are attributable to systemic adaptations that occur within the host microenvironment, such as favourable changes in metabolic insulin-related growth factors, inflammation and immune function [87–89]. In regard to the long-term effects of cancer and its treatment, these can include cancer-related fatigue, cardiotoxicity, cancer cachexia osteoporosis, diabetes, hypothyroidism, cognitive dysfunction, chronic pain, endocrine dysfunction, sexual dysfunction, psychosocial changes [83,90]. Cancer-related fatigue, cardiotoxicity, and cancer cachexia can be extremely debilitating and have a severe, negative adverse effect on survivors' health and their day to day lives following treatment [91–93].

Cancer-related fatigue is one of the most common and distressing side effects of cancer and its treatment, and it does not dissipate on completion of treatment. Many survivors are burdened with the experience of persistent fatigue for many months and years following treatment [94]. Generally, in disease free individuals, fatigue is a subjective experience in response to many aspects of daily life and PA and is alleviated through sleep in. However,

it presents very differently in cancer survivors and does not improve with adequate sleep [91]. Cancer-related fatigue is multi-dimensional and may affect the physical, cognitive, and affective domains including exacerbated weakness, less energy, and more need of rest; diminished concentration and attention; decreased motivation or interest to engage in usual activities and emotional lability [91,94,95]. In addition, levels of fatigue may also have important prognostic value, being a predictor for shorter survival [91,94]. In cancer survivors, fatigue is multi-factorial and may be influenced by a variety of demographic, medical, psychosocial, behavioural, and biological factors. Inflammation has emerged as a key biological pathway for cancer-related fatigue, with a specific focus on circulating concentrations of pro-inflammatory cytokines including IL-1β, TNF-α, and IL-6 and markers of their activity including the IL-1 receptor antagonist, the soluble TNF and IL-6 receptors, and C reactive protein (CRP) [94]. Overall, cancer-related fatigue has a significant impact on survivors QoL, making daily activities that they once were capable of performing with ease, extremely challenging, and for some particularly their ability to return to work [91,94]. Given cancer-related fatigues detrimental impact on survivors QoL, it emphasises the need for suitable management interventions. The literature documents strong evidence for the beneficial effect of PA and exercise as effective interventions in helping to reduce levels of fatigue. Furthermore, as it is one of the most common side-effects reported by survivors, and can be improved through PA and exercise, this highlights the need for better uptake and adherence to such interventions and general PA and exercise engagement.

Survivors who have had anticancer therapies such as chemotherapy are at risk of cardiovascular toxicity (cardiotoxicity) which can range from asymptomatic subclinical abnormalities including electrocardiographic changes and temporary left ventricular ejection fraction decline, to life-threatening events such as congestive heart failure (cardiomyopathy) or acute coronary syndromes [92]. Pre-existing risk factors may also contribute a high risk of cardiotoxicity in this population. A recent study found that subjects with at least one cardiovascular disease (CVD) risk factor prior to commencing their cancer therapy developed cardiotoxicity following treatment [96,97]. The use of specific chemotherapeutic agents and molecular targeted therapies can affect the cardiovascular system either through a direct effect on heart function or peripherally through haemodynamic flow alteration, hypertension and/or thrombotic events [92]. Consequently, although an individual may survive cancer, they may later go on to develop cardiomyopathy (heart failure) which has a higher mortality rate than cancer [96] and may potentially lead to premature mortality following cancer remission [98]. The incidence rates of cardiotoxicity are frequently associated with anthracyclines, high-does cyclophosphamides, and increasingly tyrosine kinase inhibitors of chemotherapeutic agents [92,96]. PA and exercise can stimulate numerous biochemical and

physiologic adaptations, including cardioprotective effects, through the cardiovascular system and cardiac muscles, where exercise has been proposed to be an effective clinical approach that can protect or reverse the cardiotoxicity from anthracyclines [98]. Aerobic exercise is traditionally the most common mode of exercise prescribed to improve cardiorespiratory fitness and cardiovascular function, and in turn reduce the risk of developing CVD [98]. Resistance exercise is also now recommended for the prevention and treatment of CVD, and there is evidence to support its effect in improving flow-mediated-dilation, a marker of vascular function, in healthy individuals and those with cardiovascular and metabolic diseases [99]. Although the literature documents promising results for the beneficial effects of PA and exercise modes on cardiotoxicity, further research is needed to understand the impact of cancer types, treatments and exercise prescriptions on both cardiac and vascular function [100]. However, engaging survivors in both aerobic and resistance exercise may help to reduce their likelihood of developing CVD following treatment.

Muscle wasting (sarcopenia), with or without fat loss, is a pivotal feature of cancer cachexia, a multifactorial condition that can negatively impact survivor's prognosis and QoL [93]. Weight loss in cancer survivors is due to equal loss of both adipose tissue and skeletal muscle mass and depending on tumour type, occurs in ~20% to ~80% of survivors [93,101]. The higher the extent of weight loss, the shorter the survival time, an important prognostic factor [101] and cancer cachexia has previously been reported to account for ~20% to ~40% of all cancer-related deaths [102]. Although there is depletion of adipose tissue and skeletal muscle mass, it is the skeletal muscle mass loss that has the greatest impact on survivors physical function and QoL [103]. The underlying mechanisms in cancer cachexia are complex and the condition may result from reduced nutrient intake and/or availability and metabolic abnormalities, triggered by a complex network of cytokines, hormones and other tumour and host-derived humoral factors and anti-cancer therapies which may exacerbate this condition [93,101]. Available evidence suggests that a prominent role is played by increased muscle protein degradation, although impaired muscle protein synthesis and defective myogenesis may also contribute. Furthermore, alterations in energy metabolism involving mitochondrial dysfunction have been associated in the wasting process [93,103,104]. The degree of wasting can also vary with cancer stage and progression, the condition is most prevalent in pancreatic, lung, colorectal and gastrointestinal cancers [102]. The loss of skeletal muscle mass is frequently associated with loss of strength in this population and along with chronic fatigue, may result in reduced PA [93]. However, in addition to nutritional interventions, PA and exercise have been proposed as another vital

component of the multimodal approach to cancer cachexia, particularly resistance exercise as this can induce muscle hypertrophy through the upregulation of muscle protein synthesis [93,102].

Overall, these side effects of the disease and its treatment may have a catastrophic impact on survivor's day-to-day lives as they navigate their new way of being. As a result, there is a growing need to address the unique health issues cancer survivors face because of the disease, its treatment, and related comorbid conditions [90]. Especially as survivors QoL may be severely compromised, one of the most concerning health issues for this population [105]. QoL throughout the survivorship period is therefore a vital consideration and evidence-based ways to improve QoL are essential. The need for long-term positive health behaviours becomes more and more essential to survival.

5.2 Physical activity, exercise, physical fitness, and sedentary behaviour

5.2.1 Definitions

A key aspect of cancer survivorship focuses on lifestyle behaviours such as PA promotion [106]. For the purpose of this thesis, physical activity (PA) is defined as any bodily movement produced by a contraction of skeletal muscle that substantially increases energy expenditure [107]. This definition encompasses 4 domains in which PA occurs and are central to understanding the assessment of PA. These include, occupational PA (work-related manual labour tasks), domestic PA (housework, gardening and shopping), transportation PA(walking, cycling, and public transport), and leisure time PA (sports, hobbies, and exercise) [108]. Exercise is a sub-category of leisure time PA and refers to activity completed in a planned, structured, and repetitive manor to maintain or improve an aspect of fitness. Physical fitness is defined as a set of attributes (i.e. cardiorespiratory endurance, skeletal muscle endurance, skeletal muscle strength, skeletal muscle power, flexibility, agility, balance, reaction time, and body composition) that people have or achieve that relate to the ability to perform PA [107]. PA is a complex set of behaviours and often described in 4 dimensions, mode or type of activity, frequency of performing activity, duration of performing activity, and intensity (rate of energy expenditure) of performing activity [108]. In relation to sedentary behaviour (SB) there has previously been inconsistencies in terminology surrounding SB which has caused confusion in the literature for researchers, policy makers, and the public [109]. Therefore, the Sedentary Behaviour Research Network (SBRN) proposed research in this field to adopt a consistent definition: SB is defined as any waking behaviour characterised by an energy expenditure ≤1.5METs while in a sitting or

reclining posture [109]. When researchers are describing those who are not meeting the recommended PA guidelines, it is suggested they do so by using the term “inactive” [109].

5.2.2 Recommendations

Historically, cancer survivors were encouraged to rest and avoid PA [100]. However, PA is a modifiable lifestyle behaviour and is positively associated with numerous physiological and psychological health outcomes for this population [110]. In addition, there is now strong evidence that PA is associated with lower risks of developing several types of cancer. These include colon, breast, endometrial, kidney, bladder, esophageal (adenocarcinoma), and stomach (cardia). There is also moderate evidence that PA is associated with a reduced risk of lung cancer. For several other cancers there is more limited evidence of an association, including myeloma and hematologic, head and neck, pancreas, ovary, and prostate. Abundance evidence now suggests that PA and exercise play a key role in improving cancer-related health outcomes with strong evidence; for reducing anxiety, fewer depressive symptoms, less fatigue, better QoL, improved perceived physical function and no risk of exacerbating upper extremity lymphedema; and moderate evidence for improved sleep and bone health regarding osteoporosis prevention [100,111]. Furthermore, engaging in regular PA and exercise improves muscular strength, cardiovascular endurance, increases energy levels and the ability to complete daily tasks and reduces the risk of chronic diseases [112]. Overall, these improvements in health and fitness parameters may thoroughly improve survivors QoL. Considering these health and fitness benefits associated with PA and exercise engagement, it is no surprise that healthcare providers are now encouraged to promote healthy lifestyle behaviours [110]. The ACSM (American College of Sports Medicine) recommends that PA and exercise should be incorporated within the routine care for individuals living with and beyond cancer [111]. Most importantly, abundance evidence suggests that exercise is safe for cancer survivors [84,100,110].

In 2010, the ACSM developed the first set of PA and exercise guidelines for cancer survivors and recommended that survivors aimed to achieve at least 150 minutes per week of aerobic activity, two or more days a week of resistance training, stretch major muscle groups daily when possible, and survivors were encouraged to avoid inactivity and be as active as possible [113]. In 2018, the ACSM provided an update based on the increase in evidence for PA and exercise in this population from high quality randomised controlled trials [100]. The new guidelines recommend moderate intensity aerobic training at least three times per week, for at least 30 minutes, and resistance training for at least two times per week, using at least 2 sets of 8-15 repetitions at least 60% of one

repetition maximum [100]. In the United Kingdom (UK), cancer survivors are advised to follow the current PA recommendations for adults: to be active daily and each week accumulate at least 150 minutes of moderate intensity activity or 75 minutes of vigorous intensity activity (or a combination of both), and to include activities to develop or maintain strength in the major muscle groups whilst aiming to minimise the amount of time spent sedentary [114]. Cancer is a complex disease, and each cancer survivor is different in terms of how much exercise they can do, their type of cancer and the treatment pathway they have followed [115]. The updated guidelines from the ACSM reflect more recent evidence that cancer survivors can still derive benefits from less exercise and may be more manageable for individuals to follow during or shortly after cancer treatment [116]. For best practice, it is recommended that PA and exercise should be tailored to the individual [98,100]. In addition, there has been an increase in the development of PA and exercise interventions/programs for cancer survivors as such interventions are increasingly being recognised as an important part of the treatment and supportive care for survivors [6,70]. PA and exercise interventions/programs have demonstrated positive effects on cancer survivors physical and mental health both during and post-treatment [84,100,110,111]. However, poor uptake to PA an exercise programs/interventions has been reported, with many cancer survivors cancelling registration or failing to attend [18].

5.2.3 Exercise modality

Current evidence supports the potential for cancer survivors to respond positively to an exercise training stimulus by improving individual components of physical fitness including cardiorespiratory fitness and muscular strength and endurance [84,100,110]. However, because of the direct effects of cancer treatments on the physiological systems, side effects of cancer treatment and/or demographic factors, there may be variation in an individual's response to a particular exercise stimulus. In addition, given the range of side effects discussed earlier in this chapter, survivors, particularly those having active treatment, abilities to tolerate any and/or specific modes of exercise may fluctuate [84,100,110]. Therefore, this may require important considerations from exercise professionals, and exercise professionals may need to tailor and individualise training programs and exercise prescriptions to meet the specific needs of an individual living with and beyond cancer. To date, research has not determined the exact exercise training program/prescription or what type of PA and exercise modality is required to induce the optimal benefits/impact on survivors' health and fitness [84,100]. In the recent update for the PA and exercise guidelines for cancer survivors provided by the ACSM, the experts concluded that as the evidence base continues to grow the next update of exercise guidelines/prescriptions could have the specificity to move

exercise oncology toward the same goal as precision oncology where treatment is matched to the specific characteristics of an individual's cancer [100].

Nevertheless, improvements in fitness components including cardiorespiratory fitness and muscular strength following aerobic and resistance exercise training interventions/programs in survivors have been increasingly recognised in the literature, and such improvements have led to an overall improvement in survivors QoL [84]. More specifically, during chemotherapy there is a well-documented decline in cardiorespiratory fitness as measured by VO_2peak [100,110]. However, although chemotherapy treatments may impair cardiorespiratory fitness, there is ample evidence to suggest that aerobic exercise training preserves and/or improves cardiorespiratory fitness in cancer survivors [100,110]. Considering muscular strength and endurance, reductions in these components of physical fitness is common in survivors following diagnosis and treatment [100,110]. These reductions in muscular strength and endurance are largely due to a reduction in general activity which leads to deconditioning due to the lack of muscular performance, and/or as a side effect of treatment such as ADT (Androgen Deprivation Therapy) [100,110].

ADT (Androgen Deprivation Therapy) is used to treat prostate cancer and reduces testosterone levels which results in the loss of lean mass referred to as sarcopenia, and is accompanied by decreases in muscular strength and endurance, reducing physical function and overall QoL [117]. However, evidence is continually growing establishing resistance exercise as an effective form of exercise training for increasing lean mass, muscular strength and performance, and in turn improving physical function and QoL in survivors [100,110,117]. Furthermore, with improvements in cancer treatment following diagnosis many survivors are now living longer [5]. It is well established that aging is associated with musculoskeletal perturbations such as osteoporosis (low bone mineral density) and sarcopenia (reduced skeletal muscle mass, strength and performance) which are associated with significant morbidity and mortality [118]. In addition, reductions in bone mineral density and skeletal muscle mass, strength and performance have been observed during and following treatment in adult cancer survivors as well as younger cancer survivors [119–123]. These conditions may place survivors at an increased risk of falls, fractures, and functional decline severely impacting QoL [121–123]. However, increased mechanical loading of the musculoskeletal system such as resistance exercise training can lead to a significant increases in bone mineral density and muscle mass [121]. Overall, resistance exercise/strength training may have particular significance in exercise training interventions/programs for this population to prevent fractures and

functional decline through enhanced bone mineral density and muscle mass. These outcomes may largely facilitate survivors QoL throughout the survivorship period.

Despite the increasing evidence for the benefits of PA and exercise following diagnosis, the recommendations for PA and exercise in this population, and the provision of PA and exercise programs/interventions, few cancer survivors are physically active [124]. As a result of the complex nature of cancer and life following diagnosis, cancer survivors may face a number of barriers for PA and exercise engagement and a lack of facilitators for adherence to PA and exercise interventions/programs and/or PA and exercise in general [125]. This highlights the need to better understand the barriers and facilitators survivors may face for PA and exercise engagement. Overall, this may help to inform effective intervention design by tailoring such interventions/programs to minimise specific barriers and improve rates of uptake and adherence in this population.

5.3 Barriers and facilitators

A cancer diagnosis has been described as a 'teachable moment' during which survivors may be amenable to change lifestyle behaviours [106,126]. This may include leading a more active lifestyle. However, survivors are rarely followed up over more than 6 months in PA and exercise studies, and it is not known whether such motivation to make better lifestyle choices continues overtime such as maintenance in PA following potential improvements post-intervention [127,128]. It is also important to note that following diagnosis, survivors may be overwhelmed during the initial diagnostic, staging and early treatment phases. This 'teachable moment' may not be fully taken advantage of, given that half of active patients/survivors are no longer active following diagnosis, while only 12% of inactive patients/survivors become active [106]. With many survivors failing to meet the recommended PA guidelines [18] or attending PA and exercise interventions/programs [6], a comprehensive understanding of the potential barriers faced for PA and exercise engagement in this population are crucial. Across other cohorts of cancer survivors/patients and other non-clinical groups, specific barriers and facilitators for PA and exercise participation have been identified, using focus groups (see chapter 6) [129,130].

5.3.1 Barriers

Physical symptoms like cardiovascular, musculoskeletal, and pulmonary diseases, weight gain and fatigue have been reported as physical barriers. Depression, no motivation, fears, lack of knowledge about PA and QoL, and

no awareness of exercise programmes have been reported as psychological barriers [106,131,132]. Environmental and social-related barriers have been reported and include, employment status, access to facilities, bad weather, and lack of time [106,128,131,133]. Survivors perceptions on what are the true recommended PA and exercise guidelines have also been noted as a potential barrier [106]. Two systematic reviews exploring barriers and facilitators for exercise experienced by cancer survivors reported persisting treatment-related side effects as the most frequently reported barrier for initiating or maintaining exercise, followed by a lack of time and fatigue [134–136]. Colorectal cancer survivors reported chronic diarrhoea and colostomy bags, breast cancer survivors reported lymphedema and shoulder stiffness, and prostate cancer survivors reported incontinence all as treatment-related side effects that hindered PA and exercise participation [134]. Although valid reasons, it is important work to encourage survivors to participate in PA and exercise during their survivorship given the documented health benefits already discussed which in turn, may help to combat some of these barriers. Furthermore, knowledge concerning the key barriers associated with PA may be helpful in designing optimally targeted PA interventions among cancer survivors [137].

5.3.2 Facilitators

Understanding what facilitates cancer survivors to engage in PA and exercise is also of crucial importance. Despite the numerous barriers to PA and exercise frequently reported, most cancer survivors show positive attitudes to PA and many cancer survivors indicate that they would be interested in taking part in PA and exercise as a means to enhance their activity levels [135,138]. A recent review reported availability of affordable PA programs, the presence of accessible, tailored amenities, availability of facilities with tailored and individualised PA programs all as facilitators for PA participation [135]. Another review reported improved physical health and mental wellbeing by managing emotions, resulting in gained feelings of control over their health as facilitators for PA and exercise [134]. The findings from this review further support the literature discussed earlier in this chapter regarding the positive effects of exercise on improving physical functioning, reducing pain and fatigue, and improving QoL. The social benefits of exercise were also reported as a key facilitator for PA and exercise participation [134]. Exercise programs being group-based offering social support, and structured and supervised have also been previously reported as key facilitators in the cancer and older adult PA and exercise literature [129,136]. Therefore, accessible, group-based, supervised exercise opportunities may facilitate the formation of health activity habits in the cancer survivor population.

Considering the key barriers and facilitators noted above including treatment-related side effects, fatigue and social support, the exploration of multicomponent interventions [136] could be used to educate survivors on the benefits of PA and exercise for fatigue and delivered in settings that offer a level of social support. Interventions that encompass such elements may be more successful in increasing levels of PA in this population and facilitate adherence. Overall, a variety of barriers and facilitators are evident for PA and exercise participation. Despite the identification of these barriers, facilitators, and the health benefits associated with increased levels of PA and exercise, the challenge remains to increase the number of survivors participating in PA and exercise as levels are currently still reported as low [135]. More effective strategies to increase PA in cancer survivors should be explored [139]. Furthermore, research aimed at promoting behaviour change may first need to apply robust methods to thoroughly assess and understand the target population. PA and exercise are only effective if the individual responds and engages in recommendations/prescriptions/exercise training programs. Changing behaviour is complex and is this process is dependent on personal, social, and environmental factors, for example, some survivors may need the support of group-based exercise settings to adhere to exercise training programs [111]. Interventions that are catered to survivors needs such as these may facilitate a change in behaviour. This may facilitate long-term change in behaviour and in turn, maintenance of PA and exercise behaviour, which is essential for the achievement of optimal health and fitness benefits in this population.

5.4 Interventions

5.4.1 Physical activity and exercise interventions

Given that a large proportion of cancer survivors do not perform regular PA and that many survivors decrease their level of PA following diagnosis, there is an urgent need for interventions aimed at increasing and maintaining PA [139]. Empirical evidence from a growing number of randomised controlled trials (RCTs) suggests significant increases in PA on completion of interventions in this population [5] As previously noted, the promotion and application of PA and exercise interventions have demonstrated positive influences for the adoption of healthy lifestyle behaviours and have been shown to improve survivors QoL and other patient-reported outcomes during and post cancer treatment [89]. Furthermore, interventions conducted during the prehabilitative and rehabilitative stages may offer significant improvements at these specific periods and across a range of cancer types [140,141].

Prehabilitation and rehabilitation exercise interventions are increasingly being implemented into the cancer care continuum [141–143]. With growing numbers of cancer survivors, there is a need to provide interventions that mitigate the adverse effects of cancer treatments and prevent future disease and cancer recurrence. Physical problems including pain and fatigue, and psychosocial problems including depression and anxiety around the fear of recurrence are the most commonly reported issues for cancer survivors [144]. Regarding prehabilitation, a systematic review exploring the effects of multimodal prehabilitation interventions in men affected by prostate cancer reported improvements in strength and functional ability, and reductions in anxiety following interventions that included home-based exercise [145]. A recent systematic review exploring multimodal prehabilitation interventions in women affected by breast cancer reported improvements in physical function, quality of life and psychosocial variables including anxiety [146]. Another systematic review and meta-analysis exploring the impact of prehabilitation exercise on cancer patients with a variety of cancer types also reported improvement in physical functioning [143]. Regarding rehabilitation, a recent systematic review exploring exercise-based oncology rehabilitation programs for cancer survivors with a variety of cancer types reported increases in limb muscle strength, improved functional strength performance and reductions in depression [144]. Another systematic review and metanalysis of randomised controlled trials exploring effects of exercise interventions on breast cancer patients during adjuvant therapy reported positive outcomes in physical fitness, strength, quality of life, fatigue, depression, anxiety and self-esteem as well as reductions in body fat percentage and body mass index [147]. These studies provide good evidence for the positive effect prehabilitation and rehabilitation exercise interventions can have on a variety of health outcomes across a range of cancer types, specifically those frequently reported including physical and psychosocial problems.

In addition, two Cochrane reviews of RCTs of PA and exercise interventions demonstrated that engagement in PA led to a significant reduction in cancer-related fatigue [148] and improvements in overall health-related QoL (HRQoL) and physical functioning, and reduced anxiety and depressive symptoms [149]. A more recent review of RCTs found that exercise interventions had positive outcomes on physical fitness, handgrip strength, QoL, fatigue, depression, anxiety, and body composition in breast cancer patients [147]. The PA and exercise interventions included in these reviews were a variety of community and home-based, supervised, and unsupervised interventions. These reviews provide evidence for the benefits of PA and exercise interventions in improving markers of health in this population. However, the interventions were conducted under tightly controlled research settings. To achieve the long-term health benefits from PA and exercise, survivors must be

habitually active highlighting the importance of PA and exercise maintenance long after an intervention has ended [5]. There is a need to translate PA and exercise interventions/programs beyond such controlled settings and into the community/real-world settings to truly improve cancer survivors' health and well-being [150]. To understand which types of programs/interventions may be most implementable in a real-world setting, it may be beneficial to explore service user and service providers experiences of such programs/interventions [150]. As previously discussed, this population face a variety of barriers and facilitators for PA participation, exploring experiences may be essential in the planning and development process of such real-world interventions, and in turn contribute towards program/intervention success.

Interventions that are structured and supervised that include exercise types and intensities tailored to cancer survivors' needs can help to overcome some of these barriers and may be most effective for increasing PA and improving physical functioning and QoL in this complex population [132,151]. A previous qualitative study exploring the factors influencing non-participation in an exercise program for cancer survivors concluded that interventions aimed at promoting PA in this population should offer home-based programs as well as include referral and advice from oncologists. The participants in this study expressed a preference for PA that was not gym- or facility-based but home-based [6]. There has been some debate in the literature around the benefits/limitations of supervised versus home-based exercise programs and interventions for this population, and concerns regarding the safety of home-based interventions, adherence and efficacy, the role of the oncologist in promoting PA and the definition of home-based interventions [152–157]. However, home-based PA and exercise interventions/programs may play a key role in overcoming the barriers associated with non-participating in PA and exercise interventions/programs in this population [70]. Home-based interventions/programs may be more advantageous because they may mitigate access and transport issues, be more cost effective than supervised, facility-based interventions/programs [153]. Overall, PA and exercise interventions are needed that meet the preferences and support the needs of cancer survivors, and that are feasible and scalable, and could be integrated into routine practice [153]. Interventions that do so may assist in the uptake, adherence, and maintenance of PA in this population [153].

Further considering specific preferences for PA and exercise in this population, survivors/patients have reported preferences for engaging in PA and exercise with other survivors/patients because of the peer/social support, shared experiences and sense of belonging being together offers as they share similar paths following diagnosis

[129]. Recent research has highlighted social support as the most frequently reported facilitator for centre-based exercise by participants, exercising as a group and the resulting group dynamic was found to be very motivating [84,158]. In addition, interventions encompassing group-based settings along with a level of supervision have been recognised as key components of successful interventions. These interventions demonstrated greater and more consistent benefit of exercise for aerobic and muscular fitness, and QoL in survivors when compared with unsupervised home-based exercise settings [84]. There is a need to explore the effects of group-based PA and exercise interventions/programs delivered in supervised settings to further understand how such contexts may facilitate PA and exercise engagement in this population. Furthermore, assessing the feasibility of home-based PA and exercise interventions and the impact of such interventions of specific outcomes including PA in this population is needed. By doing so, this may help researchers, practitioners, oncologists, and oncology care providers in the implementation of such interventions/programs for this complex population.

5.4.2 Oncologists and oncology care

In addition, it is important to acknowledge the request for advice from oncologists. Although reasons for lack of engagement in PA and exercise in survivors is multifactorial, multiple studies have documented a lack of recommendation or referral from an oncology clinician for PA and exercise following diagnosis [6,111]. Oncologists and clinicians may play a pivotal role in facilitating health behaviour change in survivors and following diagnosis, survivors may be more motivated to make health behaviour changes such as increasing PA [159]. Therefore, oncologist and oncology care providers may be in the ideal position to promote PA and refer survivors to exercise specialists. Previous work has highlighted survivors demonstrating a preference for PA and exercise information and recommendations from their oncologists and care team, and highlighted that survivors may be more motivated to change their behaviour after advice from an oncologist [153]. Previous studies have demonstrated that survivors tend to engage in higher levels of PA and exercise following advice and recommendations from their treating oncologist [153]. However, research exploring oncologists and oncology care providers knowledge, attitudes and practices for the promotion of PA to their patients/survivors demonstrated such factors are limited due to a lack of time, knowledge and referral pathways to facilitate exercise prescription in this population [159]. More recently a 'call to action' for oncology clinicians has been recognised by experts in this field [111]. There is a need to assess current PA at regular intervals, advise patients with cancer on their current and desired level of PA and highlight that moving matters, and refer survivors to appropriate PA and exercise programs or to the appropriate health care professionals who can evaluate and refer to exercise [111].

This may help to increase the number of survivors engaging in PA and exercise which may facilitate improvements in health parameters and reduce the global burden of this disease.

5.5 Quality of life

Historically, the reality of increased incidence rates combined with improved survival rates placed an emphasis on addressing cancer survivors QoL [160]. Today, this is still an area that requires much attention, especially as the number of survivors is largely increasing. QoL is a vital consideration in understanding survivorship and the lasting long-term impact of cancer and its treatment [83], as already well documented earlier in this literature review. A recent meta-analysis reported that QoL was significantly impacted 2 to 26 years after cancer diagnosis and the largest impact to quality of life was found in physical and mental health [83]. Given the need for researchers and health care professionals to further understand QoL and survivorship, QoL is increasingly used as an outcome measure in interventions and clinical trials [70,161]. The Short Form-36 (SF-36) health survey is a generic self-report survey and frequently used to measure QoL in cancer survivors [162–165] as well as healthy and other chronically ill adults [164]. The survey is regarded as valid and reliable measure of QoL in this population [163]. The survey consists of 36 items which measure 8 health concepts including physical functioning, role physical, bodily pain, general health, vitality, social functioning, role emotional and mental health. The SF-36 was used to assess QoL in participants of the home-based exercise intervention included in this thesis (see chapter 8).

Existing quantitative research has provided consistent and ample scientific evidence to suggest that PA and exercise may facilitate QoL in adult cancer survivors, more specifically, improvements in physical, psychological/emotional, and social functioning, reduce treatment side effects such as pain, nausea and fatigue, and enhance general life satisfaction [166]. However, quantitative methods may fail to cover all aspects of QoL that cancer survivors feel have been impacted by PA and exercise which in turn may underestimate the impact of PA and exercise on QoL by failing to capture the range, depth, and complexity of survivors' QoL experiences [166]. As discussed in the philosophical positioning chapter ahead in this thesis (see chapter 4), there is much benefit achieved from combining both quantitative and qualitative methods as this mixing of approaches can provide a more comprehensive understanding of the research problem. This was paramount for study 2 which

explored the feasibility of a home-based exercise intervention during the COVID-19 pandemic and the effectiveness of the intervention on markers of health including, QoL in a small sample of cancer survivors.

5.6 Aims and objectives

The overall focus of this thesis is to explore PA and exercise participation in adult cancer survivors with a focus on group-based PA and exercise. The research included in this thesis aims to explore perceptions, and barriers and facilitators for PA and exercise engagement, the feasibility of a virtual home-based exercise intervention during the COVID-19 pandemic, and to critically review the literature on the effect of home-based PA and exercise interventions on PA, PF and QoL in this population.

- Study 1 (Chapter 7) To conduct a qualitative exploration of:
  - perceptions of general PA in a sample of cancer survivors attending group-based exercise sessions, and to identify the barriers and facilitators for PA/exercise participation
  - to provide formative information to inform the design of group-based PA/exercise interventions.

- Study 2 (Chapter 8) To conduct a feasibility study utilising the RE-AIM planning and evaluation framework to:
  - evaluate intervention feasibility by exploring acceptability, satisfaction and the effectiveness of a virtual home-based exercise intervention on a variety of outcomes including PA, QoL and PF using a mixed-methods approach.
  - Retrospectively explore participant experiences moving from a gym-based to home-based exercise setting during the COVID-19 pandemic.

- Study 3 (Chapter 9) To conduct a systematic review of peer-reviewed evidence to:
  - Identify and critically explore the evidence of home-based PA and exercise interventions on outcomes including PA, PF, and QoL in cancer survivors.

6. GENERAL METHODS

The purpose of this chapter is to describe the general methods (see Crotty model chapter 4) used during data collection and analysis through the PhD programme, and to avoid repetition across the thesis. Where needed, more specific details about each study's procedures are subsequently covered in the methods sections of the relevant chapters. Both studies 1 and 2 received ethical approval from the Research Ethics Committee of Liverpool John Moores University (reference numbers for study 1 and 2: 19/SPS/015 and 20/SPS/023). The PhD researcher conducted all data collection sessions and data analysis.

6.1 Recruitment

All participants were recruited from the UTS Foundation's programme (Hoylake, Wirral) for cancer survivors. The cohort consisted of a variety of cancer types and were either having active treatment or post-treatment following diagnosis. During the recruitment process for study 1, potential participants were contacted via email and invited to participate, and the study was also advertised in the gym-facility via posters. As the PhD researcher was also the lead coach of the exercise programme, they provided verbal information about the study at the end of the weekly group-based exercise sessions. Information packs were provided to those who expressed an interest in participating. These included participant information sheets, participant consent forms as well as demographic information forms and screening questionnaires. Signed consent forms were obtained from all participants prior to any data collection for study 1. Gatekeeper consent was also obtained from Dr Colin Robertson, Foundation Director, and Trustee.

For study 2, all recruitment methods were carried out electronically and virtually due to the COVID-19 pandemic. Participants were invited to take part via email, virtually face-to-face at the end of the weekly group-based exercise sessions delivered via the Zoom platform and by an invitation in the groups WhatsApp group by the PhD researcher. The study was also advertised on the Foundation's social media platforms via a digital poster. Information packs were provided to those who expressed an interest in participating via email, like those of study 1. These included participant information sheets, participant consent forms as well as demographic information forms and screening questionnaires. Signed consent forms were obtained electronically from all participants prior

to any data collection for study 2. Gatekeeper consent was also obtained from Dr Colin Robertson, Foundation Director, and Trustee. Some of those participants who participated in study 1 also took part in study 2.

6.2 Demographic and screening information

All participants in studies 1 and 2 completed demographic information forms reporting their gender, age and date of birth, home postcodes and employment status. They also completed screening information forms reporting their date of diagnosis, diagnosis name and stage, treatment prescribed following diagnosis and current treatment status.

6.3 Methodology

METHODOLOGY.

This next section addresses the generic methods applied throughout the PhD programme including focus groups and narrative format that encompass a constructivist approach (see chapter 4).

6.3.1 Focus groups

Focus groups sit within a range of qualitative interview techniques which are grounded in constructivist/interpretivist epistemology by giving priority to seeing the world through participants own eyes and allowing them to use their own words to tell their stories in their own terms [16,167]. Focus groups enable the collection and analysis of three complementary forms of data; individual and group level data, and data generated based on participant interaction [168,169]. By creating data from multiple voices, focus groups can often reveal understanding which would have remained hidden in individual interview methods [170,171]. Focus groups allow for the exploration of how participants interpret and make sense of their experiences and the world in which they live. This offers insights into the question of "why" people engage in certain actions or behaviours [130,172–175]. Therefore are a method that enables rich insight into the phenomena being studied [170] and are a relatively cost-effective and efficient way for gathering data from multiple individuals [176]. Overall, focus groups allow individuals to share feelings, thoughts and perceptions about a certain topic, linked to an area of common interest or experiences [170,175,177] such as being a cancer survivor. This allows researchers to look at more subtle, but highly relevant understandings and behaviours [175,177].

Focus groups can also encourage greater openness, particularly if groups have been convened to reflect common experiences. This group setting and 'safety in numbers' can provide permission to participants to talk about delicate or difficult topics, for this reason focus groups are employed in cancer research [170]. More so there are further advantages to be gained by utilising pre-acquainted groups [170] like that of the groups in this PhD project. By incorporating pre-existing groups in naturally occurring settings, participants may feel more comfortable and secure, enabling complex social data to emerge, in regards to how participants speak amongst themselves and how that illuminates relational dynamics [178]. The focus group moderator was also the PhD researcher. Focus group moderators are deemed as an essential component for successful focus group discussions, particularly when broaching that of delicate topics [170,179], which was a key consideration for inclusion of focus groups in this PhD project given the population. Given that the PhD researcher had developed relationships with the members of the Foundation's exercise programme by delivering face-to-face exercise sessions to the members on a weekly basis as their coach, this relationship may have been imperative to the focus group discussion. It is important to note that to ensure potential biases were minimised, the focus groups were guided by relevant protocols whereby questions and procedures were checked with a Health and Care Professions Council Registered Practitioner Psychologist (HCPC). As this was a match-funded PhD project it is also important to note that such focus group projects have previously provided invaluable insights for service providers [170]. Given the numerous benefits of focus group methodology, the research population being studied, and the match-funded element of the PhD programme, focus groups were considered as the chosen data collection method.

Two focus groups were conducted in study 1, consisting of five participants in each (more detail on participant characteristics can be found in the relevant chapters), utilising a semi-structured focus group guide, underpinned by the PRECEDE component of the PRECEDE-PROCEDE (P-P) model [180,181] (see chapter 7 for further detail). Four focus groups were conducted in study 2, utilising a semi-structured focus group guide (see chapter 8 for further detail). Two focus groups were conducted on completion of the exercise intervention to explore participants experiences of the intervention and the transition from a gym-based to home-based setting to exercise. The qualitative data gathered here was also facilitative for the other measures used to assess each of the RE-AIM dimensions (see chapter 8). A further two focus groups were conducted at 6 months follow up to assess the Maintenance dimension of the RE-AIM framework (see chapter 8) [1,182].

6.3.2 Thematic analysis

In studies 1 and 2, thematic analysis of the focus groups transcripts was conducted to generate key themes and sub-themes through deductive and inductive analysis [183]. Thematic analysis was chosen because it is a well-established method within health and well-being research, allowing for a robust and sophisticated analysis of qualitative data that can be presented in a way that is accessible to those outside of academia, including practitioners and policymakers [184]. Thematic analysis is a method for data analysis by developing, analysing, and interpreting patterns (themes) across a given qualitative dataset that involves the systematic process of data coding to develop themes [185]. The analysis followed the 6-step phases described by Braun and Clarke 2006 [183]: familiarisation with the data, generating codes, searching for themes, reviewing themes, defining, and naming themes, and write-up/reporting. Throughout both studies 1 & 2, the constructed themes were displayed using pen profiles to provide a visual representation of datasets via diagrams of key themes, and verbatim quotations are also used to illustrate findings where appropriate, a method previously used in similar research [186]. Given that the researcher was also heavily involved with the activity program/exercise intervention as the coach, to minimise any biases and ensure a robust and rigorous interpretation of the data, themes that emerged were discussed with a HCPC practitioner psychologist by employing between them a process of member checking [187]. By doing so, this allowed for credible and trustworthy reporting of the data throughout studies 1 and 2.

6.4 Application of SDT to practice

Prior to and during the PhD project, the practitioner-researcher had been and continued to work as a Personal Trainer (PT) (see detail in background statement), working with their own clients on a weekly basis as well as delivering group-based exercise sessions at the Foundation's sister facility. During this time, they have utilised SDT to inform their professional working practice to create the conditions within which their clients can motivate themselves to adhere to their weekly training sessions and achieve goals set outside of their sessions focussed on encouraging healthy lifestyle behaviours. At the beginning of the PhD project, the practitioner-researcher observed the delivery of the group-based sessions in the gym. The numbers attending the sessions were generally low, and members would occasionally turn up for the session one week, and then not the following. Given the practitioner-researcher's experience of working with individuals in a similar environment, it became evident to them that they needed to utilise the same principles and create a need-supportive environment for these cancer survivors attending the Foundation program.

Regarding autonomy, this was about supporting a feeling that the members were the source of their own behaviour and acting in accordance with their values and free to choose how to behave, making members feel that they can do. To support this, the practitioner-researcher frequently asked for feedback from members about how they found the sessions weekly, what have they enjoyed or perhaps not enjoyed. In addition, the practitioner-researcher also offered them meaningful choices such as a choice of a core of conditioning finisher at the end of a session. By asking for feedback and offering meaningful choices, this allowed the members to feel like they had a say in how training was going and having a part in the sessions therefore supporting autonomy.

In terms of competence, this was about supporting the feeling that the members can do what they need to do and get better at doing it such as exercises during the sessions. In other words, it was about helping members feel that sense of achievement by being successful in their performance. To support this, the practitioner-researcher provided thorough demonstrations of exercises at the beginning of each session and continued to cue where appropriate during the sessions. The practitioner-researcher also provided positive verbal feedback when the members did exercises well to, facilitating that sense of achievement. The practitioner-researcher also frequently told participants how well they had progressed from the previous week or beginning of the 4-week training phase. In addition, the practitioner-researcher provided appropriate exercises and/or alternative exercises to any of the members where necessary. For example, if a member had a PICC (peripherally inserted central catheter) line and was unable to perform pressing movements, the practitioner-researcher would provide an alternative exercise, this ensured they could keep engaging in the session. Additionally, for any members struggling to perform a movement from a technical point of view, the practitioner-researcher provided a regression of that exercise, and for any members performing well, the practitioner-researcher provided progressions of that exercise.

Regarding relatedness, this was about supporting the feeling of being connected and valued by other people, being made feel to belong. To support this, the practitioner-researcher implemented several strategies. At the beginning of each session the practitioner-researcher always welcomed each member and had a brief chat with them. The practitioner-researcher also brought the group together and facilitated conversation among the members before and after the sessions, and sometimes the practitioner-researcher and group would also arrange to go for a coffee after the sessions. When any new members joined the sessions, the practitioner-researcher introduced themselves and then proceeded to introduce the new member to the rest of the group. During the sessions, the practitioner-researcher sometimes paired members up to complete exercises or a finisher at the end of a session. In addition,

the practitioner-researcher also taught members how to re-rack weights/put equipment away that had been used in the sessions. Overall, these strategies helped to create an environment with a sense of belonging among the members.

Creating this need supportive environment was also replicated virtually when the group-based sessions moved to home-based sessions during the COVID-19 pandemic. In terms of autonomy, like that of the face-to-face gym-based sessions, the practitioner-researcher still asked for feedback and offered meaningful choices to members during the online sessions. Regarding competence, the practitioner-researcher conducted the exercise sessions in the same way as they did in the gym in relation to providing thorough demonstrations, provided appropriate and/or alternative exercises, and providing positive verbal feedback to the members. Lastly, to support relatedness, the practitioner-researcher still communicated with members at the beginning and end of the online sessions and made time at the beginning and end of the sessions for the group to interact with each other. By creating these need-supportive environments, it appeared to have a positive influence on the attendance from members as numbers attending had vastly improved and the members were also attending sessions on a more consistent basis.

THESIS STUDY MAP

Study	**Aims and key findings**	**Philosophical positioning (Crotty model chapter 4)**
Study 1: Exploring barriers, facilitators and reinforcing factors for PA participation amongst cancer survivors	**Aims:** 1. To explore perceptions of general PA, 2. To identify barriers and facilitators for group-based PA participation, 3. To provide formative information to inform the design of group-based PA/exercise interventions.	**Epistemology = constructivist paradigm** **Theoretical perspective = constructivist approach** **Methodology = qualitative** **Methods = focus groups**
Study 2: Utilising RE-AIM to evaluate the feasibility of a virtual home-based exercise intervention during the COVID-19 pandemic		
Study 3: Home-based PA and exercise interventions in cancer survivors: a systematic review		

Given that there are low levels of cancer survivors engaging in PA and exercise, the purpose of study 1 was to gain an understanding of a small cohort of cancer survivors' perceptions of PA and the barriers and facilitators they may face for PA and exercise participation and who were attending a group-based exercise program with other cancer survivors based on the Wirral.

7. STUDY 1 – EXPLORING BARRIERS, FACILITATORS, AND REINFORCING FACTORS FOR PHYSICAL ACTIVITY PARTICIPATION AMONGST CANCER SURVIVORS: A FORMATIVE STUDY.

7.1 Introduction

Cancer survivors face numerous health issues including reduced physical functioning, changes in body composition, depression and fatigue [188] which may compromise QoL [189]. The current UK PA recommendations are to be active daily, each week accumulate at least 150 minutes of moderate intensity activity or 75 minutes of vigorous intensity activity (or a combination of both) and include activities to develop or maintain strength in the major muscle groups, aiming to minimise sedentary time [114]. Engaging in regular PA (including PA interventions) post cancer diagnosis is associated with many benefits [125] including better physical functioning, QoL and fatigue [89,111]. However, activity levels are low [125,190] and few cancer survivors meet the PA recommendations [137,191].

Across a range of non-clinical and clinical conditions, barriers for PA participation have been identified and are broadly categorised into three common themes, personal, environmental and social [192–197]. Cancer survivors have reported side effects of treatment [129], mobility-related comorbidities [125], physiological and psychological barriers [198,199], environmental [18], and social factors [198] as barriers for PA. These barriers are related to general PA participation rather than specific PA opportunities and many cancer survivors are referred to group-based PA and exercise programmes [200]. However, less is known about barriers and facilitators for group-based PA programs where uptake and adherence is low [18]. Overall, understanding why survivors do not engage in PA is poorly understood [18].

Focus groups have been used to identify barriers and facilitators for PA participation in cancer survivors/patients and other non-clinical groups [129,130]. However, there is limited research using such methods to explore cancer survivors' barriers, and facilitators for PA, particularly concerning group-based PA programs. Underpinning such methods utilising an appropriate health promotion model, such as the PRECEDE-PROCEDE (P-P) model of health program design, implementation, and evaluation, works to engage the target population with a comprehensive and structured assessment of their own needs and barriers to a healthy lifestyle [201].

Interventions/programs aimed at promoting behaviour change, such as increasing PA, should adopt an appropriate conceptual health promotion model like the P-P model to prioritise the key factors of the target group [202,203]. Understanding the target audience is an essential first step in any health promotion endeavour. It is also suggested that interventions/programs should be developed through the engagement of community members to develop a sound ecologically-based approach to the research problem at hand at both the planning and evaluation process [204]. Within an ecological approach, all aspects of an individual's environment, their own cognitions, skills and behaviour are considered as potential intervention targets [204]. Overall, the P-P model recognises that behaviours are complex and have multidimensional etiologies [204].

The PRECEDE component of the model comprises of predisposing, enabling and reinforcing factors that have been formatively used to guide PA intervention content and design [130,202,204]. Other studies in cancer survivors have used previous research as opposed to a theoretical framework model to inform study design [18]. To the best of our knowledge, this is the first study to adopt the PRECEDE component to identify barriers and facilitators for PA participation in cancer survivors using focus groups and present the findings in a narrative format. An advantage of using this framework allows researchers to explore determinants of PA and health status [201] and may help to improve understanding of PA behaviours in cancer survivors, particularly related to group-based activity, and inform intervention design which to the best of our knowledge has not been done previously.

7.1.1 Aims

The objectives of the present study were 1) to explore perceptions of general PA 2) to identify barriers and facilitators for group-based PA participation in cancer survivors, with a secondary aim to provide formative information to inform the design of group-based PA/exercise interventions.

7.2 Methods

7.2.1 Study design

To gain an insight into the barriers and facilitators for PA of cancer survivors this study adopted a qualitative approach using semi-structured focus groups, synthesised in a narrative format.

7.2.2 Setting

Participants were recruited from within an established group-based activity program for individuals living with cancer funded and delivered by a Registered Charity. The purpose of the activity program was to provide cancer survivors with accessible and structured coaching, health and wellbeing sessions, free of charge to the participants. Members of the activity program were allocated to group-based activity sessions, depending on their current health and fitness status. Participants were not referred by clinicians to the programme and attended voluntarily.

7.2.3 Recruitment

Recruitment posters were displayed in the activity program facility for potential participants to view when attending their weekly group-based activity sessions and emailed to potential participants by the gatekeeper (activity program manager). A total of 10 members attended the weekly group-based activity sessions. These 10 potential participants were also approached, face-to-face, by the researcher when attending their weekly sessions at the activity program either before or after their activity session. The researcher was the activity program coach, with prior knowledge and experience working with this population in an activity setting. The study aimed to recruit male and female participants; however, no males consented to take part in this study. Potential participants were provided with a participant information sheet, participant consent form and a demographic and screening questionnaire. This questionnaire asked for information on; age, gender, post code, type of diagnosis, date of diagnosis, during or post-treatment, type of treatment and medication and duration of attendance to the group-based activity sessions at activity program. Inclusion criteria were adult individuals with any type of cancer, during or post treatment and attended the activity program. Exclusion criteria were <18 years of age, pre-treatment, or no cancer diagnosis and unable to participate in PA. All participants provided informed written consent to the lead researcher.

7.2.4 Semi-structured focus group guide

A semi-structured question guide was developed and refined by the lead researcher, research team and a Health and Care Professions Council Registered Practitioner Psychologist (HCPC), acting as a mode of member checking to demonstrate rigor and minimise biases [187]. The focus group guide was underpinned by the PRECEDE component of the PRECEDE-PROCEDE model [180,181,201,202], in a group-based setting [170,177] to explore and identify perceived barriers and facilitators for PA participation [130], both in general and specifically related to group-based activity. To maximise the interaction between participants, focus group questions were reviewed by the lead researcher and a HCPC Registered Practitioner Psychologist for appropriateness of question ordering

and flow. The opening of the focus group guide consisted of a brief introduction whereby the lead researcher addressed the purpose of the focus group and the procedure participants were required to follow. The information contained in the participant information sheet was reiterated. The semi-structured question guide consisted of the topic areas; health, PA, SB and the group-based activity program. Each of these topic areas consisted of a variety of open-ended questions structured to prompt discussion with equal chance for participants to contribute [205] and helped retrieve the discussion when distracted from the purpose of the focus group. An example question from the PA section was: 'Are there specific factors that facilitate you to participate in physical activity?' Therefore, questions were transparent and relevant to both the topic and population.

7.2.5 Protocol

Two focus groups were successfully initiated and completed. Focus group 1 lasted 58 minutes and focus group two lasted 55 minutes. Information from both focus groups was digitally recorded using a Dictaphone (audio-recording device) (SONY®, ICD-PX370). The researcher asked participants to provide their understanding of the terms for health, PA and sedentary behaviour on a Post It© note. A flip chart displaying the definitions [107,206,207] of health, PA and sedentary behaviour was used to prompt discussion alongside the participants responses. To comply with safeguarding requirements if any participants disclosed personal information or experienced feelings of distress and/or emotional discomfort, they were signposted by the lead researcher, to local, accessible support services and provided with the relevant contact information and advised to contact their own personal support nurse if they had one.

7.2.6 Data synthesis

Focus groups were transcribed verbatim to produce two transcripts. The lead researcher reviewed these transcripts to ensure accuracy and a constructivist approach was adopted in interpreting the qualitative data [16]. Focus group one consisted of a fifteen-page transcript and focus group two consisted of a twenty-three-page transcript both Ariel size 12, double spaced. Transcriptions of each session were created with identifying information removed. A thematic analysis [199] allowed 'thick description' of the data via the use of direct quotations so that the reader can evaluate the interpretation [18]. This approach aims to offer a credible and trustworthy interpretation of the data that captures participants' perceptions and experiences for PA participation, although it is appreciated that other interpretations are possible [18,208]. The PRECEDE component of the PRECEDE-

PROCEDE model was used to guide qualitative data synthesis and verbatim quotations were subsequently used to provide context and verify participant responses.

Table 1- Participant characteristics (n=10)

Age	
Years	47 ± 10
Range	30-63
Gender	
Female	10
Type of cancer grade/stage	
Breast stage II	2
Breast stage III	2
Breast stage IV	1
Breast grade 2	1
Breast grade 3	1
Bowel stage IV	1
Pancreatic neuroendocrine stage III	1
Chronic myeloid leukaemia	1
Treatment status	
Active	5
Post-treatment	5
Duration of membership (months)	
<12 months	6
>12 months	4
Number of sessions attended per week	
Range	1-5

7.3 Results

7.3.1 Characteristics of participants

The average age of participants was 47 ± 10 years old and all participants in the study sample were female. Other characteristics of the study sample including type of cancer and grade/stage of cancer, treatment status, membership details and attendance are reported in table 1. Breast cancer was the most common cancer type (n=7), and 5 participants were having active treatment and the other 5 participants were post-treatment.

7.3.2 Perceptions of Physical Activity (PA)

By way of introduction into the focus groups and to help gage an understanding of the participants and their perceptions/understandings of PA the researcher conducted an activity at the beginning of the focus groups. Participants were asked to write down their understanding of the term 'physical activity' on a Post It© note and returned their answers to the researcher. Some of the terms and explanations participants provided were similar to the PA definition [107]. Their responses included phrases such as, "any activity above and beyond that of normal daily living", "not being sedentary" and "feeling out of breath". Across both focus groups, participants expressed positive perceptions of PA, all agreeing that PA is essential to maintain a healthy lifestyle, with one participant stating, *"I never used to [take part in PA], but I do now"* (P1). Four participants expressed the positive affect general PA has on their health including, physiologically by feeling stronger and having more energy and psychologically by feeling stronger mentally and feeling more positive. When discussing current PA levels, two participants reported one to two dog walks every day and attending the gym once a week, two participants reported five or six hours and two participants reported four or five hours per week of time spent in PA. When the lead researcher explained the UK PA guidelines, three participants acknowledged them. One thought the recommended amounts of PA were a lot and reported taking part in the strengthening exercises, for example:

I think that was part of the reason why I wanted to do those strength exercises, because I knew that was quite a big part of the cancer advice. (P2)

However, "edging too much towards the strength exercises and not enough cardio" and "not aware of how often I should be physically active" were individually reported. However, an individual reported feeling frustrated as they did not want to exercise for too long because they did not want to burn too many calories as "it's not going to do my body any favours".

7.3.3 Predisposing factors for general PA and group-based activity - barriers

Predisposing factors include knowledge, attitudes, beliefs, and perceived abilities. These factors may predispose a given health-related behaviour, in this case increase the likelihood of an individual engaging in PA [201]. The principle predisposing factors discussed in the focus groups are organised into constructed themes and displayed in a pen profile. Themes are divided into two higher order themes, barriers, and facilitators, and further divided into two subgroup themes, general PA and group-based activity both of which present additional sub-themes.

Within predisposing factors, barriers were constructed as a key theme with several sub-themes. Symptoms was constructed as a key sub-theme for both general PA and group-based activity sessions with participants reporting factors like tiredness and pain due to the disease/treatment as barriers for both general PA and group-based activity (see examples below). One of these participants briefly commented that following her surgery, she's had much more energy and less tiredness to be active.

…tiredness. I always seem to have a lot of tiredness, so I have to fight to keep going…sometimes I just really want to go to the gym, but I'm just so tired, and it's probably because of the tumour, so I just feel sick, and it gets in my system and I get tired (P7)

Tiredness, but I get bone pain, and sometimes crampy, like I feel like I get stuck in… (P5)

In addition, one participant mentioned that since diagnosis she has been afraid to participate in general PA due to "feeling fragile". However, after attending the group-based activity sessions she was surprised that she managed to complete a session, for example:

…but when I went to the first session with you, I got upset in the car because I was like, "Oh wow, I just did that!" It [completing the session] was really surprising, and I felt really strong. I hadn't felt that for a long time… (P5)

Time was constructed as another sub-theme for both general PA and group-based activity, with specific factors including full-time work, family commitments and hospital appointments reported by participants as barriers for attending the group-based activity sessions, for example.

It's just unfortunate…I am in full-time work, and I would love to come to more sessions, but unfortunately, my job takes over my life to a certain degree. (P1)

Well, school holidays aren't great. I'm having to completely fall off the wagon, the exercise wagon…with four kids and what that brings… (P2)

Hospital appointments are a problem for me, because my regular session's a Tuesday and every fourth Tuesday I am there, and it's pretty much an all-day kind of thing, and then if my chemo is delayed by a week because my bloods aren't right, it means I have to go the following Tuesday to be reassessed, so that stops me coming to that session, which is my favourite session. (P3)

One participant disagreed with this and explained how both general PA has become important to them for their health and attending the group-based activity sessions takes priority over anything else. Further supporting this, another participant expressed how they would like to have access to more of group-based activity sessions and requested if more could be scheduled throughout the week. All 10 participants shared consensus and acknowledged that attending more than one session per week would be beneficial. In addition to family commitments being reported as a factor for time attending the group-based sessions, participants also reported family and friends as barriers for general PA participation because they encouraged participants to rest and reserve their energy, for example:

…family and friends around you, initially I think, tend to treat you like you ought to be lying in bed, and they want to fuss. They want to fuss over you, and they think you ought to be conserving your energy, and they don't understand the really important role that physical exercise has in fighting cancer. (P3)

…I have an ileostomy, and I had gone to one of your classes, and then I came back, and my mother-in-law was at my house watching my kids, and I was going to take the bin out, and she said, oh, don't, you have a bag, and I was like, because I have this ileostomy, so if you see what I'm lifting at the gym, you would be making me do a lot more work. So that's quite funny that people don't realise what you can do. They do wrap you up a bit. (P8)

Travel costs to the gym facility and gym environment emerged as additional themes within group-based activity. Participants explained how the gym can be quite an intimidating environment, however they felt comfortable attending the group-based sessions, for example:

I do think gyms can be quite intimidating to a lot of people, to actually turn up. This gym, I think, is quite unique, isn't it [gym]? (P4)

…I'm very comfortable coming to the Foundation classes, but not so comfortable coming to the other classes. (P2)

Exercise tolerance was constructed as an additional theme with "knowing limits" as a key factor for general PA, for example.

…since diagnosis I've been a little bit afraid of what I can do and how far I can push myself… (P5)

…I struggle because I don't want to burn too many calories, which I find frustrating…but it's not going to do my body any favours. (P8)

I'm just finding I'm really struggling to gauge it…gauging how much to push it…because I've always been really active, so to be tied down to simple activities, it's killing me, I push it a bit too much, and then my back flares up. So it flip-flops backwards and forwards… (P6)

In addition, surgery was constructed as another theme for barriers in the group-based activity sessions. Participants reported that engaging in the activity can sometimes be uncomfortable, for example:

…I have a lot of scars in my core area, and I have an ileostomy, so I have, basically, my intestines are hanging outside my body, and if I go on my front, I'm afraid I'm going to pop it back in…I'm nervous about what's going to happen. (P8)

7.3.4 Predisposing factors for general PA and group-based activity - facilitators

Within predisposing factors, facilitators were constructed as a key theme with a number of sub-themes. Social support was constructed as a key sub-theme for both general PA and group-based activity sessions with participants reporting factors like "you meet new friends" for general PA. More specifically for group-based activity, all ten participants reported the group-based nature of the activity sessions as a key facilitator for their participation. Participants reported factors including "feeling excited to see everyone", the "friendly environment", "second home", "being in it together", "huge support by sharing ideas" and "the feel-good feeling

of being able to express your feelings with others in similar situations", "motivating to see other people with cancer exercising", "camaraderie" and as well as providing accountability (see examples below). Four participants also briefly commented on how the WhatsApp group with the other members and lead researcher was supportive and encouraged their participation in the group-based activity sessions.

Yes, I feel quite excited to get in [activity program], really, and see everybody, and see what we're [activity program members] going to do, yes. It's [activity program sessions] nice, yes. (P1)

…Very friendly [activity program setting] as well. You're not sort of looked upon as like, "Oh, you're one of that funny group". (P6)

It's [seeing each other] motivating to see each other, isn't it? I really enjoy it. (P7)

a lovely group of people who are tackling the same thing, fighting the same thing…that's been really, really beneficial. (P6)

It [group-based activity] makes you want to go. You feel that you're letting other people down…sometimes maybe somebody's not feeling too great, and they're just geeing them up…keep going…so you wouldn't get them if you were coming on your own…but because you've got like-minded people…then we all just gee each other up. (P4)

For general PA, physical and mental benefits, accessibility of resources and self-belief were constructed as additional sub-themes.

…I like the feeling of feeling like I'm getting stronger, fitter. I can feel it's doing good, and that makes you feel better, but it puts you in a more positive frame of mind as well… (P9)

Just the accessibility of exercise makes the difference, and having things available, whether it be walking somewhere nice, or whether it be a gym, or some of the more social activity. It's got to be very accessible to people, whether they're working or not working, and I'm not working at the moment, so I've got a bit more time, but it has to be quite accessible for me. (P6)

…it makes you believe in yourself again…when you've had a cancer diagnosis, you feel like your body's failed you…then you get back to doing some exercise, and you think, oh…I can do it, and I can maybe really get back to what I was before I got ill. (P7)

Similarly, for group-based activity, sub-themes including feeling good and improved confidence were constructed (see example below). Scheduling was constructed as an additional sub-theme for group-based activity and three participants reported the sessions being during the day as facilitators for their participation.

I think it gives you a lot of confidence…because I think your confidence is low when you're at the end of treatment. I feel like at the end of my treatment, I was just like a little ball…every week, you can feel that you're getting better, and then that gives you confidence then because you're getting yourself back…then you want to just then keep exercise in your life and just keep moving forward all the time. (P4)

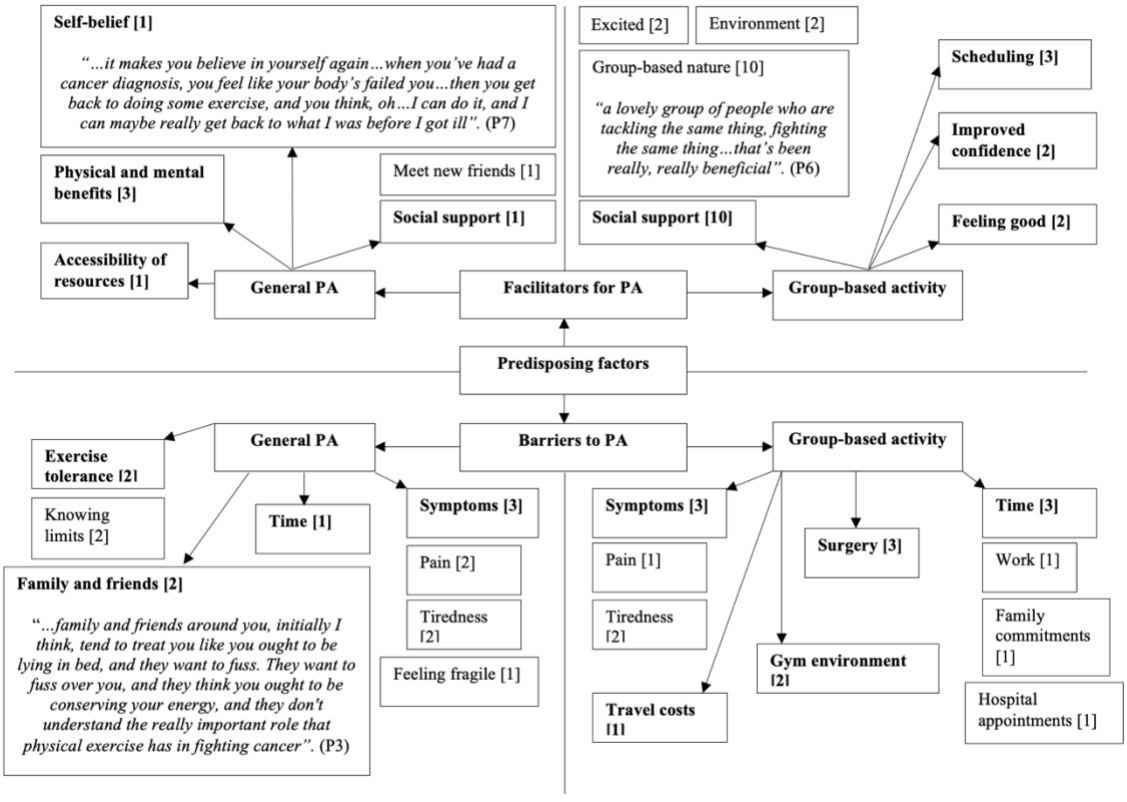

Figure 6 – Pen profile displaying predisposing factors for PA and group-based activity.

7.3.5 Reinforcing factors for group-based activity sessions

Reinforcing factors relate to the consequences of a behaviour and whether individuals receive positive or negative feedback or social support for the behaviour [201]. In the current study these are factors that reinforce PA behaviour towards the group-based activity sessions and could include the enjoyment of exercising. Within reinforcing factors, the "drive to beating cancer" was constructed as a key theme. Some participants reported how they have lots of things they want to achieve in life and want to carry on living their life in the absence of the disease.

One of the things that really makes me want to keep coming back is my drive to be beating my cancer, and I do actually think about, when I'm doing exercise, I sort of imagine that I'm treading on cancer cells. I feel like I'm stamping on cancer cells. (P3)

Another key theme constructed was the positive perceptions of the activity program, consensus for this was shared amongst all ten participants. Factors relating to positive perceptions that reinforced participants attendance to the group-based activity sessions included the physical and mental benefits of PA, "seeing progress" in their ability week to week, the "feel good factor" following participation in the activity sessions, and the feelings of a "sense of belonging" were reported by participants. When discussing their cancer journey and the impact the group-based activity program specifically has made in their lives, a participant was emotional which set off emotions in the other participants of one focus group though they were all comfortable to express these feelings with one another, for example:

It's [group-based activity program] given me so much hope, and it's [group-based activity program] been a massive help…so the fact we're all kind of in it together, and I pick up on different things what other people are going through, and I don't feel as alone. (P5)

Factors relating to enjoyment were also constructed as a key theme for reinforcing factors for the group-based activity sessions. Participants reported enjoying the variety and structure of the activity sessions and in particular the resistance training elements of the sessions.

I like the sessions and the variety of different activities that we do within one session. I like the strengthening exercises, which is not actually something that I'd ever really participated in before. (P7)

The cost-free element of the service and the gym environment/group-based sessions being regarded as “safe place” were denoted as and additional theme, ‘other factors’. These factors are important as many survivors may be unable to work due to the illness and may also feel vulnerable due to their new identity as a cancer survivor. A further two additional themes including supporting research for PA for general health and as a cancer survivor and recommendations from other patients and friends were constructed in support of reinforcing factors for the group-based activity sessions. In addition to the key themes constructed for the reinforcing factors reported above, participants also briefly commented on the positive lifestyle changes on their day-to-day lives reinforced by the activity program at the end of the discussions, including improved diet, encouragement to take part in organised sports, trying new activities, buying exercising equipment and “motivated to become more active”.

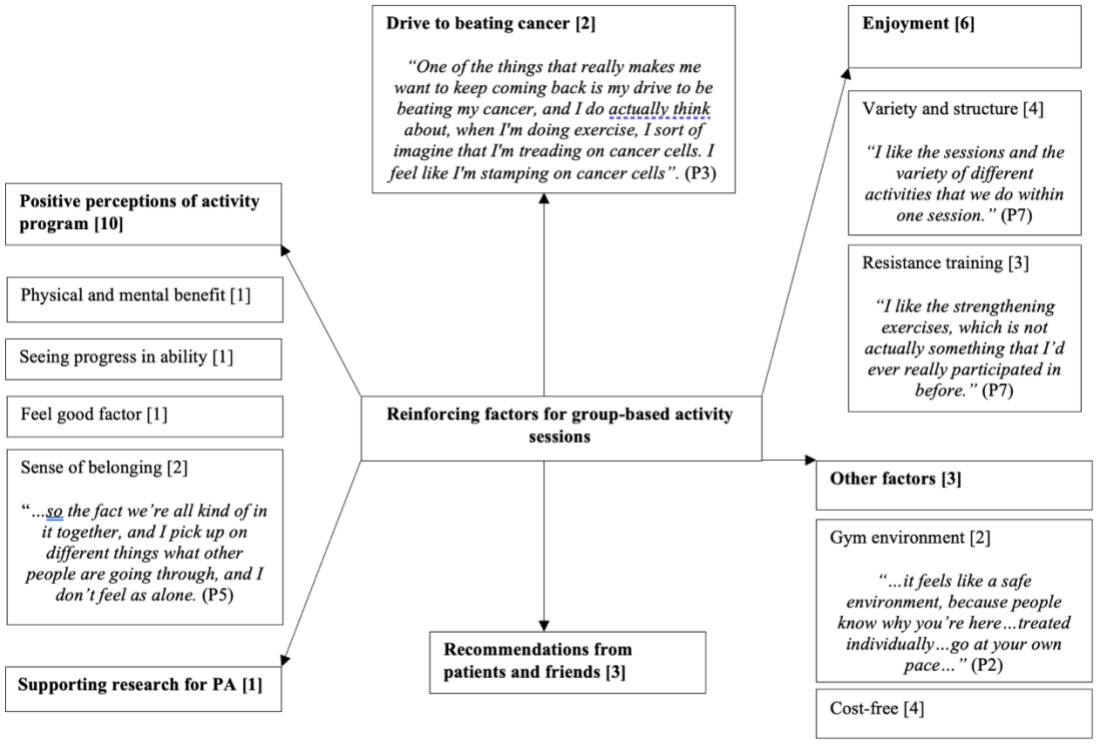

Figure 7 – Pen profile displaying reinforcing factors for group-based activity sessions.

7.3.6 Open discussion of health and Sedentary Behaviour (SB)

Given the semi-structured nature of the focus groups using open-ended questions, participants discussed other factors that encourage healthy (independence, family and "trying to stay disease free") and unhealthy behaviours (overwhelming feelings of having disease, depression and feeling mentally defeated, side effects of treatment, pain, stress, tiredness, and peers "a culture of behaving badly"). An individual expressed it feels like "you're having to battle alone" and "the amount of information" is "bewildering as a patient" and another participant agreed reporting "there's a lot of information out there, a lot of it is conflicting information". Participants also addressed their sedentary behaviour and tiredness/fatigue were frequently reported to encourage being sedentary as well as bad weather. However, participants expressed positive perceptions about engaging in PA and reducing their sedentary behaviour; engaging in the group-based activity sessions was frequently reported as socially beneficial by meeting the other members and interestingly, not taking the "no diet or exercise" advice provided by their oncologist was individually reported and another participant reported while exercising, they're "thinking less about the cancer and treatment", for example:

No, there's nothing you can do to help yourself. Nothing at all. No diet and exercise, nothing. (P6)

7.4 Discussion

The objectives of the present study were 1) to explore perceptions of general PA 2) to explore barriers and facilitators for group-based PA participation in cancer survivors, with a secondary aim to provide formative information to inform the design of a group-based activity intervention. The findings from the current study have identified a number of perceived barriers and facilitators for general PA and group-based PA participation in adult cancer survivors.

7.4.1 Perceptions of Physical Activity (PA)

In the current study, the notion that PA may be beneficial for preventing cancer recurrence was not reported by any participants, which may be because of the question guide consisting of open-ended questions. Similar findings have been reported in colorectal cancer patients [125] and these authors suggested that further educational efforts are required to ensure that such patients understand that PA may be beneficial in improving post-diagnosis outcomes. Further research demonstrates that PA advice offered during the patient's journey may result in

significantly higher levels of PA [125]. Although all participants reported positive perceptions of PA, only three participants responded when the PA guidelines were discussed. Previous evidence suggests knowledge of PA guidelines may be low within this population, for example, only 3 out of 20 cancer survivors were able to cite the PA guidelines for example, "I think it's 30 minutes a day" [18]. Similar findings have been reported in the general adult population, whereby only 18% of participants were able to accurately recall the PA recommendations [209]. Cancer survivors' knowledge about PA and the recommendations have been reported as limited and consequently there is a need to educate cancer survivors in relation to the PA recommendations, as improved knowledge has represented a step towards positive behaviour change [209] which has been supported as a prerequisite to an individual's motivation to participate in regular PA [18,210].

7.4.2 Predisposing factors for general PA and group-based activity - barriers

In contrast to previous studies, family and friends were frequently reported as barriers to PA participation by encouraging participants to rest and reserve their energy. In contrast, social support from family and friends has been identified as a key motivator and facilitator for PA participation in older (aged ≥65 years) adult cancer patients [211]. Similar to the findings from this study, other healthy adult populations reported family and friends providing a lack of support for PA participation as they were not 'interested' in physical activity and family responsibilities have been identified as barriers for PA participation [193,196,197]. Disease-specific barriers, particularly tiredness/fatigue and side effects of treatment were frequently reported as barriers to PA participation and engagement in the group-based activity program by both participants still having treatment and those post-treatment. Disease-specific side effects have been previously perceived as the greatest barrier for PA participation in cancer survivors [127]. Similar to this study, tiredness/fatigue were the most frequently reported barriers for PA participation in post diagnosis colorectal and lung cancer patients [125,199]. Cancer survivors/patients are potentially in a cycle of becoming less active and more fatigued during and after treatment, therefore this presents as a major barrier to PA participation [125]. The participants of this study would not be classed as older adults, however research in an older adult cancer population (aged ≥65 years) identified fatigue as the most profound barrier for PA participation [211]. Fatigue was reported by all participants in the current study, therefore, fatigue and treatment side-effects which can also include cancer-related fatigue, have been identified as two important barriers to PA participation in cancer survivors [199]. These findings may provide an explanation for the decline in PA participation seen following diagnosis in cancer survivors/patients [125,127] despite the documented benefits of PA including reducing fatigue [129]. Pain was also reported as a barrier for PA participation and it has

been reported that people are less likely to engage in activity if they experience pain during movement [125]. Adult female cancer survivors with a current or past diagnosis, have also reported pain (48.3%) as a side effect from cancer treatment, which influenced their ability or desire to exercise [212]. This study has identified important barriers for PA participation in cancer survivors which contributes to the growing body of research and the importance of addressing such barriers to promote PA participation in this population.

7.4.3 Predisposing factors for general PA and group-based activity - facilitators

Participants frequently reported the group-based activity program as a 'safe place' therefore a key facilitator for them to join as members. Previous research has placed an emphasis on the provision of opportunities for cancer survivors to experience the numerous benefits of activity and the need for activity programs to help cancer survivors' be active in a safe setting that provides support to meet their unique needs [213]. The cost-free nature of the current activity program was reported as a key facilitator by participants and research has highlighted that over 50% of cancer survivors lose their jobs or cease working during or after treatment [214,215]. Therefore, PA interventions aiming to promote PA in cancer survivors need carefully consider funding for such programs. Participants reported positive psychological feelings as a result of PA participation and engaging in the group-based activity program as facilitators. Similar to this study, cancer survivors/patients have also frequently reported a number of psychological benefits for engaging in PA such as, improved wellbeing, decreased stress and increased confidence for PA in general [125,129].

There was strong consensus among participants that the group-based nature of the activity program and being with other cancer survivors were key facilitators for attending the activity program. Similar findings to this study have been reported in cancer survivors/patients [211]. Cancer survivors/patients have stated a preference for exercising with other cancer patients due to sharing similar paths following diagnosis which would provide peer support, shared experiences and a sense of belonging [129], these factors were also reported by the participants in the present study for group-based activity. Participants frequently reported 'being excited to see everyone' and 'happy' on arrival to the sessions. Other evidence has indicated that cancer survivors display positive preferences for being active with others [211,216]. However, contrasting evidence reported [18] that cancer survivors expressed a preference for home-based PA, with a minority of participants preferring group-based PA. However, older (aged ≥65 years) cancer patients have expressed how being active with others of a similar level of fitness or with those who they shared something in common with such as cancer survivors, has motivated them to perform

better and demonstrated a preference for structured, supervised activity because of its motivating and facilitating nature [211]. The adults in the present study also expressed motivation for being active with others at the group-based sessions as it gave them more confidence and desire to engage in activity that was structured and supervised, therefore facilitating their attendance. Participants further reported a variety of positive lifestyle changes because of participation in the group-based activity program including becoming more active in general, trying new activities and improving other health behaviours such as diet. Participants also frequently reported their enjoyment of resistance exercise and the variety of activities included during the sessions as facilitators for attendance at the group-based PA sessions. Breast cancer survivors (≥18 years) have expressed desire for different types including; endurance activity, resistance training, various recreational activities and organised exercise classes and a variety of exercises in a community-based resistance exercise program and reported "liking the exercises" and "having fun" as motivating factors to attend [217]. As previously mentioned, older cancer survivors (≥65 years) have also reported a preference for structured and supervised exercise [211]. Therefore, an emphasis should be placed on the facilitators identified in this study to promote adherence to PA participation in this population.

7.4.4 Towards intervention design

The methods employed in this study have facilitated engagement with cancer survivors through efficient data collection and have allowed consensus raising and individual stories to emerge, providing evidence for the positive influences of group-based PA in cancer survivors. However, group-based activity for cancer survivors may appeal to some but not all survivors of cancer as demonstrated by this study and recent research [125]. Therefore researchers, practitioners and health professionals need to carefully consider and address the needs of this unique population, specifically when promoting and designing PA programs to promote positive, healthy active lifestyles in cancer survivors. Based on the current findings from this study, future group-based programs/interventions should address barriers including: an intimidating environment (gym), exercise selection and intensity to accommodate those who have had surgery, and scheduling of sessions as some cancer survivors had hospital appointments to attend therefore could not make the activity program sessions. This is also a consideration for those who return to full time work. Fatigue was a prominent barrier therefore, health/exercise professionals could educate cancer survivors on the benefits of PA for reducing fatigue. PA interventions aiming to promote PA in cancer survivors need to carefully consider funding for such programs, as participants made it clear in this study of the importance of affordability for PA participation.

7.5 Strengths and limitations

A key strength of this study was the accessibility of the lead researcher who was also the lead activity program coach, this encouraged thorough engagement and interaction of the participants because of the already established relationships. Given the constructivist approach underpinning the qualitative methods, the generalisability of the results was not based on conventional statistical probability, but based on the detailed exploration of multiple perspectives from a diverse sample of cancer survivors of varied age, disease, severity, and experiences [218]. Given that the researcher was also the activity program coach, to minimise any biases and ensure a robust and rigorous interpretation of the qualitative data, themes that emerged were discussed with the HCPC practitioner psychologist by employing between them a process of member checking [187]. Focus groups were a practical and cost-effective method of choice as participants were already engaging in group-based activity. Therefore, methodological strengths included the exploration of consensus and associated discussion through the focus groups and interpretation of the data which allowed individual insight into the barriers and facilitators for PA participation among cancer survivors. There is currently limited research using focus groups with regards to group-based interventions and previous studies have used individual telephone/face-to-face interviews to collect data. Both focus groups were led by the same lead researcher who ensured the quality of the group discussions, an asset of this qualitative study. Sociodemographic and treatment type information was not obtained during the data collection period. Participants were able to travel to the gym facility and attend the activity program on a weekly basis, therefore may identify as middle class. In addition, given that participants both during and post treatment attended the sessions on a weekly basis, this may indicate that those during treatment were receiving less invasive and/or primary forms of cancer treatments. The findings may not be generalisable to other cancer survivors who identify as lower class and those receiving primary, invasive treatments. Although health and sedentary behaviours were not the focus of this study, information reported on these areas may be beneficial for future research when exploring health perceptions and sedentary behaviour in cancer survivors and in the design of interventions and/or activity programs for PA promotion. At the end of one of the focus groups, a participant expressed their experiences of taking part in this research, for example:

It was interesting…an interesting group, and good to hear other people's thoughts on it [activity program]. It probably motivates me more, and it makes you want to keep going and work harder… (P7)

7.6 Conclusion

In this study, barriers, and facilitators for PA participation, in particular those related to cancer survivors attending group-based activity sessions have been identified. The barriers reported were mostly attributed to disease-specific and treatment-related side effects, with fatigue being the most prominent. A unique finding was the group-based activity sessions being cited as major facilitator for PA participation in this population. This information is of use to practitioners and researcher developing PA interventions within this population.

7.7 Practical implications

The methods employed have facilitated engagement with cancer survivors through efficient data collection methods and allowed consensus raising and individual stories to emerge. Future studies should consider a group-based design in activity programs and interventions for cancer survivors as there was strong consensus among the participants of this study that group-based activity was a major facilitator for PA participation. However, the participants of this study were already engaging in a group-based activity program, therefore inactive cancer survivors may express a different preference. To promote PA participation in cancer survivors the barriers highlighted in this study should be carefully considered, including educating cancer survivors on the benefits of PA for the reduction of fatigue.

THESIS STUDY MAP

Study	Aims and key findings	Philosophical positioning (Crotty model chapter 4)
Study 1: Exploring barriers, facilitators and reinforcing factors for PA participation amongst cancer survivors	**Aims:** 1. To qualitatively explore perceptions of general PA, 2. To identify barriers and facilitators for group-based PA participation, 3. To provide formative information to inform the design of group-based PA/exercise interventions. **Key findings:** • Tiredness/fatigue, family and friends, and gym environment were frequently reported barriers. • Group-based activity was frequently reported as a key facilitator for PA participation. • Other frequently reported facilitators were the perceived physiological and psychological benefits of PA. • Facilitators of group-based activity were the activity program being perceived as a 'safe place' and the cost-free nature of the activity program.	**Epistemology = constructivist paradigm** **Theoretical perspective = constructivist approach** **Methodology = qualitative** **Methods = focus groups**
Study 2: Utilising RE-AIM to evaluate the feasibility of a virtual home-based exercise intervention during the COVID-19 pandemic	**Aims:** 1. To evaluate intervention feasibility by exploring acceptability and satisfaction of a virtual home-based exercise intervention, 2. To explore the effectiveness of the intervention on a variety of participant outcomes including motivation and competence to take part in PA, PA behaviour, quality of life and physical fitness using a mixed-methods approach,	**Epistemology = Pragmatism paradigm** **Theoretical perspective = pragmatic and constructivist approach** **Methodology = mixed-methods**

	3. To retrospectively explore participant experiences moving from a gym-based to home-based setting during the global COVID-19 pandemic using focus groups.	**Methods = combination of quantitative and qualitative methods including, questionnaires, surveys, fitness test, focus groups, interviews**
Study 3: Home-based PA and exercise interventions in cancer survivors: a systematic review		

The information obtained from study 1 was to inform the design of a cross-sectional study and exercise intervention pre the COVID-19 pandemic. Due to lockdown during the pandemic, the match-funders transferred their exercise program to a virtual format to allow for service delivery to continue throughout this time. As group-based nature was reported as a key facilitator from PA and exercise participation, the virtual exercise program was conducted in a group-based format and delivered by the coach, PhD researcher. Given that the organisation was now using a new method for service delivery, and building on the outcomes from study 1, it was important to evaluate the feasibility of this new mode of delivery and the effect it had on participant outcomes including PA, PF, and QoL using an appropriate evaluation framework and the participant experiences of moving from a gym-based to home-based exercise setting.

8. STUDY 2 - UTILISING RE-AIM TO EVALUATE THE FEASIBILITY OF A VIRTUAL HOME-BASED EXERCISE INTERVENTION FOR CANCER SURVIVORS DURING THE COVID-19 PANDEMIC: TRANSITION FROM A GYM-BASED TO VIRTUAL HOME-BASED SETTING.

8.1 Introduction

Cancer survivors will encounter different physical and psychological side effects related to cancer and its treatments [219], which may affect their QoL. PA has been regarded as a safe [100,220], non-pharmaceutical and cost-effective way to optimise recovery, manage side-effects and improve QoL [221,222] with a reduced risk of recurrence highlighted in this population [220]. As a result, PA and exercise are now recommended as part of the cancer care pathway [223]. More specifically, home-based exercise interventions have reported beneficial effects on survivor's health and fitness outcomes [161,224–226].

More recently, it has been reported that survivor's QOL may have been adversely affected during the COVID-19 pandemic [227,228]. In addition, the pandemic and has led to challenges in healthcare and supportive cancer care services delivery [227]. The UK and other national governments advised cancer survivors to shield for several months as they were classed as a serious risk group and being more susceptible to manifest complications of the viral infection [220,227]. It is therefore speculated that this population may have decreased their levels of PA during this time [220]. This is a major cause for concern as after diagnosis numbers engaging in PA and exercise in this population were already low [125,222,229], but may have diminished further because of restrictions, amplifying the deleterious effects of SB and physical inactivity [220]. Physical inactivity and prolonged sitting time are already highly prevalent in this population, partially due to persistent symptoms such as fatigue, which may contribute to these behaviours in addition to self-isolation measures [230].

There is currently limited evidence on the feasibility of such interventions in this population [225]. The existing evidence is largely derived from face-to-face facility- or community-based interventions [231], and few studies have evaluated the effectiveness of an exercise intervention performed at home virtually with an exercise professional [232], Furthermore, little is known about the experiences of cancer survivors taking part in these interventions [233]. Exploring participant experiences is important, particularly in light of the recent COVID-19 pandemic, where the promotion of virtual home-based interventions may be essential for this population [70].

Furthermore, for home-based interventions to be successful in delivery, evaluation is necessary utilising an established framework. A framework that has been utilised to evaluate interventions in this population is the RE-AIM framework [1,182,234–237]. The RE-AIM framework was developed to help health practitioners and researchers to attend to specific implementation factors essential for success in the real and complex world of healthcare and community settings [182,238].

The majority of research that establishes the efficacy of health interventions is conducted in tightly controlled research settings, focusing on internal validity, often well-funded with access to the requirements essential for the delivery of the intervention and fidelity to the study protocol presented [239]. When translated and implemented into 'real-world' settings, such interventions may be less successful. By adopting a more pragmatic approach, this may offer more generalisable findings when interventions are implemented under 'real-world' settings. Currently, amongst the cancer literature, little is known about the outcomes of exercise interventions when implemented using pragmatic approaches or the external validity of how best to implement and evaluate exercise interventions in 'real-world' settings [239]. Evaluating interventions is recognised as an integral part of health research by the Medical Research Council (MRC) to improve the sustainable adoption and implementation of effective evidence-based interventions [240]. For exercise interventions to be successfully implemented in 'real-world' settings, there is a need for researchers to follow a standard evaluation framework when planning and implementing exercise interventions to establish intervention feasibility, effectiveness, and maintenance over the long-term.

The RE-AIM framework consists of five dimensions including Reach, Effectiveness, Adoption, Implementation, and Maintenance. Reach is described as the absolute number and representativeness of individuals who participant in a program. Effectiveness refers to the effect of the program on the anticipated "real world" outcomes. Adoption is the proportion of individuals that uptake a program, at an individual and organisational level and implementation is described as the extent to which the program was delivered as intended. Lastly, maintenance refers to the extent to which the program and/or behaviours are sustained at least 6-months following program completion [1]. Evolutions in the framework have highlighted the need for both quantitative and qualitative methods to be used in conjunction when utilising the framework in evaluation research. Qualitative methods used in evaluation research have been reported to help provide detail and context, such as understanding experiences, perceptions, facilitators, and barriers of cancer survivors when delivering interventions and to assist in the interpretation of quantitative data [241]. Research that employs a mixed-methods approach encompassing both

quantitative and qualitative methods when utilising the RE-AIM framework may therefore yield unique and rich data [231].

8.1.1 Aims and objectives

Utilising the RE-AIM framework, this study aims to;

1) evaluate intervention feasibility by exploring acceptability and satisfaction of virtual home-based exercise intervention for cancer survivors

2) explore the effectiveness of the intervention on a variety of participant outcomes including motivation and competence to take part in PA, PA behaviour, quality of life and physical fitness using both quantitative and qualitative methods.

3) retrospectively explore participant experiences moving from a gym-based to home-based setting during the global COVID-19 pandemic using focus groups. This rich, qualitative data will also provide support for the RE-AIM dimensions, particularly for Effectiveness.

8.2 Methods

8.2.1 Design. To achieve the study aims, a mixed-methods approach was employed through the use of quantitative and qualitative research tools to address the 5 dimensions of the RE-AIM Evaluation Framework [1] reported in Table 1. Ethical approval was granted by Liverpool John Moores University Research Ethics Committee (UREC), 20/SPS/023.

	Measures		
	BASELINE	**6 WEEK POST-INTERVENTION**	**6 MONTH POST-INTERVENTION**
Reach	Baseline Questionnaire (number and characteristics of participants)	Program Evaluation Survey (Recruitment Methods)	
Effectiveness	SF-36 (QoL) BREQ-3 (Motivation) PCS (Competence) Wall Squat (Fitness)	SF-36 (QoL) BREQ-3 (Motivation) PCS (Competence) Wall Squat (Fitness) Program Evaluation Survey (Acceptability and Satisfaction)	
Adoption	Adherence Log Adherence to Intervention, Number of Sessions) Program Evaluation Survey (Barriers and Facilitators)		
Implementation	Adherence Log (Engagement) Recorded Exercise Sessions (Delivery)		
Maintenance			Focus Groups (PA Maintenance, Barriers and Facilitators) Stakeholder Interview (Continuation of Intervention)

Figure 8- Timeline of data collection process from baseline, 6-weeks post intervention and 6-month follow up.

8.2.2 Participants and Recruitment. All participants attending a gym-based activity program for cancer survivors at a charity-based organisation on the Wirral were invited to take part. To be eligible for inclusion in the study, participants had to be adult with a current or past cancer diagnosis, either in active treatment or post-treatment and able to participate in physical activity. Participants were invited to take part by a recruitment email, virtually face-to-face and an invitation in the groups WhatsApp by the PhD researcher/coach. The study was also promoted using a recruitment poster which the organisation advertised on their social media pages including Facebook and Instagram. Participants provided informed, written consent to take part in the study.

8.2.3 Virtual home-based exercise intervention. The lead activity program coach was an experienced personal trainer and a qualified Level 4 Cancer Rehabilitation Coach who had been leading the organisation's program for cancer survivors for 2 years. Prior to the COVID-19 pandemic, the coach delivered face-to-face exercise sessions to the members of the activity program in a gym-based facility that were largely resistance training based with some aerobic conditioning exercises . Following instruction from the UK government for the closure of gym-based facilities during initial lockdown in March 2020, the program was set up in a virtual format and delivered via Zoom to the members of the program. A virtual home-based exercise intervention was then developed and

conducted across a 6-week period using the Zoom platform as part of this PhD project. Each session of the 6-week intervention was structured and supervised by the coach. The ultimate goal of the training program was to provide a training stimulus and initiate a response to achieve physiological adaptations such as improvements in strength. Progression in terms of exercises and volume and intensity of training was included weekly in order for participants to maximise training adaptations. When necessary, alternative exercises and regressions were provided to tailor the training program to suit the individual. The 6-week period consisted of 2, 3-week training blocks and each session lasted for approximately 60 minutes. At the beginning of each session, the coach guided participants through a dynamic warm up based on a modified version of the RAMP protocol (Raise, Activate, Mobilise and Potentiate) [242] with a key focus on mobility and activation exercises (please see detail on exercises used in Figure 6 below). The core of each session had a total body focus and consisted of fundamental movement patterns, incorporating bilateral and unilateral components, and exercises were classified as knee or hip dominant, vertical push or pull, horizontal push or pull and core rotation or stabilisation exercises, and was developed in line with the FITT principle. This helped to create balance across the program and allowed incorporation of all major muscle groups and joints. The sessions were largely resistance training based with the addition of some aerobic style exercises. At the beginning of the lockdown period when the face-to-face sessions moved to a virtual format, participants invested in some pieces of equipment as recommended by the coach including, resistance bands, free weights such as dumbbells and kettlebells. During the sessions, participants used these pieces of equipment, items in their home such as a rucksack filled with some books to add additional weight, cans of beans and/or their own bodyweight to perform the exercises. Weeks 1 to 3 followed a similar format in terms of exercise utilisation/structure and the session was progressed weekly by additional sets of exercises, increased repetitions and/or time (exercise dependent). Weeks 4 to 6 followed a similar format to weeks 1 to 3. However, exercises utilised/structure were changed to add variation to the program while training virtually, following on from weeks 1 to 3. Like weeks 1 to 3, sessions in weeks 4 to 6 were progressed weekly by additional sets of exercises, increased repetitions and/or time (exercise dependent). Please see Figure 6 below which provides a detailed overview of the exercise training program. A suggested guide for rest between exercises was 60 to 90 seconds, and rest varied among participants depending on their ability and treatment.

Figure 9 - Training program delivered during virtual home-based exercise intervention.

Megan Hewitt Personal Training - UTS Foundation Training Program

Week 1								**Week 2**							
SESSION 1								SESSION 2							
Exercise	**Rest**	**Sets**	**Repititions**	**Repititions**	**Repititions**		**Kg (weight)**	**Exercise**	**Rest**	**Sets**	**Repititions**	**Repititions**	**Repititions**		**Kg (weight)**
1.a Chair squat with 3s eccentric	60-90s	2	12	12				1.a Chair squat with 3s eccentric	60-90s	3	12	12	12		
1.b Single leg hip thrust with 2s ISO		2	12	12				1.b Single leg hip thrust with 2s ISO		3	12	12	12		
1.c Wall sit		2	30s	30s				1.c Wall sit		3	35s	35s	35s		
2.a Elevated press up	60-90s	2	12	12				2.a Elevated press up	60-90s	3	12	12	12		
2.b Weighted single arm row		2	12	12				2.b Weighted single arm row		3	12	12	12		
3.a Goodmorning + Y raise	60-90s	2	12	12				3.a Goodmorning + Y raise	60-90s	3	12	12	12		
3.b Side-lying hip raise		2	8	8				3.b Side-lying hip raise		3	8	8	8		
4.a Bear crawl	60-90s	2	2L hallway	2L hallway				4.a Bear crawl	60-90s	3	4L hallway	4L hallway	4L hallway		
4.b Plank or tall plank		2	15s	15s				4.b Plank or tall plank		3	20s	20s	20s		
Dynamic warmup:								**Dynamic warmup:**							
Thoracic rotations x10ea	Lying hip thrust 10		Plank shoulder taps x5ea					Thoracic rotations x10ea	Lying hip thrust 10		Plank shoulder taps x5ea				
Dynamic shoulder circle x10ea	Inchworm to hip lunge x5ea							Dynamic shoulder circle x10ea	Inchworm to hip lunge x5ea						
Bird dog x5ea	Standing ITWL x10ea							Bird dog x5ea	Standing ITWL x10ea						

Week 3								**Week 4**							
SESSION 3								SESSION 4							
Exercise	**Rest**	**Sets**	**Repititions**	**Repititions**	**Repititions**		**Kg (weight)**	**Exercise**	**Rest**	**Sets**	**Repititions**	**Repititions**	**Repititions**		**Kg (weight)**
1.a Chair squat with 3s eccentric	60-90s	3	15	15	15			1.a B-stance goodmorning	60-90s	2	12	12			
1.b Single leg hip thrust with 2s ISO		3	15	15	15			1.b Long lever glute bridge		2	12	12			
1.c Wall sit		3	40s	40s	40s			1.c Stairwalk		2	4xL	4xL			
2.a Elevated press up	60-90s	3	15	15	15			2.a Weighted floor press	60-90s	2	12	12			
2.b Weighted single arm row		3	15	15	15			2.b Negative press up		2	8	8			
3.a Goodmorning + Y raise	60-90s	3	15	15	15			2.c Seated sprints		2	20s	20s			
3.b Side-lying hip raise		3	10	10	10			3.a Bulgarian split squats	60-90s	2	12	12			
4.a Bear crawl	60-90s	3	6L hallway	6L hallway	6L hallway			3.b Side-lying hip raise		2	10	10			
4.b Plank or tall plank		3	25s	25s	25s			3.c Single-leg wall sit		2	15s	15s			
Dynamic warmup:								**Dynamic warmup:**							
Thoracic rotations x10ea	Lying hip thrust 10		Plank shoulder taps x5ea					Thoracic rotations x10ea	Lying hip thrust 10		Plank shoulder taps x5ea				
Dynamic shoulder circle x10ea	Inchworm to hip lunge x5ea							Dynamic shoulder circle x10ea	Inchworm to hip lunge x5ea						
Bird dog x5ea	Standing ITWL x10ea							Bird dog x5ea	Standing ITWL x10ea						

Week 5								**Week 6**							
SESSION 5								SESSION 6							
Exercise	**Rest**	**Sets**	**Repititions**	**Repititions**	**Repititions**		**Kg (weight)**	**Exercise**	**Rest**	**Sets**	**Repititions**	**Repititions**	**Repititions**		**Kg (weight)**
1.a B-stance goodmorning	60-90s	3	12	12	12			1.a B-stance goodmorning	60-90s	3	15	15	15		
1.b Long lever glute bridge		3	12	12	12			1.b Long lever glute bridge		3	15	15	15		
1.c Stairwalk		3	4xL	4xL	4xL			1.c Stairwalk		3	4xL	4xL	4xL		
2.a Weighted floor press	60-90s	3	12	12	12			2.a Weighted floor press	60-90s	3	15	15	15		
2.b Negative press up		3	8	8	8			2.b Negative press up		3	10	10	10		
2.c Seated sprints		3	30s	30s	30s			2.c Seated sprints		3	40s	40s	40s		
3.a Bulgarian split squats	60-90s	3	12	12	12			3.a Bulgarian split squats	60-90s	3	15	15	15		
3.b Side-lying hip raise		3	10	10	10			3.b Side-lying hip raise		3	10	10	10		
3.c Single-leg wall sit		3	20s	20s	20s			3.c Single-leg wall sit		3	30s	30s	30s		
Dynamic warmup:								**Dynamic warmup:**							
Thoracic rotations x10ea	Lying hip thrust 10		Plank shoulder taps x5ea					Thoracic rotations x10ea	Lying hip thrust 10		Plank shoulder taps x5ea				
Dynamic shoulder circle x10ea	Inchworm to hip lunge x5ea							Dynamic shoulder circle x10ea	Inchworm to hip lunge x5ea						
Bird dog x5ea	Standing ITWL x10ea							Bird dog x5ea	Standing ITWL x10ea						

8.2.4 Measures and procedures. Data informing each RE-AIM dimension were collected at baseline, post 6-week intervention and 6-month follow up. Methods of data collection included: Demographic and Screening questionnaires, Perceived Competence Scale (PCS) for Physical Activity, Short Form-36 (SF-36) Health Survey [243] and the Behavioural Regulations in Exercise Questionnaire (BREQ-3) [244] and a Program Evaluation Survey, a fitness assessment including a wall squat test to assess lower body strength, focus groups and stakeholder interview. Baseline and post 6-week intervention questionnaire packs were emailed to participants to complete and return electronically to the PhD researcher. Questionnaires were an easily administered and efficient way to gather data from participants electronically during the pandemic [245]. Fitness assessments (wall squat test) were conducted virtually and performed at baseline and post 6-week intervention. An adherence log was kept weekly by the researcher and to monitor participant attendance and each activity session was recorded and delivered using two, 3-week structured training programs. A total of four focus groups were conducted virtually using the Zoom platform. Two focus groups and a stakeholder interview were conducted at 6-months follow up. Interviews are similar to that of focus groups whereby they provide rich insights into or understanding of opinions, attitudes, experiences, processes, behaviours, or predictions [245]. An additional two focus groups were conducted after completion of the 6-week intervention to explore participant experiences of the intervention and the transition from a gym-based to home-based setting to exercise.

8.2.4.1 Demographic and Screening Questionnaires **(R)**. The purpose of these questionnaires was to gather characteristics of participants and highlight the representativeness of participants to the target population. The Demographic Questionnaire collected information including age, gender, area postcode and employment status. The Screening Questionnaire collected diagnosis and treatment information including, date of diagnosis, name and stage of diagnosis, treatment status (active or post-treatment) and treatment prescription.

8.2.4.2 Perceived Competence Scale (PCS) **(E)**. The PCS is one of the most face valid instruments designed to assess constructs from the Self Determination Theory (SDT) (Tao et al., 2019; Kim et al., 2020). The PCS consisted of 4-items to assess participants' feelings of competence about participating in physical activity regularly. Example statements included, "I feel confident in my ability to be physically active" and "I now feel capable of being physically active regularly". Participants responded to each statement using a 7-point Likert scale, from 1 "not at all true" to 7 "very true".

8.2.4.3 Behavioural Regulations in Exercise Questionnaire (BREQ-3) **(E)**. Participants completed the BREQ-3 questionnaire [244], underpinned this SDT continuum [246] which was used to measure why participants choose to engage or not engage in physical activity and exercise [247,248]. The questionnaire consisted of 24-items and included statements such as, "It's important to me to exercise". Participants responded to each statement using the scale to indicate which item was true for them to some extent, from 0 "not true for me" to 4 "very true for me".

8.2.4.4 Short Form-36 Health Survey (SF-36) **(E)**. The Short Form-36 (SF-36) is a generic health self-report survey used to measure quality of life [243]. The survey consisted of 36 items which measure 8 dimensions of health status including physical functioning, role physical, bodily pain, general health, vitality, social functioning, role emotional and mental health. Highers scores represent better health. Participants answered questions using the available option provided for each item. For example, "In general, would you say your health is: 1-Excellent, 2-Very good, 3-Good, 4-Fair, 5-Poor".

8.2.4.5 Wall squat (**E)**. To assess the effectiveness of the intervention on lower body strength and endurance, participants were required to complete a wall squat test at baseline and post 6-week intervention. Although it is acknowledged that other measures of physical fitness could have been utilised such as the sit-to-stand or chair rise tools [249], there was specific reasoning behind choosing the wall squat test. This test was chosen as it could be easily administered in participant's homes with no need for equipment. From a safety point of view, participants had previous experience of performing this exercise from the face-to-face sessions in the gym facility pre pandemic. In addition, given the aim of assessing intervention effectiveness on lower body strength, the wall squat test specifically targets the quadriceps muscle, assessing leg strength [250]. The wall squat test has been previously used in a cohort of cancer survivors to assess lower body strength and endurance [251], and a previous systematic review exploring the reliability and validity of the wall squat test concluded that this test was a reliable and valid measure for assessing lower body strength [252]. Participants were provided with written instructions on how to perform the wall squat test in the participant information sheet and the PhD researcher provided a virtual demonstration before participants performed the test. To ensure participants completed the test correctly, the coach/PhD researcher virtually observed each participant and provided verbal instruction for technique where necessary.

8.2.4.6 Program Evaluation Survey (PES) **(R, E and A)**. Intervention feasibility in terms of satisfaction, acceptability and appropriateness of the online home-based program was evaluated using this non validated self-report survey consisting of questions such as, "Do you think the online home-based activity program was appropriate for cancer survivors" and "Did you enjoy the online home-based activity program" respectively. Questions regarding how participants were recruited to the virtual home-based intervention, participants perceptions of PA and barriers and facilitators they encountered for participation were also included. The data gathered from these surveys is formative within the development of the question guide for the follow-up focus groups to address the Maintenance dimension of the framework.

8.2.4.7 Adherence log **(A and I)**. Participant adherence and the number of sessions conducted was recorded each week using this adherence log. Participant engagement i.e reasons for non-attendance was also recorded from participants when they did not attend a session.

8.2.4.8 Recorded sessions and 6-week program log (**I)**. Delivery of the intervention was facilitated by a structured training program log and sessions were recorded for observation alongside this to ensure consistency.

8.2.4.9 Focus groups **(M)**. Two focus groups were conducted at 6-month follow-up to assess the Maintenance dimension of RE-AIM. Each focus group ranged from 6 to 7 participants in each. Additionally, after completing the 6-week home-based exercise intervention, two focus groups were also conducted to narratively explore participants' experiences of the intervention and the transition from a gym-based to home-based setting to exercise. Semi-structured question guides were developed by the lead researcher, research team and a Health and Care Professions Council Registered Practitioner Psychologist (HCPC). The opening of the focus group guide consisted of a brief introduction whereby the moderator of the focus group (PhD researcher/ coach) addressed the purpose of the focus group and the procedure participants were required to follow as part of the research process. Given the relationships already established prior to commencement of the study, participants may have felt comfortable to talk openly and share both positive and negative experiences, this may have facilitated the discussion among the groups. Given this context, a narrative approach was chosen as the focus was to understand how participants interpreted their lived/personal experiences of the program. The question guide consisted of open-ended questions structured to prompt discussion with equal chance of participants to contribute [170] and

also retrieved the discussion when distracted from the purpose of the focus group. To maximise the interaction between participants, focus group questions were reviewed by the lead researcher and a HCPC Registered Practitioner Psychologist for appropriateness of question ordering and flow. Participants were asked to introduce themselves at the beginning of the focus groups and by way of providing a comfortable environment for discussion. The question guide at 6-month follow-up addressed participants perceptions of maintaining PA behaviour and barriers and facilitators to maintaining PA to address the maintenance dimension of RE-AIM. The question guide used to explore participants' experiences of the intervention consisted of two sections. Section 1 addressed the purpose of the intervention and what it set out to achieve. Section 2 addressed the transition participants made from a gym-based to a home-based setting. The role of the moderator was to facilitate discussion and provided the discussion remained on track, they did not intervene as this may have disrupted discussion among participants. The moderator was the PhD researcher and intervention coach. Given the rapport already established between participants and the researcher-coach, this may have further promoted engagement and interaction from the participants. Focus groups were recorded using the digital mibao V100 Digital Voice Recorder and transcribed verbatim.

8.2.4.10 Stakeholder interview ***(M)***. A semi-structured interview was conducted by the PhD researcher using the Zoom platform with the organisation's trustee. Like the focus group questions, interview questions were reviewed by the lead researcher and a HCPC Registered Practitioner Psychologist for appropriateness of question ordering and flow. The Zoom interview was conducted within 2 weeks after the 6-month follow-up data collection period. The semi-structured interview guide consisted of asking the director open-ended questions about the continuation of the virtual home-based exercise intervention and members feedback of experiences of the intervention. The interview was recorded using the digital mibao V100 Digital Voice Recorder and transcribed verbatim.

8.2.5 RE-AIM Evaluation Framework. The RE-AIM dimensions were evaluated at both participant and organisational level [1,182]. **Reach** was assessed in terms of sample size, recruitment methods and population representativeness. The **effectiveness** of the intervention was evaluated by changes in perception of physical activity behaviour, quality of life, motivation to exercise, competence to be physically active, markers of fitness and perceived acceptability and satisfaction of the intervention. Barriers and facilitators, adherence to the intervention and number of sessions conducted reflected **adoption**. Consistent delivery of the intervention as intended, and participant engagement reflected the **implementation** dimension. Lastly, **maintenance** was

assessed by participant perceptions of maintaining physical activity, facilitators, and barriers to maintaining physical activity and continuation of intervention at the organisational level. Table 2 provides a detailed description of the methods used to assess each of the 5 RE-AIM dimensions.

Table 2- Methods and outcome measures for each RE-AIM dimension.

DIMENSION	OUTCOME MEASURES	METHODS
Reach (individual level)	-Number and proportion of participants who are cancer survivors	-Baseline questionnaire (n=13)
	-Participant characteristics	-Baseline questionnaire (n=13)
	-Recruitment methods	-Program evaluation survey (n=13)
Effectiveness (individual level)	-Perceptions of PA behaviour	-Program evaluation survey (n=13) -Focus groups
	-Quality of Life	-Short Form-36 Health Survey (n=13) -Focus groups
	-PA motivation	-Behavioural Regulations in Exercise Questionnaire (n=13) -Focus groups
	-Competence to be physically active	-Perceived Competence Scale (n=13) -Focus groups
	-Fitness assessment	-Wall squat test (n=13 group setting) -Focus groups
	-Perceived acceptability and satisfaction of intervention	-Program evaluation survey (n=13) -Focus groups
Adoption (individual and organisational level)	-Barriers and facilitators to cancer survivors adopting intervention	-Program evaluation survey (n=13) -Focus groups
	-Adherence to intervention	-Adherence log -Focus groups
	-Number of sessions conducted	-Adherence log
Implementation (individual and organisational level)	-Delivery of sessions	-Observation of recorded sessions and 6-week program log
	-Participant engagement (reasons for non-attendance)	-Adherence log -Focus groups
Maintenance (individual level and organisational level)	-Perceptions of maintaining PA	-Focus groups at 6-month follow up
	-Barriers and facilitators to maintaining PA	-Focus groups at 6-month follow up
	-Continuation of intervention	-Interview with stakeholder at 6-month follow up

8.2.6 Analysis

8.2.6.1 Quantitative analysis. Effectiveness was assessed by changes in outcomes including PCS, SF-36 8 dimensions, BREQ-3 6 motivational types and wall squat measures from baseline to post intervention using paired

t-tests. Descriptive statistics are presented as mean ± SD. The level of significance was set at P< 0.05. All statistical analyses were conducted using IBM's Statistical Package for Social Sciences (SPSS Version 26.0).

8.2.6.2 Thematic analysis. Focus groups and stakeholder interview were transcribed verbatim to produce transcripts. The lead researcher reviewed these transcripts to ensure accuracy before reporting the findings. Focus groups that were conducted to explore participants' experiences of the intervention consisted of a 22-page transcript and a 23-page transcript both Ariel size 12, double spaced. Focus groups conducted at follow up to address the Maintenance dimension of RE-AIM consisted of a 14-page and a 13-page transcript. Transcriptions of each session were created with identifying information removed. A thematic analysis [199] was employed to report findings as this allowed for 'thick description' of the data via the use of direct quotations [18]. This approach aimed to offer a credible and trustworthy interpretation of the data that captured participants' experiences of the intervention [18,208]. The stakeholder interview consisted of an 8-page transcript and thematic analysis was also employed here.

8.3 Results

8.3.1 Reach. Reach was assessed at the individual level using the baseline questionnaire and Program Evaluation Survey.

8.3.1.1 Number and proportion of cancer survivors

A total of 13 participants took part in the study. The sample included 10 breast cancer survivors (77%), 1 pancreatic neuroendocrine cancer survivor (8%), 1 bowel cancer survivor (8%) and 1 prostate cancer survivor (8%). All participants were members of the organisations program for cancer survivors. Out of the 13 participants, 5 were having active treatment and 8 were post-treatment for their cancer.

8.3.1.2 Sources of recruitment

The primary sources of recruitment included a recruitment email, a poster which was shared on the organisation's social media pages, an invitation via Zoom with participants who were already engaging in exercise sessions virtually or an invitation in the groups WhatsApp from the PhD researcher/coach. Findings from the self-report program evaluation survey reported that 4 participants received a recruitment email (31%), 8 participants received an invitation via Zoom (61%) and 1 participant received a recruitment email and invitation via WhatsApp (8%).

8.3.1.3 Characteristics of participants

The average age of participants was 52.9 ± 11.1 years old. Other characteristics of the study sample including age, gender, employment status, name and grade/stage of cancer, treatment status, and treatment prescribed are reported in Table 2.

Table 3- Participant characteristics (n=13)

VARIABLE	PARTICIPANT N (%)
Age (years)	
35-49	7 (54%)
50-64	4 (31%)
65 years and over	2 (15%)
Gender	
Male	1 (8%)
Female	12 (92%)
Employment status	
Full-time work	1 (8%)
Part-time work	6 (46%)
Unemployed	1 (8%)
Caring for family/managing household	1 (8%)
Recovering from illness	1 (8%)
Retired	2 (15%)
Other	1 (8%)
Name and grade/stage	
Prostate cancer T3	1 (8%)
Breast cancer stage I	1 (8%)
Breast cancer stage II	3 (23%)
Breast cancer stage III	2 (15%)
Breast cancer IV	1 (8%)
Breast cancer IA	1 (8%)
Breast cancer stage IB	2 (15%)
Pancreatic neuroendocrine stage III	1 (8%)
Bowel cancer IIIA	1 (8%)
Treatment status	
Active	5 (39%)
Post-treatment	8 (62%)
Treatment	
Radiotherapy	10 (77%)
Chemotherapy	9 (69%)
Hormonal therapy	2 (15%)
Cryotherapy	1 (8%)
Mastectomy	10 (77%)
Surgery	2 (15%)
Lymphadenectomy	2 (15%)
Endocrine therapy	2 (15%)

8.3.2 Effectiveness. Effectiveness was assessed at the individual level using the Program Evaluation Survey, SF-36, BREQ-3, PCS, and Wall squat.

8.3.2.1 Program Evaluation Survey

8.3.2.1.1 Perceptions of physical activity behaviour

Findings from the self-report PES revealed that the majority of participants (92%) already viewed PA as important and beneficial for their physical and mental health as cancer survivors before taking part in the intervention, for example, "…it [physical activity] should be a way of life to increase your chances of staying fit and healthy and improving your mental wellbeing…" (P11) and "…I can see how important it is to exercise regularly for my physical and mental wellbeing and to prevent the cancer returning." (P3).

Participants (77%) reported how the intervention was effective at helping them increase their current PA levels, for example, "…made me more determined to get in some kind of exercise each day." (P12), "Having the weekly program has given me a focus and has enabled me to increase my level of exercise" (P1), "I was more active during the program and have been since…" (P11) and "This online program has been crucial in keeping up the momentum of exercising at least once a week and then fitting in other general exercise throughout the week, such as walking" (P5).

Almost half of participants (46%) reported their enjoyment of performing resistance style training and its benefits over the 6-week period, reporting feeling stronger and more flexible, for example, "Since attending this program, I have come to realise that strength training is very important as my perceptions of physical activity have always been cardio" (P2) and "The online program has been beneficial as it has shown me the benefits of progressive training, and it has measured my improvements, which is always nice to see" (P8).

8.3.2.2 SF-36

8.3.2.2.1 Quality of life outcomes

Each of the 8 scales from the SF-36 are reported individually: Physical functioning (PF), Role physical (RP), Bodily pain (BP), General health (GH), Vitality (VT), Social functioning (SF), Role emotional (RE) and Mental health (MH). Mental health scale scores significantly improved from baseline to post 6-week intervention (see Table 3).

Table 4- Mean and standard deviations of SF-36 dimensions at baseline and post 6-intervention.

Scale	Baseline assessment, mean ± SD	6-week post intervention assessment, mean ± SD	*P*-value
Physical functioning (PF)	86 ± 16	88 ± 12	0.719
Role physical (RP)	69 ± 34	71 ± 38	0.856
Bodily pain (BP)	76 ± 13	81 ± 18	0.376
General health (GH)	65 ± 19	65 ± 17	0.843
Vitality (VT)	60 ± 22	62 ± 21	0.745
Social functioning (SF)	86 ± 21	83 ± 12	0.583
Role emotional (RE)	82 ± 26	95 ± 13	0.096
Mental Health (MH)	75 ± 12	84 ± 7	**0.002***

Paired *t*-test, n=13, * = *P* <0.05.

8.3.2.3 BREQ-3

8.3.2.3.1 Motivation outcomes

The mean Relative Autonomy Index (RAI) score at baseline (70.92 ± 15.07) did not significantly improve (*P* = 0.752) post 6-week intervention (70.00 ± 15.87). Across each motivational type (amotivation, external regulation, introjected regulation, identified regulation, integrated regulation, and intrinsic regulation) there were no significant improvements in participants scores (see Table 4).

Table 5- Means and standard deviations of BREQ-3 scores for motivational types at baseline and post 6-week intervention.

Motivational type	Baseline assessment, mean ± SD	6-week post intervention assessment, mean ± SD	*P*-value
Amotivation	0.06 ± 0.21	0.19 ± 0.37	0.03
External regulation	0.19 ± 0.34	0.27 ± 0.44	0.44
Introjected regulation	2.69 ± 1.12	2.69 ± 1.14	1.00
Identified regulation	3.69 ± 0.31	3.71 ± 0.17	0.75
Integrated regulation	3.42 ± 0.55	3.58 ± 0.55	0.24
Intrinsic regulation	3.48 ± 0.72	3.48 ± 0.53	1.00

Paired *t*-test, n=13

8.3.2.4 PCS

8.3.2.4.1 Perceived competence outcomes

The mean PCS average at baseline (6 ± 1) did not significantly improve (P = 0.941) post 6-week intervention (6 ± 1). Although there was no significant improvement from scores at baseline to post intervention, there was an improvement in 3 participants scores post intervention (23%) (see Table 5).

Table 6- Participant PCS averages at baseline and post 6-week intervention.

Baseline assessment, PCS average	6-week intervention assessment, PCS average
7	7
6	5
7	7
7	7
7	7
6	7*
6	7*
4	5*
7	7
6	4
7	5
7	7
6	6

Paired *t*-test, n=13, * = improved PCS average (n=3).

8.3.2.5 Wall squat

8.3.2.5.1 Physical fitness outcomes

The mean wall squat recordings at baseline (118 ± 68s) significantly improved (P = 0.003) post 6-week intervention (264 ± 174s).

Table 7- Participant wall squat recordings at baseline and post 6-week intervention.

Baseline assessment	6-week intervention assessment
0.42.39	2.31.87
01.11.54	02.21.47
01.13.84	05.19.83
02.45.02	08.45.19
02.10.25	03.09.72
01.03.06	02.12.89
01.27.45	03.07.78
01.33.03	06.14.39

00.53.60	01.50.47
04.40.66	04.55.09
01.47.18	03.04.06
01.16.84	02.09.89
03.13.97	11.23.20

8.3.2.6 Program evaluation survey

8.3.2.6.1 Perceived acceptability and satisfaction of intervention

Findings from the PES indicated that intervention was effective in terms of acceptability and satisfaction.

More specifically, participants, (100%) felt that the intervention was appropriate for cancer survivors, for example, “I think that the program was acceptable for cancer survivors. Some members were at different stages in their treatment and others were post treatment. The programme allowed for various levels of activity and exercises were adapted accordingly. I believe that members benefitted from the motivation provided within a group and gave focus at an emotional time in their life. The exercising at any level creates a feel-good factor which can help participants to feel more positive” (P11), “Yes, we are familiar and comfortable with the group members who are post cancer treatment and supportive of those still having cancer treatment, it’s a safe environment and we all go at our own pace so there’s no peer pressure keeping up with others, C [coach] tailors the exercises for some members who find particular exercises challenging” (P3) and “I think the program has been differentiated for each of the cancer survivors. I had the perception, prior to doing the online activity course that I would not have the energy to exercise, but I’ve been pleasantly surprised as to how much I’ve been able to do on this program. If I hadn’t been on this course, I would have lost my previous level of fitness. This course has been an absolute blessing during treatment and COVID lockdown/self-isolation due to treatment” (P5).

Participants (100%) would recommend the intervention to other cancer survivors, for example, “I would 100% recommend the program. I don’t think you could take anything other than positives from being part of it” (P8), “I would definitely recommend the program and advise anyone who thinks they might not be up to it to still give it a go, C [coach] provides alternative exercises when appropriate to make it a bit easier for those of us who found some things more difficult, whilst still working on the same muscle groups” (P1) and “I recommend the online activity program to every cancer survivor I meet, it is a fantastic provision for cancer patients, who would possibly feel really isolated during treatment, especially with the COVID lockdowns…” (P5).

Participants (92%) enjoyed the intervention, for example, “Yes, the online activity program was very enjoyable, I do prefer in person but as all the advice during lockdown is to shield I was so grateful to have the online support with C [coach] and still be able to see some of my dear friends that have been a wonderful network during my own survivor journey” (P12), “Initially I felt some dread at the prospect of it but I did enjoy the program and was disappointed that I had to miss one of the sessions” (P1) and “I really did and although it was a commitment and felt challenging, it never felt daunting” (P4).

Participants (100%) looked forward to the weekly sessions of the intervention, for example, “…they were the highlight of my week” (P11), “Yes, I did, and it was often a great source for a sense of personal achievement” (P4) and “Absolutely. I would partially dread it the day before if I wasn’t feeling very well, but each Monday morning I felt fresher and was really pleased I had this to start my week off on a positive note” (P5).

Participants (85%) felt physically and mentally stronger, for example, “…I started hormone treatment over six years ago, my bone density is stronger now than when I started treatment. It is two and a half years ago that I started coming to the classes…and I firmly believe the credit is due to this” (P6), “I know my muscle strength has improved as well as maintaining suppleness and the classes always made me feel more buoyant, positive and ready for the next challenge” (P4) and “…it has made a difference on both levels, and I feel stronger for the sessions” (P3).

Participants (77 %) reported being able to better perform daily living tasks and move better, for example, “My stamina is improved, and I have less back pain because my core is stronger as well as my arms and legs. I am able to lift and carry quite heavy stone rocks in the garden, without pain the next day…” (P4), “My legs and upper body feel stronger which builds up your confidence, especially after going through cancer treatment where you feel so weak and depleted” (P3) and “…most of the time, although the chemo prevents me sometimes, due to tiredness or achy limbs” (P5).

Participants (100%) felt the coach had a positive impact on their participation, for example, “…C [coach] was the glue that bound us all together. She understood how much to challenge the group and yet I never felt intimidated or that something was beyond my achievement. C [coach] had a marvellous ability to encourage. She is so thorough in her lesson/activity planning and an excellent communicator and observer. She always made sure we

were all achieving exactly what the exercises intended" (P4) and "The coach was welcoming and clearly demonstrated the exercises, adapting them accordingly, for various levels of fitness. C [coach] was professional, friendly, motivating and patient which was why our sessions were fun" (P11).

Participants (100%) found the group-based format of the intervention beneficial, for example, "Absolutely, the group-based nature was really beneficial as you could see others at all different stages of their cancer treatment, and it spurred me on" (P5) and "Being part of the group was definitely beneficial because we probably spurred each other on. There was lots of support and camaraderie. Plus, though we don't know the specifics of each other's cancer experiences, we all have that common bond and empathy for one another" (P1).

Participants (92%) felt that the intervention caused no additional stress or inconvenience to their day/week, for example, "…if anything the opposite as it was quick and easy to access from home or any other suitable location if required…" (P4) and "The timing of the online sessions was perfect for me because I don't usually have work on a Monday. Also, being in the morning, it did not disrupt the day as a whole and I felt that it gave me a very positive start to my week" (P1).

8.3.3 Adoption. Adoption was assessed at the individual and organisational level using the Program Evaluation Survey and adherence log.

8.3.3.1 Program evaluation survey

8.3.3.1.1 Barriers and facilitators to intervention adoption

Findings from the PES highlighted factors influencing the uptake of the intervention including barriers and facilitators for participation. Over half of participants (54%) reported engagement with the group as a key facilitator to attend the sessions, to quote, "the group is so supportive" (P1). Almost half of participants (46%) also reported the coach as a key facilitator to attend the sessions. Work was reported as a barrier by participants (23%) and family commitments was reported by 1 participant for example, "I have a 5-year-old child, so sometimes found it difficult because of looking after him" (P8). However, some participants reported rescheduling their work and other friend/family commitments to ensure they could attend the sessions. Another participant reported barriers, for example, "…hospital appointments, tiredness due to the side-effects from my cancer treatment and meeting up with friends, although I arranged these meet-ups mainly around the activity

program" (P5). Participants commented on the degree of accessibility and flexibility of the intervention by still being able to participate even when on holiday (15%), for example, "I was also able to complete a session while on holiday. I still had the ability to participate with the rest of the group, which was great, as well as having excellent tuition, guidance from the coach, thus ensuring I got the most from the session and completed the exercises correctly" (P4)

8.3.3.2 Adherence log

8.3.3.2.2 Adherence to intervention and number of sessions conducted

Findings from the adherence log revealed that more than half of participants attended each session across the 6-week period. Attendance across Weeks 1, 3, 5 and 6 was 69% (n=9), week 2 attendance was 77% (n=10) and week 4 achieved 92% attendance (n=12). Reasons for non-attendance have been reported under the Implementation dimension for participant intended engagement. At an organisational level, the intervention was conducted for the duration of the 6-week period, every Monday at 10:00 and all sessions were delivered as scheduled.

8.3.4 Implementation. Implementation was assessed at the individual and organisational level using the adherence log, recorded sessions and program training log.

8.3.4.1 Adherence log

8.3.4.1.1 Participant engagement

Participant reasons for non-attendance to sessions was recorded using the program adherence log. Participants checked in with the coach each Monday morning and if they could not attend a session, they were asked to provide a reason for their absence. Treatment side-effects, hospital appointments/phone calls, holidays, work commitments and not being able to access Zoom were provided as reasons for participants being unable to attend a session.

8.3.4.2 Recorded sessions and intervention training log

8.3.4.2.1 Delivery of intervention

Observations of the recorded activity sessions in line with the 6-week program log, conducted by the PhD researcher/coach demonstrate that each session was delivered as intended. Given the nature of the population,

alterations/alternative exercises were provided to participants where necessary. For example, one participant has a stoma therefore couldn't lie on their stomach for certain exercises. The coach provided an alternative exercise to ensure the participant could still engage in the session and perform to the best of their ability. Some participants had PICC lines fitted therefore could not perform some of the pressing exercises/support their bodyweight using their arms for core exercises. Again, the coach provided an alternative exercise for these participants. A vital component of the organisation's ethos is the quality of service delivered to their members, having a qualified Level 4 Cancer Rehabilitation Coach lead the activity program was essential for program implementation/engagement.

8.3.5 Maintenance. Maintenance was assessed at the individual and organisational level using focus groups and interview.

8.3.5.1 Follow up focus groups

8.3.5.1.1 PA Maintenance

By way of introduction into the focus groups participants were asked if the home-based intervention had any impact on their activity levels over the course of the six-months following the intervention period. Five participants reported increased activity levels compared to before the intervention. Two of these participants expressed how the home-based intervention changed their mindset towards exercise and they now see it as a priority to do on a regular basis. Four participants reported their enjoyment of strength training and realising the importance of performing such exercise on a regular basis which they now do (see example below). Eight participants (62%) were still attending the virtual home-based intervention at six months follow up.

I feel it's [intervention] motivated me, and I realise the importance of strength training, which I didn't before. (P7)

The principal factors for PA maintenance discussed in the focus groups are organised into constructed themes and displayed in a pen profile. Themes are divided into two higher order themes, barriers, and facilitators, and further divided into sub-themes. Social support was constructed as a key sub-theme for facilitators for PA maintenance, specifically including the group and coach as key factors. Participants shared consensus for the group-based nature being a key facilitating factor for PA maintenance. Participants reported factors like "being accountable to the

group and coach" and "improved confidence from the coach" which has helped to foster their motivation and discipline to keep participating in the home-based sessions as well as exercise on their own as facilitating factors for their PA maintenance.

…being part of the group has really helped as well. It's a pleasure to see everybody on a Monday…it's just like you still feel a part of something, and it's just really nice. I think the group encourages you as well to continue to be involved. (P1)

…it's always been an important part of that sense of returning to the group…you kind of feel that to some degree you owe it to everybody else to be there on a Monday…I think what drives you isn't the fear of a telling off, it's the fear of letting down. (P4)

…I think being accountable…having the set days and set group, you feel, oh I need to turn up because I don't want to…you're not letting people down. (P5)

…I think it's really helpful because you've always given alternatives, and so it does give us that confidence that you can do it, but it gives you the confidence without… (P12)

…you feel so confident after your sessions. You're so good at telling us the right moves for each individual person…so it [coach] gives you the confidence to do it yourself at home and continue and motivates you to want to do it because you feel so good afterwards. (P2)

In addition, the perceived physical benefits of regular exercise were constructed as another subtheme with factors including "seeing progress" (see examples below) and "facilitating recovery" as factors for PA maintenance. One participant expressed how she had been recently diagnosed with osteoporosis because of their cancer treatment and how that has encouraged her to continue with exercise, specifically strength training to help manage the condition. Similarly, another participant reported trying to lead as active of a lifestyle as possible to help facilitate recovery from surgery and prepare them any future health challenges that may arise (see example below).

…seeing the progress by the end when we re-measured, because like I said, you don't necessarily see notice it week on week…but when you measure it at the end, you think oh actually, we definitely did gain from that… (P8)

…I get like to the third set [of exercises]and I just want to cry, because it's [exercise] hurting so much, and then I think, "Come on, you'll be alright. You'll do it", and it's just that sense of achievement afterwards…I know that as the weeks go on, I'll feel better and more confident, and I'll be able to do things better. (P5).

…none of us know what's happening right around the corner, so I think it's always good to keep as strong and fit as we can. (P12)

Regarding barriers, family commitments, work and active treatment were constructed as key sub-themes for PA maintenance barriers. Participants discussed the difficulties such factors have had on their attendance to the group-based intervention as well as general PA participation.

…sometimes family commitments get in the way. I look after my Mum and Dad in between, and I've also got two children at home… (P1)

I think for me, it's work, because I work the whole time from home, and there's certain things I need to have done within the month… (P3)

…it's been the treatment, because I had my operation…and then I had my chemotherapy and I did come when I could, and then having radiotherapy…have stopped me turning up… (P5)

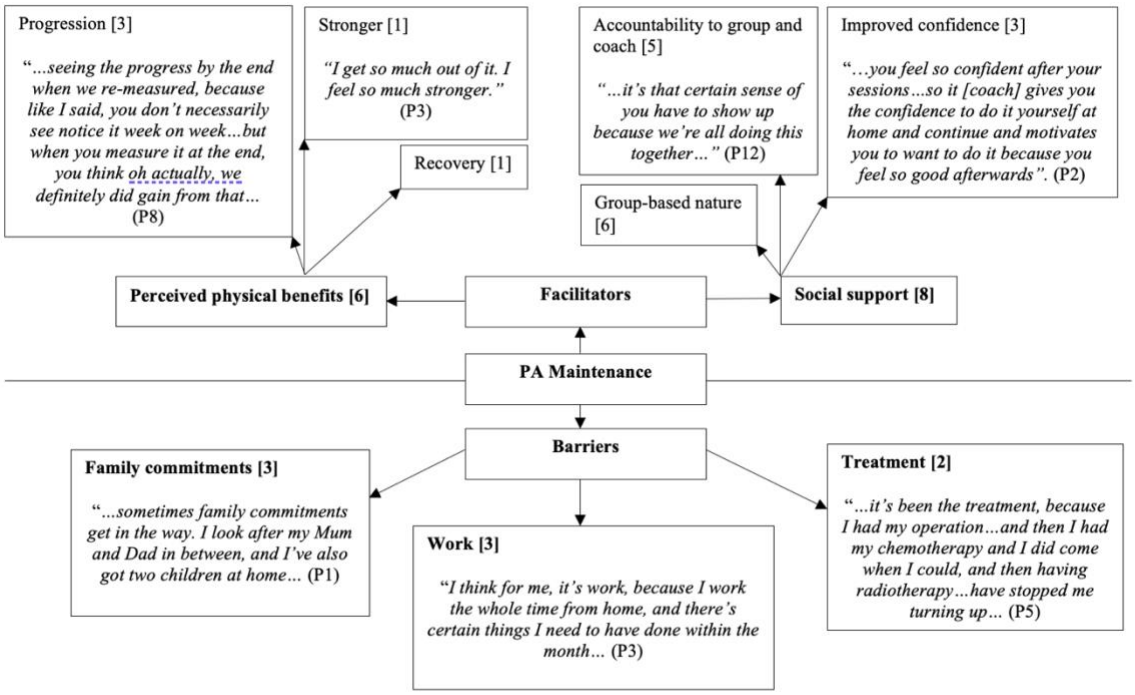

Figure 10 – Pen profile displaying PA Maintenance.

8.3.5.2 Stakeholder interview

8.3.5.2.1 Continuation of intervention

By way of introduction the Stakeholder described their primary role, trustee of the organisation, as someone who looks at how research informs practice with regards to structured exercise for individuals going through active treatment or have completed treatment for cancer, as well as long-term intentions, for example:

The intention was always to grow it [the programme] from a strategic point of view, which is kind of despite all that's been going on in the world, we've kind of been able to do, which we've been really fortunate, and the aims of the organisation were always to establish a model that worked on the Wirral, and then show that to the world and say how we can make that kind of structured provision work for people within your community.

8.3.5.2.2 Impact of COVID-19

The Stakeholder reported how the COVID-19 pandemic "changed everything" in terms of service delivery. In terms of the referral pathway, the organisation developed an online method to facilitate this but with delays in treatment, less people were coming through to look at rehabilitation, highlighting the detrimental impact of the COVID-19 pandemic on the oncology care system. However, they also reported being "kind of thankful that new people weren't coming through because we were trying to manage this shift and everything changing".

8.3.5.2.3 Impact of home-based intervention on members

The stakeholder reported the positive effect the intervention has had on the members, for example:

…I think across the board, what it gives people is continuity, that element of consistency. It's uplifting, it's engaging, it becomes the highlight of that person's week…it gives people a bit of a sense of normality when everything else doesn't feel normal at all.

8.3.5.2.4 Understanding of the intervention

The Stakeholder showed good understanding of the intervention through reporting demographics of the members including, adults across a broad age range and a variety of cancer types, which they reported as a beneficial aspect of the programme, for example:

…it's more diverse, and there are people given the opportunity to be part of a bigger team of people taking part.

They reported how the intervention has incorporated the core components of the gym-based program with regards to what can be delivered when there's less available kit for improving the fundamentals such as aerobic capacity and strength in this population. They also reported the value of the coach in terms of facilitating this and making the transition from a gym-based to home-based intervention a success, for example:

I think your [the coach] capacity as a coach to be able to coach a complex group like that remotely is not standard practice. I don't think a lot of people would have the confidence, and I don't think a lot of people genuinely would have the eye to it, because you've got to be able to see where you can, and coach what you can, based off these little boxes on a screen. So, I think throughout all that, and certainly the feedback that we've had, which has only ever been positive, it's been a triumph, really.

8.3.5.2.5 Advertising

When making the transition to online delivery, they reported being less proactive at encouraging people to join the program through advertising, for example, "let's just make a good job of what we've got". They reported social media promotion of the program having some success, with email being "really poor". More recently, they reported having partnered with another organisation on the Wirral to increase their contact point, for example:

…we are going to start to get a bit more partnership-based, and up close, front and centre with people to make those kind of referrals and engagements happen, rather than…internet and email is like the old school putting the leaflet up in the corridor, so people just walk past it. So that's our approach, and that's how it's going to be.

8.3.5.2.6 Feasibility, practicality, and continuation of intervention

The stakeholder reported "high feasibility…I think it's [intervention] the future…the retention and compliance has been excellent" and because of this, the stakeholder stated long-term delivery of the intervention would be included in the future service delivery model of the organisation, even when face-to-face delivery can take place, noting particularly that the online offer enables more through increased geographical reach.

They also noted how interesting it may be when members are invited back into the facility, for example:

There's no commute, there's no worry over parking, no worry about weather, and what it's kind of revealed, and particularly for certain levels, is that you can do this really effectively in the comfort of your own home…

8.3.5.2.7 Challenges

The Stakeholder reported no specific challenges with the 6-week home-based intervention. However, they reported two significant challenges: screening, for example:

The challenges have been screening people and being able to add new recruits to the class, because it's harder to do, and because everybody's kind of gone into hibernation, people just haven't been coming forward for it, so the numbers have slowed down.

And funding, for example:

…we're seeing that with regards to the people who typically support us financially, and then it's hard. We lost huge fundraising opportunities… because we weren't able to deliver those events, and that has an impact.

8.3.5.2.8 Improvements

The Stakeholder reported "increasing touch points" as the main improvement of the program by way of being able to offer more in terms of physical activity and exercise to members after initial engagement in a safe way through the online dimension.

8.3.6 Participant experiences of 6-week virtual home-based exercise intervention.

8.3.6.1 Focus groups

8.3.6.1.1 Participant experiences

By way of introduction, participants initially discussed their thoughts of the group format when they first joined the program initially in the gym. Phrases such as, "like-minded people" (P3), "similar experiences" (P3, P8, P9), "support and encouragement" (P4, P6, P8, P12,), and "motivating" (P5, P7) were commonly reported and when

responding to a 5-point Likert scale indicating the influence the group format had on their weekly attendance, 100% of participants reported this as "very positive".

At the beginning of the focus groups, participants were provided with the 3 aims on the virtual home-based exercise intervention 1) to provide members with a similar service from the Foundation that they were already receiving in the gym-based setting, 2) to keep members exercising and engaging with each other on a weekly basis, and 3) to keep members participating in the service from the safety of their own home during the pandemic. When addressing aim 1, six participants (50%) reported achievement of this aim. When addressing aim 2, three participants reported achievement of this aim and three participants shared agreement about how being together on Zoom is somewhat different to being together in the gym in terms of engagement with each other and offering motivation during exercises, for example:

…everyone's logged on, everyone's ready, everyone does it [intervention] at the same time. It keeps that sense of community. That's the only thing I miss is the thing about motivating each other. It's much harder to do that through Zoom. (P8)

When addressing aim 3, five participants reported achievement of this aim, "yes, 100% safe" (P8) and one of these participants reported safety of the equipment by using things in the home and safety of the environment.

8.3.6.1.2 Intervention evaluation

The principal factors for intervention evaluation discussed in the focus groups are organised into constructed themes and displayed in a pen profile. Themes are divided into four higher order themes, delivery, perceived benefits of intervention, logistics of intervention and expectations of intervention. Within delivery, two sub-themes were constructed including social support and home versus gym. Like that of the themes from the focus groups above exploring PA maintenance, participants shared consensus for the group-based format and supervision of the coach as key factors for the delivery of the intervention.

8.3.6.1.3 Delivery

Delivery was constructed as a theme and included two key sub-themes, social support which included the group-based format and supervision from the coach as factors and home versus gym which included accessibility, and resources and equipment as factors. Structure was constructed as an additional subtheme within the delivery.

Social support: All twelve participants reported the group format as a fundamental part of facilitating their participation throughout the six-week intervention period reporting phrases like, "motivating", "support", "encouragement" and "sense of commonality" (see examples below). Some participants reported the group format keeping them more accountable to participate in the intervention because of the "fear of missing out" (P3) and not wanting to "let someone down like not to be there" (P12).

…It's just a nice refreshing thing [intervention] to come to, and to see our familiar faces, and knowing that we're all doing well still…I think that it still has that…I would feel the same way if I was missing the class at the gym as I would feel missing it from a virtual standpoint…it's like a little family to me. (P12)

…the benefits of the group sessions…I think our group, we give support and encouragement to each other…so that encouragement and support, I think goes a long way, in addition to the actual physical exercises. (P6)

…there's something else that brings joy, really, I think, and a sense of commonality with the group. (P4)

…this is the only time where I've made friends who are in similar situations, and we can share experiences. (P3)

I found it motivating being with others. I tend to find it easier to work out if I'm with other people. I can't seem to motivate myself on my own. (P7)

In addition, one participant reported not being part of the gym-based program initially but appreciated joining the home-based intervention during the pandemic from a social perspective as they wouldn't have been able to interact with other people because of the COVID-19 restrictions.

…I was happy for it to be a group session. I think it motivates your more as well…I've not made any friends going through my treatment, because all my treatment's been during this COVID period…so it's a good way of just checking in with people and interacting with them. (P5)

The supervised delivery of the intervention was reported as a facilitating factor to attend by seven participants. Participants shared consensus and reported how the coach gave them confidence in their abilities during the sessions (see examples below). Additionally, two of these participants reported "we've got confidence in you [coach]" (P3, P6) because the coach was already familiar to them as they had attended the program in the gym-based setting prior to the pandemic.

…you [coach] giving us definitely the confidence that we can do things, and to push ourselves that much harder, which I think is really helpful, and as much as you did it in the gym, you still have the ability to do it on the Zoom class as well, which is great. (P12)

…you do instil that confidence…I see myself as superwoman, because of the confidence that you've instilled…people say to me, "Don't you get tired?" but I seem to have this energy all the time…I feel the more I do, the more energy it creates. (P11)

…having confidence in one's trainer and one's coach goes a long way as well. (P6)

Eight participants reported the coach as an encouraging, fundamental element of the virtual delivery, and four of these participants reported how the coach positively facilitated the transition from a gym- to home-based setting (see example below). Six participants reported factors like "you're very motivating" (P7), "thorough explanations and demonstrations of exercises" (P2, P8), "you're really knowledgeable", and "very, very specific about positioning" (P4) (see examples below). Three participants also reported the attentive nature of the coach by how they would "remember and recall" (P12) if a participant couldn't do a certain exercise because of having to wear a stoma and how the coach would offer alternative exercises to ensure they could still take part in the sessions.

I felt as if the progression was quite seamless, but I think a lot of that was down to your expertise. I think you very much, you explain everything so clearly. You're very, very specific about positioning…It's the way you deliver it

[intervention], and I suppose that's not a difference between, because you'd have done that in the gym as well, but I feel that all the benefit of you actually physically being with us in the gym was translated to this more difficult medium in terms of communication, because you're so very good at the communication and the observation…and of course your huge knowledge of the body and musculature…we're just so very fortunate to be part of the programme. (P4)

I think your [coach] demonstrations are really good, obviously, but you explain it [exercises] really well as well as showing us, and so I don't feel like I've felt any worse than it would be doing it [intervention] face-to-face…I knew exactly what we were supposed to be doing and I felt like if I didn't, or I needed to check that I was doing it right, that I could just ask you like I would in the gym anyway…I really appreciate your coaching. (P8)

It [supervised delivery] was encouraging too. You're very motivating, and you know exactly what you're doing, you're really knowledgeable and you give alternatives if people can't do what you set…you make you feel confident that you can do it. (P7)

<u>*Home Vs. Gym:*</u> Participants frequently compared the home- and gym-based setting reporting factors like the accessibility, resources and equipment and exercise capacity. Three participants reported the accessibility and flexibility of the intervention from home being better than when the sessions were delivered in the gym, reporting factors like "it was more of an effort to get to the gym" (P4). In addition, two participants reported still being able to take part in the intervention even though they were on holiday (see examples below).

…you haven't got that effort of physically getting yourself somewhere…you're there straight away at the touch of a button. (P1)

I just wanted to say something about the accessibility of the programme from home…it was more of an effort to get to the gym, whereas at home, I can just wander in with any old…I know you can't see the dog hairs on my black leggings…and I think it's just easier. You just feel more relaxed…if for some reason we've been away, we would never be able to do the gym, but actually, some of us have managed to make the class even though we're somewhere entirely different. So the flexibility that gives is important. (P4)

I feel like I have to show up, like there's no excuse to not…We went away just for a couple of nights, and I was like, "Well, I can just do the class because it's only forty-five minutes, an hour…I know I'll feel a lot better after I do it. (P12)

Aside to this, one participant reported the negative impact not being able to access all the sessions had on their mental health in relation to cancer recurrence (see example below).

The worry starts coming through that I'm not getting the exercise that I need, and that means the cancer could come back because I'm not doing the proper training that I normally do…when I can't access it, I beat myself up. (P9)

In terms of equipment, two participants reported using items in their home as beneficial, one of these participants stated it was great not having "to go out and buy all this new equipment" (P12) and one of these participants reported feeling quite surprised at what you could do with "your own bodyweight" (P3). Two participants reported having missed the access to and lifting "heavy weights" (P8, P11), but both agreed they found the home-based sessions "quite challenging" (P11) and one was "surprised as to how hard it could be" (P11) from using items in their home. Two participants reported that they felt they had "a really good workout" (P11) and "had really great workouts" (P12) exercising virtually.

…what we do miss is probably the likes of the rower and the treadmill… (P6)

…I'd say I miss the access to the heavy weights, but I always find what you gave us hard, so despite not having a heavy weight, I still found what you set us quite challenging… (P8)

Yes, I was just really surprised at how hard it could be on a home session, using what we've got…I've missed doing stuff like the chin ups or whatever and lifting the heavy weights, but I'd still had a really good workout doing what we've been doing. (P11)

…every time I'd finished, or the next couple of days, I've always felt as if I've exercised. I can definitely tell I've done something, and maybe I would have pushed myself a bit more in a gym setting, but I think I've had really great workouts doing it virtually as well. (P12)

One participant reported feeling "more invested" (P3) using the virtual platform and how the home-based model seemed "more focussed" (P3) in comparison to the gym-based model.

This is my first experience of using Zoom, so I didn't really know what to expect with it…doing it virtual might have felt like, oh you wouldn't be invested in it, but in a way, I think you are more invested…I just think it's been a little bit more focussed. (P3).

Two participants reported how they feel there is "more pressure" (P1) in the gym environment and how sometimes they may push themselves "too far" (P1) than when at home. In contrast, two participants reported, "not pushing myself as hard at home" (P8, P12), and one of these participants reported how they did feel they could do everything at home but in the gym, they would encourage themselves to do more but at home they wouldn't.

…I'm not pushing myself as hard at home, but still feel like I can do stuff…I think had I been in the gym, I would have pushed myself a bit more because of that feeling of oh I can probably do a few more, but then at home I'm like, no, that is enough. Oh like when we had to go up and down the stairs, there were a couple of times when I was like, because I've got the stairs, then a landing and then stairs up, and I was like, I'm just going to stop here, and I think I wouldn't have done that if I was in the gym, but I still felt I could do everything at home. (P12)

Two participants reported less social interaction on the virtual sessions compared to the gym-based sessions due to being muted to control for background noise but one of these participants reported being able to communicate through the WhatsApp group as beneficial from a social factor.

Aah, we're obviously mates. You can have your little chats in the gym, but it's not quite the same on Zoom. That's the only thing you miss, chatting before the class and after. (P7)

One participant reported how vulnerable they would feel at the thought of returning to the gym environment post pandemic but feel "safe at home" (P6) and in terms of exercise regime, feel they cover all the "essentials from mobility to the muscle and strengthening exercises" (P6) at home. In addition, another participant reported that perhaps someone new would "potentially feel more confident doing it at home" (P8) because of feeling comfortable in their own home environment particularly if they hadn't met anyone and perhaps felt nervous about joining an already established group. Three participants reported and agreed how the home-based environment was "more comfortable" (P1, P2, P3) because they felt there was more freedom to stop if needed or "dip in and out" (P3), particularly if having active treatment and felt the need to rest. One of these participants reported a preference for the home-based delivery.

I found it as good. No different, possibly better for me…I think I preferred it, actually (P2)

<u>*Structure:*</u> Four participants were positive with their responses when discussing the 6-week training program, "it was really great" (P11) and "it's just been brilliant" (P12). Two of these participants reported enjoyment of the combination of training style including resistance and aerobic exercises, "the mixture of training is good". One of these participants reported enjoying the changes in the program after 3 weeks whereas another participant reported initially, they felt apprehensive about the change but then liked being "moved out of our comfort zone" (P5) and two of these participants reported liking the progression each week, for example:

I liked it being split into three weeks because sometimes when you know you're coming up to the fourth week, it's like, oh god, this is going to be hard…the mixture of training is good, and the fact that it's [intervention] obviously slightly progressive each week, but also I was genuinely shocked with the wall sit as the measurement. You don't necessarily feel like you're getting better as you go week by week, but to have that measure, and it's like, "Wow!" Obviously we all did, yes, that was really motivating, to know that in just six weeks you can change how you perform something by so much…I thought it was really good. (P8)

…throughout the period, I can't fault any of it. It's just been brilliant, and it's been at the right level. I've enjoyed the change in the programme, and it's given me something to look forward too. (P12)

8.3.6.1.4 Perceived benefits of intervention

When responding to the 5-point Likert scale, all twelve participants agreed that the home-based intervention had a very positive impact on their wellbeing during the pandemic. Seven participants reported how the continuity of the service in a home-based format has helped their overall health and wellbeing during the pandemic with two participants reporting that it brought them a "sense of normality". One of these participants reported how they already felt "singled out" and "isolated" because of their diagnosis by shielding and continuously being told to "be careful" during the period of the pandemic was "mentally, it was very difficult" as they felt they were on the "endangered species list" (P12) but being able to attend the virtual intervention brought them that sense of normality, for example.

I think it continued the momentum of exercising and just helped with the whole wellbeing and mental health through COVID, really…this has definitely helped to bring a sense of normality, really, to the whole thing. (P5)

In addition, another participant expressed their concerns if the sessions had stopped when the gyms closed, for example:

…where would we be without them [the home-based sessions] …if they had stopped, I know I probably would not have undertaken such specific exercise programmes…I think that evaluation of where we are now to where we might have been without them would be quite revealing. (P4)

Four participants reported feeling more motivated to be physically active and engage in regular exercise while taking part in the intervention. One of these participants expressed how the intervention made them feel more capable to be active and another participant reported feeling, "more physically active and able" (P4), for example:

So, without it [intervention], I definitely think I would have just…It would have been much easier to say, "Oh, I can't really be bothered today", but because it [intervention] just kept me focussed, and doing it once a week, I think it was just that thing of it [exercise] always makes you feel better, so when you're at least doing it [exercising] once a week, you think, "Actually, you know what? I need to keep doing this because it makes me feel so much better when I've done it", and if we hadn't had it [intervention], I don't think I'd have motivated myself to keep it up…but I think that if I hadn't done the programme, I probably would have done less. (P8)

I'd say it definitely motivated me…so I made it with my kids, like we have to, rain or shine, we go for at least half an hour walk a day. (P12)

Seven participants reported feeling physically stronger because of the intervention, "definitely feel stronger" (P2, P3). Two of these participants reported improvements in their ability to climb the stairs and noticing how their core strength had improved. Another two participants reported how they had been struggling with joint pain and noticed when they didn't exercise their bodies tended to stiffen up but noticed considerable improvements during the 6-week intervention. Two participants reported being able to carry shopping more easily because they felt stronger. One of these participants also reported feeling better while gardening and being able to do so for longer with another participant reporting positive effects of the intervention on their ability to garden, cycle and walk throughout the week, for example:

I've gained so much more while doing the sessions, and I think uphill cycling, walking uphill and up the stairs, and for myself, I suppose to think, "I can do it", you know, and I think that's been a great benefit… (P4)

Two participants reflected on their journey from joining the program initially in the gym-based setting and how far they have come in terms of physical progress, for example one participant reported:

…when I think about how far I've come from when I started at the Foundation…I'm a million miles away from where I was at the beginning…we go off to the Lakes quite a lot and we climb the fells…I feel the difference when I'm up there [fells], big time. The fact that I can manage it [climbing], and I would never have been able to manage it [climbing] when I first started in the Foundation. I couldn't even go up the stairs without being out of breath. (P9)

More specifically, two participants reported how taking part in the intervention has facilitated their treatment pathway, for example:

I was kind of dreading going through chemo, and I had this sort of vision in my head that I was going to struggle to get upstairs. People say that your breathing starts to go funny and all sorts, and I think the fact that I've been able to come to your classes, it's kind of blown all that out of the water. (P5)

Three participants shared agreement regarding the positive relationship between physical and mental health. Two of these participants reported, "they do go hand in hand" (P2, P3) and one of these participants reported by feeling physically stronger, they feel more positive. The other participant reported how "mental health and fitness just are parallel" (P2) for them. One participant expressed how the intervention helped their physical and mental health during the lockdown period (see examples below).

Improving my physical state, in terms of muscle strength and range of movement, has definitely impacted on my mental health and in terms of energy levels…I have got more energy. (P4)

I found it hard during the first lockdown, just life in general, and like a lack of routine and lack of whatever, and I found that the [intervention] really helped. It's just like every Monday is this [intervention], and this is time for me, and it [intervention] makes me feel better. I always feel better after doing it [intervention], and then I think it [intervention] pushed me to do it [exercise] on other days of the week as well.

8.3.6.1.5 Logistics of intervention

Logistics of the intervention was constructed as a third theme with participants reporting factors including scheduling and advertising. Consensus was shared by the majority (nine) of participants for the convenience of the scheduled day and time of the intervention, each Monday at 10am. Participants reported factors like "it was a great way to start your week". Two participants reported that this was largely because they generally feel more tired of an evening and find it harder to motivate themselves later in the day (see examples below).

…it [intervention] just makes you feel so positive after you've completed it…it just sets you up and you can get on with the rest of your week…Monday's absolutely ideal for myself… (P1)

Yes, the timing was good for me. I generally prefer to do stuff in the morning, I feel like by the time the rest of the day has come and gone, it's much harder to have the energy or motivate yourself in the evening…I liked the fact it was morning, and you kind of got it done. I felt better for the day. (P8)

Participants discussed how they initially found out about the gym-based program. Three participants reported finding out about the gym-based program initially from friends and other patients. Four participants recommended testimonials from current members as a means of advertising and recruitment for the activity program, including the gym-based and home-based models. These participants reported how sharing their own experiences of the intervention could be beneficial for someone who is hesitant about joining and to "give them confidence in joining" (P3), for example,

…in encouraging people, it would be really useful to have examples of people who have really gone through it [intervention] or were using it because that kind of makes it more real for you, and if you're a bit hesitant about whether you'd fit in or how the group progresses, I think it's so useful to talk to someone who's already been through the process. (P4)

…if you hear people say what they're got out of something, you're definitely more likely to take part…actual testimonials from people who've taken part would definitely help. (P8)

One of these participants also reported how she felt the likes of the service should be incorporated into clinical care, especially as her breast care nurse was also aware of it, so that more people can become aware of it and utilise it, for example,

I found out about it [the program] from another patient…when I had my sign-off with the breast care nurse, I mentioned it [the program] to her then to say I was interested, and she said, "Oh yes, I am aware of it", but I think they need to factor that in to that appointment, because you're finished with your treatment, you're getting signed off, you're an absolute shell of your former person, and so it's just a way of saying, "We've got this added support", because sometimes you feel as if the hospital finishes with you, and you're just left high and dry So they'll always being doing a closing sort of interview with you, and a finishing interview, so that's when they should be promoting UTS…if UTS used testimonials from the likes of ourselves who've gone through it, then I

think that would be helpful for people who are not aware of it. That would give them confidence in joining as well… (P3)

In addition, another one of these participants suggested contacting breast clinics to promote the program as her breast care nurse was "really enthusiastic" about the gym-based program when the participant first made them aware of it and "thought it [gym-based program] was wonderful" (P9). In contrast, one of these participants recalled having a conversation with a substitute oncologist about the gym-based program and the negative regard that the oncologist had for the program, for example,

…I was telling this substitute consultant what I was doing at the gym and everything, and about my diet and how I was keeping fit, and he said, "Oh, that won't make any difference. That won't stop it coming back"…I couldn't believe it…I was on a downer for ages after that. (P11).

8.3.6.1.6 Expectations of intervention

Expectations of the intervention was constructed as an additional theme and consensus was shared amongst three participants for the intervention "exceeding expectations" (P4, P6, P11). One participant expressed how they initially had negative expectations prior to taking part in the intervention, however, this changed after completing their first session of the home-based intervention (see examples below).

I think it was far more than I expected it to be. I really think I gained a lot more than I expected in terms of just how motivational it is, and how it has become part of my routine and the benefits of doing it in a group. It was very beneficial when we were in the gym, and you got to know people and chat, but we've almost recreated a lot of those plus factors, even though we're not physically in the same room. (P4)

I was a little bit negative about it at first because I thought…I don't think it's [intervention] going to be that good, but I was really surprised at how well it worked, and I don't think I've ever missed one [a session]. It [intervention] has been the highlight of my week, and because I'm not working and I've got no family, it really has been a godsend to me, this. (P11)

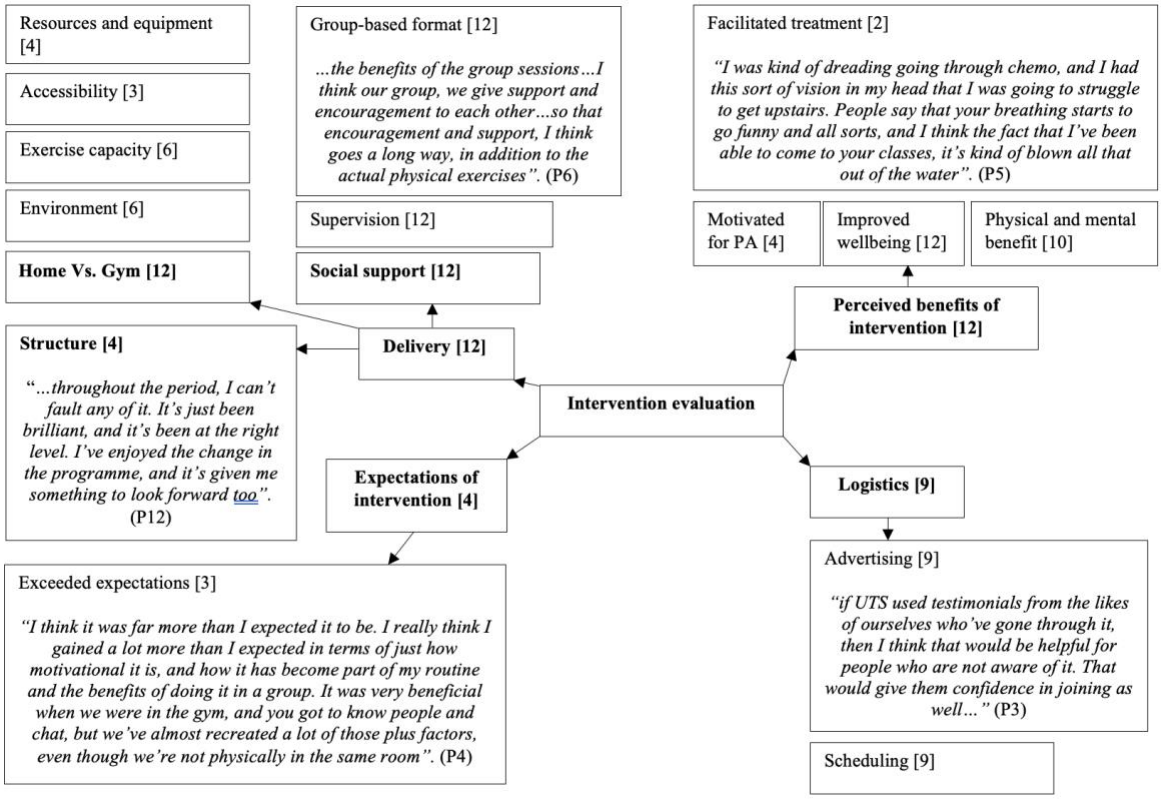

Figure 11 – Pen profile displaying intervention evaluation.

8.4 Discussion

Whilst the benefits of PA and exercise on markers of health and fitness in the cancer population are well-known (Campbell et al., 2019; Lee et al., 2018), the COVID-19 pandemic has highlighted the need for home-based exercise interventions for clinical groups. Based on the RE-AIM framework, the findings from this study support the feasibility of home-based exercise interventions by demonstrating improvements in markers of physical fitness and health-related quality of life in cancer survivors.

The main aim of this current study was to utilise the RE-AIM framework to evaluate the feasibility of a virtual home-based exercise intervention for cancer survivors. The study involved a mixed-methods design and data collection measures were conducted across multiple timepoints. To demonstrate feasibility, effectiveness of the intervention on participant outcomes including, motivation and competence to take part in PA, PA behaviour, quality of life and marker of physical fitness were evaluated. Acceptability and satisfaction were explored through the use of qualitative methods. Additionally, participant experiences of the program and making the transition from a gym-based to home-based setting during the COVID-19 pandemic was retrospectively explored using focus groups. A further two focus groups and stakeholder interview was conducted at 6 months follow up to assess PA behaviour, barriers and facilitators and program continuation.

8.4.1 Reach

The intervention was successful in reaching cancer survivors both during and post treatment and displayed representativeness of the target population in terms of age, diagnosis and treatment pathway when compared with those in similar studies involving cancer survivors [1,237]. Prior to the intervention, participants were already engaging in exercise sessions with the coach who was also the researcher for this study. In a recent systematic review, it was reported that participants choosing to enrol in physical activity interventions tended to already be engaging some physical activity [5]. Initially, face-to-face in a gym-based facility, this was moved to virtual delivery because of the COVID-19 pandemic. This may have facilitated the recruitment process as it provided an opportunity for the researcher to directly engage with survivors and inform them about the intervention [1]. Participants (61%) reported being recruited to the study through these virtual exercise sessions. Given the researcher had been engaging with this group for two years previously, rapport had already been established. Participants were therefore familiar with the researcher which may have also largely facilitated their uptake of the

program as reported by participants, for example, “we know you, then we’ve got confidence in you” (P3) “you were familiar and made me feel extremely comfortable” (P2). A total of thirteen cancer survivors took part in the intervention and these individuals were already engaging in virtual exercise sessions with the coach. The exact reasons as to why more cancer survivors did not enquire or sign up for the intervention are unknown. It is therefore important in future research to focus on understanding why recruitment and uptake levels are low in this population.

Recruitment rates of individuals with cancer to exercise interventions have been previously described as particularly challenging and time-consuming possibly as a result of barriers this population may face such as treatment appointments [253]. The intervention was advertised on the organisation’s social media pages using a recruitment poster which included details of the intervention and inclusion criteria to take part. It was hoped that this method would broaden recruitment outside of the members already engaging with the program to enhance the sample size. However, there was no uptake by other cancer survivors to the program using this method. The stakeholder highlighted how social media has only had “some success” previously when trying to add new members to the program. Four participants reported how testimonials from current members may be beneficial in the recruitment of new members. Participants felt that by sharing their own experiences this may encourage and offer confidence to other survivors. Participants also reported how initially before they became members of the organisations program, they had been made aware of the service by friends or other patients with no direct referral pathway. Therefore, a patient-centered pathway is needed that can guide oncology and primary care professionals in the efficient assessment of an individual’s condition and enable referrals for exercise interventions that promote physical activity [254]. By establishing a referral pathway with local hospitals and support services, the organisation may see an increase in the number of survivors wanting to sign-up to the program. It can also be speculated that the pandemic may have influenced recruitment.

During the stakeholder interview, they highlighted how screening to recruit new members to the program was a significant challenge during the pandemic despite having developed an online referral pathway but with “delays in treatment, less people were coming through to look at rehabilitation” and as a result of isolation, “everybody’s kind of gone into hibernation, people just haven’t been coming forward for it [the program]”. A recent survey conducted by the World Health Organisation found that out of 155 countries, 42% reported disruptions to cancer treatment and 63% reported service disruptions in rehabilitation services which include survivorship care [255].

The emergence of the pandemic has resulted in radical changes in the global healthcare delivery landscape which has seen practical repercussions for cancer survivors including disruption to routine medical care and treatment [255,256]. Essential components of survivorship care have traditionally been heavily dependent on in-person healthcare interactions but as a result of COVID-19, the accessibility for support services has been extremely limited [255]. Furthermore, cancer survivors in the UK were told to shield for several months as they were classed as a high-risk group and more susceptible to the virus [220,227]. As a result of the unavailability of support systems, lack of face-to-face interactions and shielding [255] cancer survivors may have become more isolated during this time which may have negatively influenced their emotional wellbeing and heightened feelings of anxiety and depression [255] and as a result, this may have caused them to engage less with virtual services that were on offer.

8.4.2 Effectiveness

For home-based exercise interventions to have a public health impact in this population, they must be effective. The effectiveness of the home-based intervention was explored by examining changes in perceptions of physical activity behaviour (PES), quality of life (SF-36), motivation to exercise, (BREQ-3) competence to be physically active (PCS), markers of fitness (wall squat) and perceived acceptability and satisfaction of the program (PES). Qualitative data from the focus group discussions around participant experiences of the intervention also offer illustration for the above measures.

The home-based intervention was an effective approach to increase PA levels in cancer survivors, Participants (77%) reported how the intervention helped them to increase their current PA levels. Therefore, the intervention positively influenced behaviour change, and this is important from a health perspective for this population, as for the sustainability of long-term health and well-being benefits achieved from exercise interventions, cancer survivors must be habitually active [5]. Although there were no statistically significant improvements in motivation dimensions, participants frequently reported how the intervention motivated them to engage in more physical activity and exercise. Furthermore, although no statistically significant improvements in perceived competence scores were found, three participants' scores improved from baseline to post 6-week intervention. Participants (2) scores improved from 6 to 7 and from 4 to 5 (1). An important consideration is that participants were already engaging in PA prior to the intervention. The mechanisms of behaviour change may therefore vary for those who are engaging in no PA to those who are already active to some extent and alternative intervention

methods may be required when targeting the more inactive and sedentary cancer survivors [5] which may possibly make up a large proportion of this population as estimates suggest that anywhere from 50% to 80% of cancer survivors do not meet physical activity guidelines [257]. These figures may have been further exacerbated by the lockdown periods and advice to shield during the pandemic [220]. Therefore, more remote access models are needed [70].

As an additional indicator of effectiveness, participants reported high levels of acceptability and program satisfaction when responding to a series of open-ended questions in the self-report PES. Participants (100%) reported the intervention as appropriate, 100% reported that they would recommend the intervention to cancer survivors, 92% reported enjoying the intervention, 100% reported looking forward to the intervention each week, 100% reported the coach and group format having a positive impact on their participation and 92% reported no additional stress caused by the intervention. Similar findings have been reported by a recent mixed-methods study assessing the feasibility and acceptability of an 8-week remote rehabilitation and exercise program for cancer survivors [231]. Data from semi-structured interviews demonstrated high levels of acceptability for the program. Participants highlighted health coaching calls as a valuable program component that encouraged accountability and provided an appreciated human touch element and support. The findings from this study are similar to this home-based intervention as participants reported how the supervised delivery, group-based nature and coach interaction encouraged accountability and was, for example, “the highlight of their week” (P11). Based on these findings, future remote studies may consider including an exercise professional in the delivery of such interventions [258].

Statistically significant improvements were seen in mental health scores from baseline to post 6-week intervention (75 ± 12 to 84 ± 7). Participants (85%) also reported feeling mentally stronger in the PES. In contrast to our finding, a recent study found no statistically significant intervention effects on QoL despite changes in exercise behaviour [259]. This is a common finding amongst unsupervised/home-based exercise interventions that produce significant improvements in self-reported exercise behaviour, similar to this study, with limited changes in patient-reported outcomes [260–264]. Conversely, supervised exercise interventions have demonstrated significant improvements in patient-reported outcomes across similar time frames [189]. The superior benefits of supervised exercise compared to home-based exercise are suggested to be as a result of more demanding exercise prescriptions, exercise progression, better adherence and social interaction with the coach/trainer and study

participants [189,265]. The reason why our findings seem to mirror supervised findings may possibly be because the exercise training intervention consisted of a fully structured, progressively overloaded training program and incorporated both aerobic and resistance exercises. This facilitated a weekly progressive pathway for participants and progression was also demonstrated by statistically significant improvements in physical fitness scores from baseline to post 6-week intervention (118 ± 68s to 264 ± 174s). 85% of participants also reported feeling physically stronger in the PES. Increased muscle strength and endurance has also been reported in previous remote intervention studies [124]. Participants (7) also reported this during the focus groups highlighting how seeing such improvements after 6 weeks of training could markedly improve their physical performance as encouraging factors to maintain exercise and PA. Adherence across the 6-week period was above 65% each week, with 4 out of the 6 sessions demonstrating a 69% adherence rate. The exercise sessions were group-based which allowed for engagement amongst participants and each session was supervised and delivered by the coach providing high levels of social interaction. The group-based nature and presence of a coach were both reported as two key components of the exercise intervention to facilitate adherence. Therefore, these findings may have been largely influenced by these elements included in the intervention structure and design.

8.4.3 Adoption

Exercise interventions are being increasingly recognised as an important part of the cancer care pathway due the beneficial effects exercise has on many physiological and psychological factors in this population [266]. However, despite this, uptake of PA programs and exercise interventions are low [133] and this is suggested to be due to several barriers cancer survivors face for participation in PA and exercise [70]. Perhaps exercise interventions need active implementation strategies that successfully deal with the barriers and facilitators this population experiences [133,267]. In this study, work commitments (23%), family commitments (8%) and hospital appointments and tiredness because of treatment (8%) were reported by participants as barriers in the PES. Participants (15%) highlighted accessibility as a positive element of the intervention when on holiday and still being able to take part whereas this would have previously been a barrier for their participation. Accessibility has previously been reported as a common barrier for participation in exercise interventions in this population [70,124,231,258]. During the additional focus groups, participants (25%) reported accessibility as a positive element of the intervention in comparison to when the service was delivered in the gym, and they physically had to get themselves to the facility. In a previous intervention study, commuting to the facility was reported as a significant reason for non-participation by participants (71%) [268]. As demonstrated by this study and previous

research, home-based exercise interventions have the potential to overcome such barriers [70,231,258] which may facilitate uptake to exercise interventions and improve the number of cancer survivors participating in PA and exercise.

When assessing adherence, two key themes emerged: the presence of the coach and group format. Adherence was more than 65% each week, with 4 out of the 6 sessions demonstrating a 69% adherence rate. For home-based intervention studies, an additional challenge beyond exercise adherence in participants is the measurement of adherence in the absence of supervisory researcher staff to observe participants as they complete their exercise training [269]. In this study, the coach/PhD researcher, was present at each session to measure adherence and furthermore, as regards to Adoption at the organisational level all 6 exercise sessions were also conducted as planned. Participants (46%) reported the coach as a key facilitator for adherence. Given the findings from this study regarding the impact of including an exercise professional in intervention delivery and as supported by previous research [70], future remote studies may benefit from including this component. Findings from the PES revealed that participants (54%) reported the group as a key facilitator for attendance. Participants (92%) reported how the group-based nature of the intervention was a key facilitator for their adherence when exploring participant experiences during the additional focus groups due to the social interaction and friendships developed and having shared similar experiences as cancer survivors. Similar findings have been reported by a previous qualitative study whereby participants reported engagement with those of similar circumstances and being able to share experiences as a key facilitator for participation in PA programs [133]. Group-based interventions have also been shown to create fun, motivational and supportive environments [1] by the social support from other participants [270]. As a result of the influence the coach and group format had on participants' adherence, these findings emphasise the need for future home-based interventions to ensure positive dynamics are established amongst the coach and group.

8.4.4 Implementation

Similar to the barriers reported for Adoption at the individual level, treatment side-effects, hospital appointments/phone calls, holidays, work commitments and not being able to access Zoom were provided as reasons for participants being unable to attend a session. However, as previously stated, attendance each week was more than half of the participants (65%) therefore supporting the feasibility of home-based exercise interventions in overcoming barriers faced and reasons for non-engagement by this population [70,258].

At the organisational level, the home-based intervention was designed to provide a similar a service as possible to when participants attended the gym-based programme. The exercise sessions were scheduled at the same time each week, the same as when they were initially delivered in the gym. Participants (75%) reported how convenient this was and that it "sets you up for the week" (P1). The exercise training programme consisted largely of resistance training as this was the style of training participants were already engaging with in the gym setting. Like the gym-based delivery, thorough demonstrations, explanations of exercises, regression and progression exercises were provided, and alternative exercises were also provided for a participant wearing a stoma or those who had PICC lines fitted. This allowed participants to remain engaged throughout the session. Participants (27%) reported in the additional focus groups feeling more comfortable exercising at home as they could take the session at their own pace which was important for those in active treatment It has been previously highlighted that for home-based interventions to ensure participation and high attendance, in terms of delivery, adaptations of training contents to individual needs and the training frequency and duration to the current performance and preferences of the individual, independent of recommendations or training programme [221]. The stakeholder reported how well the home-based intervention incorporated the "core components" of the original gym-based programme for improving the fundamentals of aerobic capacity and strength in this population. Although this study did not include a measure of aerobic capacity, the exercise sessions consisted of some aerobic style exercises and participants were encouraged to increase their step count outside of the weekly exercise sessions. The stakeholder also reported the coach's ability to deliver the intervention virtually encompassing the above, as a valued asset of the design. Participants also reported the coach as a fundamental component of the intervention delivery transition from a gym-based to home-based setting to exercise in the additional focus groups. The presence of an exercise professional has also been previously recognised as an important component of intervention delivery [221]. The coach/PhD researcher was qualified at Level 4 Cancer Rehabilitation and had been working with participants for two years previously to the home-based intervention.

8.4.5 Maintenance

Current evidence suggests that PA and exercise are beneficial for improving many negative consequences such as changes in strength and body composition, reduced physical function, debilitating fatigue and quality of life [271], reported by adults diagnosed with cancer [5]. PA increases physical functioning among cancer saviours and provides physiological and psychological benefits [266]. Therefore, it is recommended that cancer survivors should become or stay physically active as soon as possible following diagnosis [7]. PA maintenance is important for sustaining such health benefits achieved from engaging in exercise interventions [5]. Participants (45%) reported increased PA levels over this past 6 months after taking part in the intervention and participants (55%) reported the physical benefits as facilitating factors to maintain PA. Participants (62%) were still currently engaging with the home-based intervention as it has continued as a means of service delivery due to COVID. Findings from this study revealed not letting the group or coach down facilitated PA maintenance as well as participant retention during the program. Participants (64%) reported the group-based nature as a key factor for still attending the program 6 months post intervention. Group-based interventions have been highlighted as an effective way to encourage cancer survivors to maintain PA and exercise [1] possibly as a result of the social support they offer [270]. Interestingly, participants (36%) reported enjoying resistance training during the intervention and learning about the importance of such exercise, they now continue to do it on a regular basis. Resistance training has been widely used to reduce the effects of aging and chronic disease [188]. It is now becoming a focal point in cancer patients during and after treatment because of the many health benefits it offers including, increased muscle strength, endurance and bone mass, enhanced ability to perform activities of daily living and improved cardiovascular health and self-esteem therefore overall improving quality of life [188,271,272]. In terms of barriers to maintaining PA, participants (27%) reported family commitments, work (27%) and treatment (18%) were reported.

From an organisational point of view, the stakeholder highlighted how the intervention has had “high feasibility” with excellent retention and compliance rates. They noted the accessibility of the intervention by “no commute”, “no worry over parking” and “no worry over weather”. Accessibility has previously been reported as a barrier for engagement with interventions in this population and home-based interventions have been recognised to overcome such barriers and improve engagement [70]. The stakeholder reported how the initial plan was to grow the service from a strategic point of view and despite how COVID “changed everything”, they were still able to do this and

praised the coach for making the transition from a gym to home-based setting such a "success". As a result of this, they reported that the intervention would continue over the long-term, especially as it incorporated the "core components" that the gym-based service offered. Organisations that offer a home-based element as part of their service delivery may therefore see an increase in uptake and adherence by this population.

8.5 Strengths and limitations

This study was purely home-based whereas many studies in this field investigate or evaluate multicomponent interventions, therefore findings from this study add to a unique area of research. A major strength of this study was the accessibility of the PhD researcher who was also the activity program coach. They communicated directly with participants and can therefore be highlighted as a beneficial factor for the effective implementation of the program. Focus groups were a practical and cost-effective method, especially as participants were already engaging in group-based activity. More specifically, methodological strengths included a mixed-methods design including both quantitative and qualitative measures at multiple time points throughout the data collection process, the exploration of consensus and associated discussion through the focus groups and thematic interpretation of the data which allowed individual insight into participants experiences of the program and the transition from a gym to home-based environment for exercise. All focus groups were led by the same PhD researcher who ensured the quality of the group discussions, an asset of this study, as well as each measure used to address each dimension of the RE-AIM framework. The PhD researcher has worked alongside the stakeholder for several years, therefore similar to the focus groups, the working relationship already established here may have facilitated the interview discussion. There were no adverse events reported during the 6-week intervention period, therefore the intervention can be regarded as safe. Follow-up measures were conducted 6 months post intervention whereas previous studies exploring maintenance of outcomes from physical activity interventions in cancer survivors only assessed outcomes at least 3 months post intervention [5].

Certain limitations can be presented from this study, the first being the small sample size. However, similar findings to this study regarding feasibility and acceptability have been previously documented in a previous study of seven lung cancer patients (Hoffman et al., 2013), with these authors highlighting such findings warranting further investigation in a larger RCT population. Participants had a variety of cancer types and were either having active treatment or post-treatment and one out of the thirteen participants was male, the rest female. Experiences may differ from that of males to females, therefore results may not be generalizable to males or other cancer

survivors at different stages of diagnosis or treatment, specifically pre-treatment. Participants were already engaging in an activity program therefore, there is potential for sampling bias and findings may not be generalizable to inactive cancer survivors. Although participants reported changes in their PA behaviour, PA was not objectively measured due to the practicalities with the COVID-19 pandemic therefore, future studies should aim to objectively assess PA to examine any actual changes in PA behaviours overtime.

8.6 Conclusion

This feasibility study has a provided a significant insight into whether a home-based exercise intervention would be feasible for cancer survivors with a variety of different cancer types. Findings from this study will add to the novel, growing body of literature of home-based PA and exercise interventions for cancer survivors, particularly during the COVID-19 pandemic. Although the pandemic has altered the face of survivorship care, it is important to note that it has led to innovations in healthcare and support services delivery for this population. The process evaluation framework was useful to guide the researcher through the areas necessary to address the feasibility and acceptability of the home-based intervention.

8.7 Future directions and recommendations

Learning that the intervention was highly acceptable and that specifically participants having active treatment adhered to the exercise intervention provides important data to justify that this intervention may be feasible when applied to a larger RCT population. Although the home-based intervention was conducted over six weeks as part of the research process for this study, the program has continued and is currently being delivered in the same format via Zoom. During the six-month follow-up data collection period, it was established that 62% of participants are still attending the program each week. The participants' commitment to participate over this past six-months provides further data justifying that this intervention study is worthy of extension to a larger RCT population.

THESIS STUDY MAP

Study	**Aims and key findings**	**Philosophical positioning (Crotty model chapter 4)**
Study 1: Exploring barriers, facilitators and reinforcing factors for PA participation amongst cancer survivors	**Aims:** 1. To explore perceptions of general PA, 2. To identify barriers and facilitators for group-based PA participation, 3. To provide formative information to inform the design of group-based PA/exercise interventions. **Key findings:** • Tiredness/fatigue, family and friends, and gym environment were frequently reported barriers. • Group-based activity was frequently reported as a key facilitator for PA participation. • Other frequently reported facilitators were the perceived physiological and psychological benefits of PA. • Facilitators of group-based activity were the activity program being perceived as a 'safe place' and the cost-free nature of the activity program.	**Epistemology = constructivist paradigm** **Theoretical perspective = constructivist approach** **Methodology = qualitative** **Methods = focus groups**
Study 2: Utilising RE-AIM to evaluate the feasibility of a virtual home-based exercise intervention during the COVID-19 pandemic	**Aims:** 1. To evaluate intervention feasibility by exploring acceptability and satisfaction of a virtual home-based exercise intervention, 2. To explore the effectiveness of the intervention on a variety of participant outcomes including motivation and competence to take part in PA, PA behaviour, quality of life and physical fitness using a mixed-methods approach,	**Epistemology = Pragmatism paradigm** **Theoretical perspective = pragmatic and constructivist approach** **Methodology = mixed-methods**

	3. To retrospectively explore participant experiences moving from a gym-based to home-based setting during the global COVID-19 pandemic using focus groups. **Key findings:** • Significant improvements in mental health dimension of SF-36 from baseline to post-intervention. • Significant improvements in physical fitness (wall squat duration) from baseline to post-intervention. • High levels of acceptability and satisfaction for the intervention. • Group-based format of intervention and coach were reported as key facilitating factors for adherence to intervention. • Stakeholder recognised coach as fundamental component of intervention's success. • At 6-month follow-up, intervention was still being delivered and over half of the participants were still attending.	**Methods = combination of quantitative and qualitative methods including, questionnaires, surveys, fitness test, focus groups, interviews**
Study 3: Home-based PA and exercise interventions in cancer survivors: a systematic review	**Aims:** 1. To conduct a systematic review of peer-reviewed evidence to explore the effects of home-based PA and exercise interventions on outcomes PA, PF, and QoL in cancer survivors.	**Epistemology = Positivist paradigm** **Theoretical perspective = positivism** **Methodology = experimental research (review of)** **Methods = statistics (within each study reviewed)**

Study 2 evaluated the feasibility and effectiveness of a virtual home-based exercise intervention on outcomes including PA, PF and QoL. To broaden our perspective of remote/home-based interventions and their effects on these outcomes, a critical review of the literature was conducted in this area. Although an empirical chapter adopting a positivist approach was never intended, this chapter developed as a direct result of the circumstances associated with the COVID-19 pandemic and has largely contributed to the overall development and findings in this thesis.

9. STUDY 3 – HOME-BASED PA AND EXERCISE INTERVENTIONS IN CANCER SURVIVORS: A SYSTEMATIC REVIEW.

9.1 Introduction

In England, the incidence of cancer diagnoses increased from 309,453 new cases in 2017 to 320, 395 new cases in 2018, and the total prevalence was 1,953,645 [69]. Worldwide, an estimated 19.3 million new cases and almost 10.0 million cancer deaths occurred in 2020, and the global cancer burden is expected to be 28.4 million cases by 2040, almost 50% higher than in 2020 [70,71]. Diagnosis and treatments associated with cancer present survivors with a number of long-term health challenges such as persistent symptoms of fatigue and decreased physical function, and the burden of these conditions can negatively impact survivors health-related quality of life (HRQoL) [111,273]. The importance of supportive care and rehabilitation services such as exercise interventions has been increasingly recognised as a crucial part of the cancer care pathway to improve the quality of life (QoL) of survivors [83,111,274]. The World Health Organisation defines QoL as an individual's perception of their position in life in the context of the culture and value systems in which they live, and in relation to their goals, expectations, standards, and concerns [275]. Historically, survivors were advised to rest and avoid physical activity (PA). However PA and exercise are now recognised to play a key role in improving cancer-related health outcomes including fatigue, physical function, anxiety and depressive symptoms and overall quality of life [100,111].

PA is defined as any bodily movement produced by contraction of skeletal muscle that substantially increases energy expenditure, this includes leisure-time PA, occupational PA, and exercise. Physical fitness is defined as a set of attributes (i.e. cardiorespiratory endurance, skeletal muscle endurance, skeletal muscle strength, skeletal muscle power, flexibility, agility, balance, reaction time, and body composition) that people have or achieve that relate to the ability to perform PA [107]. A variety of device-based and self-reported methods are reported in the literature for the assessment of PA in adult cancer survivors, however, inconsistencies in measurement tools, outcome measures reported, and study design utilised limit our understanding of PA behaviour and its health associations in this unique population. Data from the United Kingdom (UK) indicated that 31% of survivors are completely inactive [111]. These low levels of PA and high levels of sedentary behaviour (SB) are consistently reported in the literature [125,137].

To increase engagement in PA in cancer survivors, evidence-based guidelines recommend the implementation of PA programs and exercise interventions to increase the number of survivors participating in PA across the cancer care continuum [133]. However, uptake to PA programs and exercise interventions is low [125,133]. This poor uptake may be because of certain barriers cancer survivors face such as accessibility as many programs/interventions are conducted at supervised facilities that require travel time and cost [70,133,276]. Home-based PA and exercise interventions may be more accessible and affordable for this population [70,277] and may offer a more convenient way for survivors to engage in PA. In addition, considering the recent COVID-19 pandemic, alternative remote access models and their variations are strongly supported [70].

A systematic review of home-based exercise interventions has been previously published [70]. However, the authors only included nine randomised controlled trials (RCT's) of home-based aerobic and resistance exercise interventions up to January 2021. Systematic reviews offer the benefit of collating evidence from a variety of sources and attempt to bring together all available evidence on a specific, clearly defined topic [278]. Limiting reviews to only include RCT's may exclude a wealth of key evidence that did not employ a traditional RCT design. The present review identified relevant home-based PA and exercise intervention studies with a variety of study designs up to August 2021. The purpose of this review was to explore the effect of home-based PA and exercise interventions on PA, physical fitness (PF), and quality of life (QoL) in cancer survivors.

9.2 Materials and Methods

The Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) guidelines were utilised to inform the review process [2]. Studies that assessed PA in adult cancer survivors and were published from database inception to August 2021 were identified. An a priori defined protocol was utilised to identify relevant articles that were then systematically screened against inclusion and exclusion criteria. The published protocol can be accessed via the PROSPERO database (CRD42020214759). A narrative synthesis was performed to provide a summary of the outcomes reported and an assessment of the quality of evidence was made to support the strength of the findings and conclusions made. It was not possible to conduct a meta-analysis due to the wide variation in the methods used to assess PA, the inconsistency of outcome measures reported and the low-quality ratings of the available literature.

9.2.1 Search Strategy

The Web of Science, SCOPUS, PubMed, EBSCOhost and PsycInfo databases were searched for this review. Boolean and MESH terms, modified for each database were searched from the databases date of inception to August 2021. The following search terms were used: ("Physical Activity OR "Exercise" OR "Intervention" OR "Programme") AND ("Home-based" OR "Remote" OR "Telehealth") AND ("Quality of life" OR "Health-related Quality of life") AND ("Cancer" OR "Oncology"). To ensure a thorough identification of the relevant literature, a librarian with expertise in the area of systematic reviews in defining search terms, search strategies, and databases was consulted in the early stages of the review process, as per recommended guidelines [278]. Title and abstract screening then commenced to identify relevant articles and remove articles that were not eligible. No restrictions were applied to the date of publication, owing to the limited number of studies in a relatively novel field. A total of 76 potential studies were identified and duplicates were removed, leaving 62 full-text studies which were screened against inclusion and exclusion criteria resulting in 28 studies being assessed for eligibility, leaving 14 studies for data extraction (Figure 1). Hand screening of refence lists was conducted and systematic reviews and meta-analyses were excluded from the review. The remaining full texts of the selected 14 studies were further evaluated by two independent reviewers and disagreement were resolved through discussion with a third reviewer consulted were necessary.

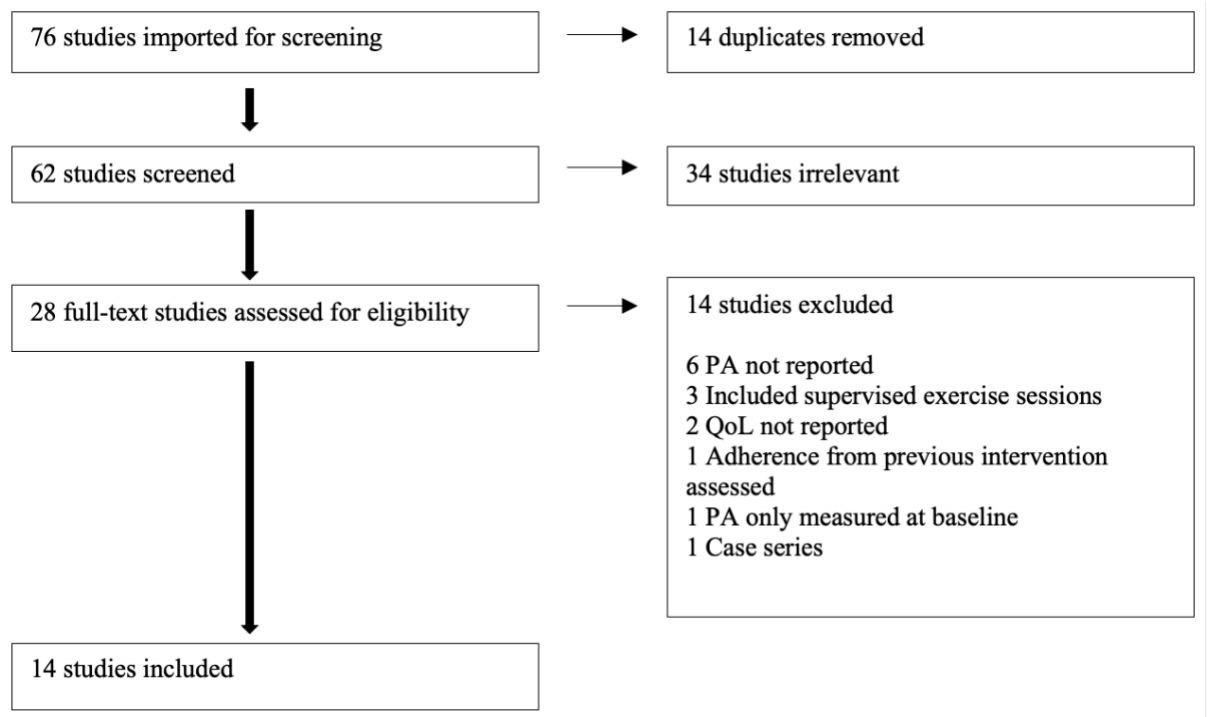

Figure 12 - PRISMA flowchart.

9.2.2 Application of eligibility criteria

Inclusion criteria included: adults (≥18 years) with a diagnosis of any type of cancer, undergoing active treatment or post-treatment for cancer, home-based intervention including a PA or exercise component, reporting baseline and post-intervention outcomes including measures of PA, physical fitness and QoL. Exclusion criteria included: paediatrics (<18 years) or combined adult and paediatric populations where data were not reported separately, pre-treatment, home-based interventions without a PA or exercise component, post-intervention outcomes not reported. Additionally, studies not written in English, providing no original data that were not peer reviewed were also excluded. No restrictions were applied for study design and randomized controlled trials, interventional and observational studies were considered based on satisfaction of the inclusion/exclusion criteria outlined above. Additionally, for the 14 studies that were excluded before data extraction, reasons are listed in Figure 1.

9.2.3 Data extraction and assessment of the evidence

A modified version of the 'Cochrane Data Extraction Form', from the Cochrane Handbook for Systematic Reviews of Interventions was used [279]. The form was modified to include relevant participant characteristics and outcome measures. A researcher (MH) independently extracted the data, assisted by a second reviewer (ED) where necessary, discrepancies were resolved through discussion and when needed, with a third reviewer (LB). Extracted information included: author, year of publication, study design, participant characteristics, intervention description, study methods, outcomes, times of measurements, and information for assessment of the risk of bias. Two researchers, (MH) and (ED) independently assessed the risk of bias for the included studies using the Cochrane Risk of Bias tool and a third reviewer (LB) was available to reach agreement for scoring conflicts. Risk of bias was described as 'low', 'high' or 'some concerns'.

9.3 Results

Data extraction consisted of retrieving data for each outcome from the journal article and or supplementary material. Of the fourteen studies included in this review, three studies included participants post-treatment and the remaining eleven studies included participants who were during treatment. A detailed overview of the fourteen studies included in this systematic review, including information on stages of treatment, is provided in Table 11. The influence treatment periods may have had on outcomes reported in this review are discussed in the discussion section of this study. The description of the intervention has been populated with content directly from the journal article given the wide variety of intervention descriptions across the fourteen studies. Figure 2 presents the risk

of bias assessment of studies included in this review. Overall, most studies were judged as ‘high risk’ due to the variability in reporting of measures and outcomes reported.

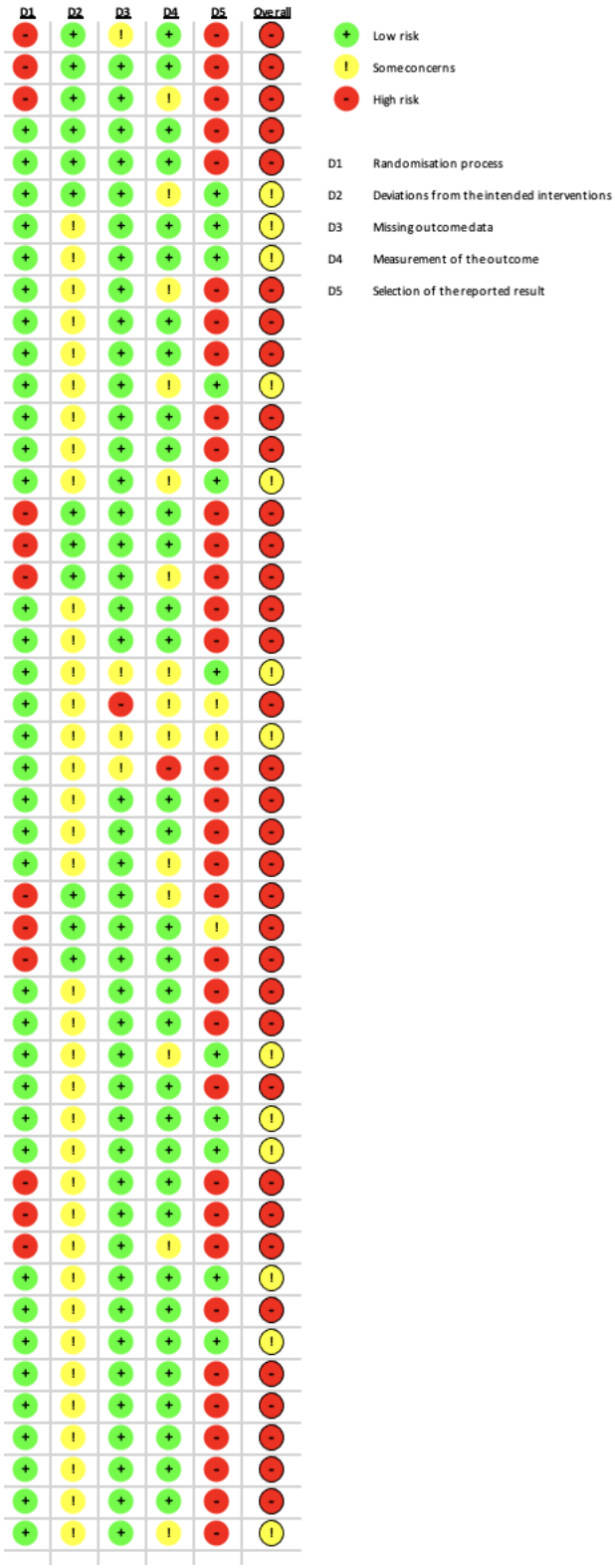

Figure 13 - Risk of bias assessment of included studies.

9.3.1 Interventions

The home-based PA and exercise interventions varied across the fourteen studies included (see Table 1). The intervention duration ranged from 8 to 52 weeks and all studies used different forms of remote monitoring throughout the intervention period such as phone calls, emails, and exercise/diary logs. Seven studies provided weekly phone calls generally to monitor PA/exercise participation, review exercise programmes, provide symptom management support, encourage adherence, and identify any barriers and facilitators to the interventions [163,262,263,280–283]. The frequency, modality, intensity, duration, and prescribing of the interventions varied across studies as reported in Table 1. Eight studies conducted aerobic interventions, with walking predominately prescribed, alongside cycling and swimming [163,164,262,263,283–285], another study prescribed high-intensity interval training (HIIT) [286]. One study conducted a resistance training intervention designed to stimulate all major muscle groups using adjustable dumbbells or bodyweight loading with three stages of exercises that were progressed and adapted to the needs of the cohort. Supervised sessions were also provided to participants every 12 weeks to demonstrate the next stage of exercises and to ensure proper techniques were being utilised at home [162]. Five studies conducted combined aerobic and resistance training interventions [276,280–282,287]. Like that of the solely aerobic interventions, walking was predominantly prescribed as the aerobic component [280–282] in the combined interventions. Resistance exercises varied across the combined interventions and included; lower limb functional exercises including sit to stand, squats, press-ups, heel raises and a wall press [281], total body exercises targeting 5 muscle groups including abdominal, hamstrings, quadriceps, triceps, and gluteus maximus [280], and upper body exercises including lateral and front raises, wall or modified floor push-ups, chest press, bent over row, arm curls and triceps stretches; lower body exercises including, chair squats, chair leg raises, hamstring curls and calf raises; and core exercises including, bridge, crunches, reverse crunches, and obliques [282]. Two studies did not provide any specific details for aerobic and resistance exercise components of their interventions [276,287].

9.3.2 Assessments of physical activity

Twelve studies used self-reported measures including Seven-day Physical Activity Recall (7-day PAR) [263], Community Healthy Activities Model Program for Seniors (CHAMPS) [263], computer iPAQ [163], International Physical Activity Questionnaire (IPAQ) [280–283], Leisure Score Index (LSI) [262,285], Godin Leisure-Time Exercise Questionnaire (GLTEQ) [276,287], Global Physical Activity Questionnaire (GPAQ) [286], and diaries

[162,163]. Seven studies used device-based measures including ActiGraph GT1M [163], Sense Wear Armband (SWA) [281], ActiGraph GT3X [284,287], activPAL 3 [164], Actical [282], a pedometer, G-sensor [162]. Five studies used a combination of both self-report and device-based measures [162,163,281,282,287].

9.3.4 Self-report-based measures

Two studies out of twelve [263,282] reported significant increases in PA in intervention groups, one of which reported a significant increase in PA in the control group post intervention and further reported an increase in PA at follow-up in the intervention group [263]. Another study reported a significant decrease in domestic PA and sitting time, however, no change in total PA [283]. Three studies [262,263,285] reported significant group differences in PA post-intervention, however, one study added that group differences attenuated at follow-up [263]. No significant changes in PA were reported in five studies [276,280,281,286,287], however, one of which reported that the intervention group doubled its total PA but did not describe a statistical significance in this context [280], and another reported a non-significant increase of 8.5 points post-intervention and 15.2 points on the GLTEQ score at follow-up in the intervention group [276].

9.3.5 Device-based measures

Three out of the seven studies that used device-based measures [164,282,284] reported significant increases in PA. One of which also reported a significant decrease in SB (lower-intensity group) in the intervention groups post-intervention and further reported a significant increase in PA at follow-up in the lower intensity intervention group [284]. Four studies reported significant group differences in PA [162,164,284,287] between intervention and control groups post-intervention, one of which also reported a significant group difference in SB between the intervention (lower-intensity group) and control group [284]. No significant changes were reported in one study [281].

One study used a combination of device-based and self-report measures to provide an overall value of minutes of exercise and reported significant increases in PA in both intervention groups (obese and non-obese) from baseline to post-intervention [163].

Table 8- Physical activity variables including device-based and self-report measures. Significant increases are represented by ↑ and significant decreases are represented by ↓ . Significant group differences are represented by $.

Author	Experimental Groups	Measure	Group	Baseline	Post-intervention	Follow-up
[1]Pinto (2013)	PA and control group	Questionnaire (PAR-min/week)	Intervention	38±72	$↑223±204	↑149±210
			Control	29±32	↑98±88	87±103
		Questionnaire (CHAMPS-cals/week)	Intervention	1423±1655	↑2713±2205	1767±1927
			Control	1113±1590	1240±1328	1370±1942
[2]Basen-Engquist (2014)	Obese and non-obese group	Computer (iPAQ), Accelerometer (ActiGraph GT1M and Diary (combined all 3)-minutes of exercise/day)	Intervention (obese)	13.64±12.48	↑15.88±10.64	-
			Intervention (non-obese)	16.35±9.90	↑19.80±10.14	-
[3]Edbrooke (2019)	Intervention and usual care group	Accelerometer (SWA-MVPA min/day and steps/day)	Intervention	45.3 (24.8-76.6) 2859.6 (2034.0-3849.2)	-3.17 (14.32) -254.55 (602.31)	-7.30 (15.95) 361.02 (643.64)
			Control	69.6 (31.7-123.6) 3195.2 (2161.3-4839.0)	-9.39 (16.44) -429.04 (593.82)	16.08 (22.27) -212.96 (634.55)
		Questionnaire (IPAQ-total MET min/week)	Intervention	294.5 (99.0-594.0)	334.26 (294.90)	471.30 (444.49)
			Control	235.5 (0.0-834.0)	651.85 (421.74)	38.05 (579.56)
	APA and control group	Questionnaire (IPAQ-MET-min/week)	Intervention	1400,00~	2700,00~	2900,00~

[1] Post-intervention is 3 months and follow-up are 12 months.
[2] Post-intervention is 6 months.
[3] Post-intervention is 9 weeks and follow-up are 6 months.

[4]Cornette (2016)			Control	1400,00~	1800,00~	1600,00~
[5]McNeil (2019)	Lower-intensity PA, higher-intensity PA and control group	Accelerometer (ActiGraph GT3X+-Total PA time, MVPA, LPA, SB mins/day)	Intervention (lower intensity)	360±90	↑414±90 (n=15)	372±84 (n=14)
				102±42	$↑138±36 (n=15)	↑120±48 (n=14)
				258±66	↑276±72 (n=15)	252±60 (n=14)
				600±90	$ ↓534±72 (n=15)	576±66 (n=14)
			Intervention (higher intensity)	318±102	↑360±78 (n=14)	348±84 (n=12)
				90±42	↑114±48 (n=14)	108±36 (n=12)
				222±72	246±54 (n=14)	240±60 (n=12)
				576±102	576±84 (n=14)	576±108 (n=12)
			Control	318±108	348±96 (n=13)	318±96 (n=12)
				84±60	96±48 (n=13)	84±54 (n=12)
				234±66	246±66 (n=13)	234±66 (n=12)
				576±78	594±96 (n=13)	564±60 (n=12)
[6]Courneya (2003)	Exercise and control group	Questionnaire (LSI-total exercise min/week)	Intervention	212.90±248.04	193.52±146.36	-
			Control	260.65±323.77	180.12±185.82	-

[4] Post-intervention is 27 weeks and follow-up are 54 weeks.
[5] Post-intervention is 12 weeks and follow-up are 24 weeks.
[6] Post-intervention is 16 weeks.

		%>60 min moderate/strenuous exercise	Intervention	40.3	$75.8	-
			Control	41.9	51.6	-
[7]Blair (2021)	Tech support, tech support plus health coaching and waitlist control group	Accelerometer (activPAL3-steps per 15 hour awake, MPA minutes per 15 hours awake, MPA (guideline bouts) minutes per 15 hours awake and sedentary, minutes per 15 hours awake)	Intervention (tech support)	6686 (5166 to 8206)	7339 (5594 to 9085)	-
				53.2 (40.2 to 66.1)	59.5 (44.5 to 74.6)	-
				5.8 (-3.2 to 14.8)	13.0 (2.2 to 23.8)	-
				598.5 (550.1 to 646.9)	604.6 (549.1 to 660.0)	-
			Intervention (tech support + health coaching	6663 (5099 to 8227)	↑8338 (6749 to 9926)	-
				52.1 (38.8 to 65.4)	↑67.2 (53.7 to 80.8)	-
				3.0 (-6.3 to 12.2)	$↑19.7 (10.2 to 29.1)	-
				567.7 (517.9 to 617.5)	575.6 (525.0 to 626.1)	-
			Control group	8132 (6590 to 9674)	7898 (6378 to 9418)	-

[7] Post-intervention is 13 weeks.

				64.0 (51.0 to 76.9) 12.1 (3.1 to 21.1) 555.4 (507.0 to 608.3)	65.7 (52.6 to 78.9) 12.3 (3.1 to 21.4) 552.9 (503.8 to 602.0)	- - -
[8]Spector (2014)	Intervention group	Questionnaire (IPAQ-total MET-min/week and total min/week)	Intervention	153.9±168.7 39.1±44.0	↑1204.1±862.3 ↑251.8±141.9	- -
		Accelerometer (Actical-counts/min and MVPA min/day	Intervention	142.8±66.2 12.2±9.1	↑194.5±77.3 ↑17.6±9.6	- -
[9]Courneya (2003)	GP+EX or GP group	Questionnaire (LSI-total minutes, moderate/strenuous minutes combined and %> 60 min moderate/strenuous)	Intervention Control	192.53±227.43 72.71±98.20 47.1±50.4 137.68±117.76 49.30±86.52 33.3±47.7	$196.65±149.56 $141.10±129.25 $84.3±36.7 100.91±104.24 39.24±74.30 22.2±42.0	- - - - - -
	Intervention group	Questionnaire (IPAQ-total MET-min/week,	Intervention	2031±2213 980.8±1423.0	1940±1762 ↓471.6±587.2	- -

[8] Post-intervention is 16 weeks.
[9] Post-intervention is 10 weeks.

[10]Delrieu (2020)		domestic PA MET-min/week and sitting time min/week		2250.6±1149.2	↓1703.6±853.3	-
[11]Lam (2020)	PRT or usual care group	Pedometer (G-sensor 2026) and Diary-step count and MPA hours	Intervention Control Intervention Control	28838 ± 5377 40173 ± 8502 3.3 ± 1.4 3.9 ± 1.8	$30303 ± 6309 27343 ± 8424 2.8 ± 1.7 5.7 ± 2.3	- - - -
[12]Villumsen (2019)	Intervention and usual care group	Questionnaire (GLTEQ-total score)	Intervention Control	29.3±29.2 27.3±21.8	38 32	45 -
[13]Ochi (2021)	Exercise or control group	Questionnaire (GPAQ-total score min/week)	Intervention Control	89±112 142±179	309±564 257±354	- -
[14]Evans (2021)	Intervention or wait-list control group	Accelerometer (ActiGraph GT3X-MVPA min/day, steps/day, MPA min/week)	Intervention Control 	30.57±22.0 4977±3146 203.0±149.7 38.4±22.2 6169±3001 256.9±150.0	$35.1±23.6 $5885±3071 $232.7±158.8 32.0±22.7 5556±3141 208.6±142.3	- - - - - -

[10] Post-intervention is 6 months.
[11] Post-intervention is 12 months.
[12] Post-intervention is 12 weeks and follow-up are 24 weeks.
[13] Post-intervention is 12 weeks.
[14] Post-intervention is 8 weeks.

		Questionnaire (GLTEQ-total score)	Intervention	37.9±37.7	52.3±38.8	-
			Control	40.6±29.2	36.7±28.0	-

9.3.6 Assessments of physical fitness (PF)

Oxygen consumption (VO_{2peak} or VO_{2max}) was used in seven studies to evaluate cardiorespiratory fitness. One study used a submaximal treadmill walk test [263], five studies used submaximal cycle ergometer tests [162,163,280,282,286], three studies used submaximal Balke treadmill tests [262,284,285], four studies used the 6MWT (minute walk test) [276,280,281,283], and one study used the 400MWT [287]. A variety of methods were used to assess muscular strength in nine studies. One study assessed quadriceps force and handgrip strength but did not provide any information in their methodology [281]. Other methods include an isometric bench with strain gauge (Globus system) [280], the Short Physical Performance Battery (SPPB) to assess lower extremity physical function [164], isokinetic dynamometer (leg extension and low row exercises) [282], a hand and back-leg dynamometer [283], isometric dynamometer [162], a power rig [276], leg press [286] and chest press [287]. All PF data is reported in supplementary table 9.

9.3.7 Cardiorespiratory fitness (CRF)

Five studies [263,280,282–284] reported significant increases in CRF in intervention groups, three [263,280,284] post-intervention and follow-up and only two [282,283] post-intervention (see Table 2), one of which also reported a significant increase in the control group post-intervention and follow-up [263], and another that reported a significant decrease in the control group post-intervention [280]. Seven studies [163,263,276,280,284,286,287] reported significant group differences, six [163,276,280,284,286,287] post-intervention, and only one [263] post-intervention and follow-up. One of these group differences was observed in an obese and non-obese intervention group, with non-obese survivors having significantly better CRF [163]. One study found a significant difference in per-protocol analysis (not intention-to-treat) [280]. No significant changes in CRF were reported in four studies [162,262,281,285]. Of the five studies that reported significant increases in CRF in intervention groups, four of these studies used submaximal fitness tests on either a treadmill or ergometer using a variety of apparatus [263,280,282,284], and one study used the 6MWT [283]. Each of these tests were

used to assess aerobic capacity and endurance. The four studies using submaximal fitness tests were able to provide an esitimate of oxygen consumption (VO_{2peak} or VO_{2max}) [263,280,282,284]. In general, aerobic fitness is measured by maximal oxygen consumption (VO_{2max} or VO_{2peak}) and this is considered the gold standard for measurement of aerobic fitness [288]. The study using the 6MWT reported a measure of maximum walking distance in metres during 6 minutes [283]. Although this study did not report a measure of oxygen consumption, the test is still a valid and reliable measure used to assess aerobic fitness [289] and may be a easily conducted in a remote setting.

9.3.8 Muscular strength

Two studies [282,283] reported significant increases in strength post-intervention, one of which reported significant increases in five out of the eight strength parameters measured [282] (see Table 2). Two studies [286,287] reported significant group differences post-intervention. No significant changes were reported in five studies [162,164,276,280,281]. Of the two studies that reported significant increases in strength [282,283], one study reported a test measure of 1 repetition maximum (RM) [282], and the other study reported a test measure of peak strength [283]. The 1RM test is often considered the gold standard for assessing strength capacity [290]. In a remote setting a valid and reliable measure to assess strength may be the sit-to-stand or chair rise tests [249].

Table 9- Physical fitness variables of cardiorespiratory fitness and muscular strength. Significant increases are represented by ↑ and significant decreases are represented by ↓ . Significant group differences are represented by $.

Author	**Experimental Groups**	**Measure**	**Group**	**Baseline**	**Post-intervention**	**Follow-up**
[15]Pinto (2013)	PA and control group	Tread walk test, min	Intervention	24.2 ± 3.8	↑20.6 ± 2.84	$↑20.7 ± 2.9
			Control	22.7 ± 3.0	↑21.1 ± 3.07	↑20.8 ± 3.4
		VO_{2peak} mL min^{-1} kg^{-1}	Intervention	21.90 ± 7.59	$↑26.44 ± 6.04	$↑24.57 ± 7.09
			Control	23.80 ± 8.66	26.18 ± 8.38	24.65 ± 9.58
	Obese and non-obese group	Predicted VO_{2max} based on RPE	Intervention (obese)	17.00 ± 5.40	18.25 ± 4.47	-

[15] Post-intervention is 3 months and follow-up are 12 months.

[16]Basen-Engquist (2014)			Intervention (non-obese)	21.75 ± 8.42	Δ22.25 ± 5.25	-
[17]Edbrooke (2019)	Intervention and usual care group	6MWT, m	Intervention	467.0 ± 117.6	-33.25 (13.57)	23.30 (25.23)
			Control	482.7 ± 115.9	-7.88 (14.39)	-64.64 (22.20)
			Between-group change scores		−25.36 (−63.98 to 13.26)	41.34 (-26.67 to 109.35)
		Quadriceps force, Nm	Intervention	53.7 (46.7 to 65.8)	2.79 (4.24)	1.91 (5.47)
			Control	64.5 (51.4 to 84.0)	2.48 (4.43)	1.02 (4.55)
			Between-group change scores		0.31 (−11.76 to 12.38)	0.89 (−13.16 to 14.95)
		Handgrip strength, kg	Intervention	25.6 ± 9.3	0.09 (0.80)	1.13 (1.42)
			Control	29.8 ± 11.0	-0.01 (0.72)	0.75 (1.16)
			Between-group change scores		0.11 (−2.02 to 2.23)	0.39 (−3.31 to 4.08)
[18]Cornette (2016)	APA and control group	VO_{2peak} mL min^{-1} kg^{-1}	Intervention	22.5 ± 4.4	↑24.4 ± 4.9	↑24.9±5.4
			Control	23.4 ± 5.1	↓22.1 ± 5	22.7±5.2
		Per-protocol analysis	Intervention		$24.4±4.9	
			Control		21±4.8	
		6MWT, m	Intervention	527.3 ± 46.1	↑549 ± 53	↑552±54.2
			Control	527.1 ± 61.5	517.5 ± 69.3	522.3±65.2
		1RM lower, kg	Intervention	25.3±8.7	24±5.5	24.6±7.1
			Control	28.7±8.4	28.2±8.3	28.6±8.8
[19]McNeil (2019)	Lower-intensity PA, higher-intensity PA and control group	VO_{2max} $mLkg^{-1}min^{-1}$	Intervention (lower intensity)	19.9 ± 7.9	$↑24.0 ± 7.0 (n=15)	↑23.9±8.0 (n=13)
			Intervention (higher intensity)	17.2 ± 8.3	$↑23.1 ± 9.2 (n=15)	↑20.4±7.6 (n=12)

[16] Post-intervention is 6 months.
[17] Post-intervention is 9 weeks and follow-up are 6 months.
[18] Post-intervention is 27 weeks and follow-up are 54 weeks.
[19] Post-intervention is 12 weeks and follow-up are 24 weeks.

			Control group	18.0 ± 6.5	18.3 ± 6.7 (n=13)	18.0±5.1 (n=11)
[20]Courneya (2003)	Exercise and control group	Treadmill time, s	Intervention Control	396 ± 291 314 ± 270	548 ± 300 406 ± 301	- -
[21]Blair (2021)	Tech support, tech support plus health coaching and waitlist control group	SPPB	Intervention (tech support) Intervention (tech support + health coaching Control	10.4 (9.7, 11.2) 11.2 (10.4, 11.9) 10.7 (9.9, 11.4)	10.7 (9.9, 11.5) 11.5 (10.8, 12.3) 10.7 (10.0, 11.5)	- - -
[22]Spector (2014)	Intervention group	VO_{2peak}	Intervention	16.9 ± 3.7	↑18.9 ± 4.7	-
		Upper and lower muscle strength-peak torque	Intervention	10.2 ± 5.4 (left arm extension) 13.9 ± 3.0 (left arm flexion) 12.4 ± 5.2 (right arm flexion) 59.6 ± 19.2 (left leg extension) 59.3 ± 17.7 (right leg extension)	↑14.5 ± 2.5 (left arm extension) ↑15.7 ± 3.3 (left arm flexion) ↑15.4 ± 6.0 (right arm flexion) ↑68.9 ± 21.0 (left leg extension) ↑70.6 ± 20.5 (right leg extension)	- - - - -
[23]Courneya (2003)	GP+EX or GP group	Treadmill time, s	Intervention Control	475.33 ± 336.69 430.56 ± 333.43	528.80 ± 362.44 485.82 ± 345.71	- -
[24]Delrieu (2020)	Intervention group	6MWT (m)	Intervention	451.6 ± 99.7	↑482.6 ± 106.3	-
		1RM lower, N	Intervention	194.2 ± 69.1	↑236.4 ± 78.6	-
[25]Lam (2020)	PRT or usual care group	VO_{2max} $mLkg^{-1}min^{-1}$	Intervention Control	27.3 ± 1.1 26.3 ± 2.4	29.1 ± 1.9 29.2 ± 1.8	- -

[20] Post-intervention is 16 weeks.
[21] Post-intervention is 13 weeks.
[22] Post-intervention is 16 weeks.
[23] Post-intervention is 10 weeks.
[24] Post-intervention is 6 months.
[25] Post-intervention is 12 months.

[26]Villumsen (2019)	Intervention and usual care group	6MWT (m)	Intervention	526.8 ± 65.6	$556.1 ± 59.0	-
			Control	497.3 ± 79.8	500.8 ± 80.6	-
		LEP (leg extensor power)	Intervention	319.3 ± 102.4	349.2 ± 93.0	-
			Control	267.3 ± 108.2	272.3 ± 95.8	-
[27]Ochi (2021)	Exercise or control group	VO_{2peak} (mL/kg/min)	Intervention	25.0 ± 3.0	$25.9 ± 2.8	-
			Control	24.9 ± 4.6	24.1 ± 4.0	-
		1RM lower, kg	Intervention	93.6 ± 24.3	$106.6 ± 26.7	-
			Control	98.7 ± 40.6	98.2 ± 30.9	-
[28]Evans (2021)	Intervention or wait-list control group	400MWT, min	Intervention	5.49 ± 1.52	$5.23 ± 2.02	-
			Control	4.53 ± 1.36	4.80 ± 1.94	-
		1RM upper, kg	Intervention	58.75 ± 14.36	$65.00 ± 16.83	-
			Control	56.67 ± 11.55	56.67 ± 11.55	-

9.3.9 Quality of Life (QoL)

Three studies used the SF-36 (Short Form-36) [162–164] and one study used the PF (physical functioning) subscale of the SF-36 [263]. One study used the QLACS (Quality of Life in Cancer Survivors) in conjunction with the SF-36 [163], one study used the FACT-L (Functional Assessment of Cancer Therapy-Lung) [281], four studies used the EORTC-QLQ-C30 (EORTC-Core Quality of Life Questionnaire) [276,280,283,287], one study used the SF-12 (Short Form-12) [284], two studies used the FACT-B (Functional Assessment of Cancer Therapy-Breast) [282,284], two studies used the FACT-C (Functional Assessment of Cancer Therapy-Colorectal) [263][262], one of these studies also computed the FACT-G (Functional Assessment of Cancer Therapy-General) score by excluding the CRC (Colorectal Cancer) subscale and the TOI (Trial Outcome Index) score by summing

[26] Post-intervention is 12 weeks.
[27] Post-intervention is 12 weeks.
[28] Post-intervention is 9 weeks.

the physical and functional well-being scales and the CRC subscale [262] and another study used the FACT-G [285], one study used the FACT-P (Functional Assessment of Cancer Therapy-Prostate) [276] and one study used the EQ-5D (EuroQoL) [286]. One study [263] reported a significant increase in QoL in both the intervention and control groups post-intervention and follow-up. Two studies [163,285] reported a significant increase in QoL in the intervention groups, four subscales of the SF-36 and nine subscales of the QLACS [163], and one subscale of the FACT-G [285]. One study noted stable scores for QoL, however reported a significant decrease in one domain (appetite loss domain) of the symptom scales of the EORTC-QLQ-C30 [283]. Another study noted non-significant increase in QoL, however reported scores significantly increased in the FACT-B TOI (Trial Outcome Index), and BCS (Breast Cancer Subscale) post-intervention [282]. Four studies [162,163,281,285] reported significant group differences, one of which reported one of the intervention groups (non-obese) to have significantly better QoL on three SF-36 subscales and two QLACS subscales post-intervention [163]. No significant changes were reported in seven studies [164,262,276,280,284,286,287], one of which reported the intervention group had same QoL as control group post-intervention [276].

Table 10- Quality of life variables. Significant increases are represented by ↑ and significant decreases are represented by ↓ . Significant group differences are represented by $.

Author	Experimental Groups	Measure	Group	Baseline	Post-intervention	Follow-up
[29]Pinto (2013)	PA and control group	Survey (SF-36 PF subscale)	Intervention	79.4 ± 16.8	↑88.8 ± 9.9	↑86.6 ± 13.0
			Control	75 ± 16.3	↑87.3 ± 11.4	↑84.8 ± 17.6
		Survey (FACT-C)	Intervention	105.3	↑111.3 (105.9 to 116.6)	↑110.7 (105.6 to 115.8)
			Control	105.3	↑110.8 (106.1 to 115.4)	↑110.6 (105.9 to 115.2)
[30]Basen-Engquist (2014)	Obese and non-obese group	Survey (SF-36)	Intervention (obese)	69.18 ± 23.40 (PF) 63.85 ± 22.25 (GH) 51.69 ± 22.18 (V)	↑76.34 ± 24.57 (PF) ↑71.01 ± 20.86 (GH) ↑60.00 ± 20.59 (V)	- - -

[29] Post-intervention is 3 months and follow-up are 12 months.
[30] Post-intervention is 6 months.

				75.10 ± 16.36 (MH) 65.97 ± 24.12 (BP)	↑80.88 ± 12.25 (MH) 73.10 ± 20.92 (BP)	- -
			Intervention (non-obese)	84.40 ± 14.13 (PF) 76.87 ± 13.74 (GH) 58.19 ± 16.99 (V)	$↑90.17 ± 10.90 (PF) $↑84.65 ± 10.5 (GH) ↑64.14 ± 16.8 (V)	- - -
				76.11 ± 14.72 (MH) 76.11 ± 18.79 (BP)	↑81.38 ± 15.32 (MH) $↑78.59 ± 18.40 (BP)	- -
		Survey (QLACS)	Intervention (obese)	11.49 ± 4.58 (NF) 20.80 ± 4.74 (PF) 10.88 ± 4.47 (CP) 11.06 ± 5.16 (P) 12.27 ± 6.19 (SP) 14.97 ± 3.11 (E/F) 9.64 ± 5.06 (SA) 18.51 ± 6.16 (BS) 12.74 ± 6.41 (DR)	↑9.95 ± 3.76 (NF) ↑22.38 ± 4.60 (PF) ↑9.71 ± 3.80 (CP) ↑9.05 ± 4.56 (P) ↑9.78 ± 4.70 (SP) ↑13.80 ± 2.59 (E/F) ↑7.80 ± 3.60 (SA) ↑19.10 ± 5.86 (BS) ↑10.85 ± 5.82 (DR)	- - - - - - - - -
			Intervention (non-obese)	11.33 ± 4.23 (NF) 21.47 ± 4.40 (PF) 11.19 ± 4.31 (CP) 8.72 ± 3.43 (P) 13.20 ± 6.49 (SP) 14.58 ± 2.68 (E/F) 8.25 ± 4.27 (SA)	↑8.93 ± 4.05 (NF) ↑22.66 ± 3.87 (PF) ↑9.97 ± 3.61 (CP) $↑7.60 ± 2.65 (P) ↑11.45 ± 6.03 (SP) ↑13.80 ± 2.95 (E/F) ↑6.43 ± 3.43 (S/A)	- - - - - - -

				17.53 ± 5.59 (BS) 9.42 ± 4.07 (DR)	↑18.80 ± 5.83 (BS) $↑8.10 ± 3.36 (DR)	- -
[31]Edbrooke (2019)	Intervention and usual care group	Survey (FACT-L total scale)	Intervention Control	96.7 ± 17.8 103.0 ± 16.2	2.42 (2.85) -1.41 (3.20)	Δ5.18 (3.25) -7.84 (3.13)
[32]Cornette (2016)	APA and control group	Questionnaire (EORTC-QLQ-C30)	Intervention Control	62.1±25.1 59.1± 27.5	71.7± 18.9 64.8± 17.1	75±16.7 69.9±21.7
[33]McNeil (2019)	Lower-intensity PA, higher-intensity PA and control group	Survey (SF-12) -physical component (PCS) and mental component (MCS)	Intervention (lower intensity)	46.5±4.2 (PCS) 54.6±6.7 (MCS)	44.8±6.8 (PCS) (n=15) 54.0±5.4 (MCS) (n=15)	48.3 ± 6.4 (PCS) (n=15) 49.2 ± 11.4 (MCS) n=15)
			Intervention (higher intensity)	46.5±6.2 (PCS) 55.1±6.8 (MCS)	48.6±7.8 (PCS) (n=15) 53.4±8.8 (MCS) (n=15)	49.8 ± 6.4 (PCS) (n=13) 53.8 ± 7.1 (MCS) (n=13
			Control	50.0±4.5 (PCS) 48.8±13.3 (MCS)	49.9±4.6 (PCS) (n=13) 50.1±13.1 (MCS) (n=13)	51.0 ± 5.4 (PCS) (n=12) 50.2 ± 12.6 (MCS) (n=12)
		Questionnaire (FACT-B total score)	Intervention (lower intensity)	112.5±11.7	109.7±13.8 (n=15)	109.6 ± 14.9 (n=15)
			Intervention (higher intensity)	118.8±11.0	116.8±17.7 (n=15)	118.5 ± 19.2 (n=13)
			Control	115.4 ±18.7	113.5±16.4 (n=13)	113.4 ± 18.3 (n=11)

[31] Post-intervention is 9 weeks and follow-up are 6 months.
[32] Post-intervention is 27 weeks and follow-up are 54 weeks.
[33] Post-intervention is 12 weeks and follow-up are 24 weeks.

[34]Courneya (2003)	Exercise and control group	Questionnaire (FACT-C)	Intervention Control	106.0 ± 14.0 107.0 ± 16.0	107.4 ± 16.5 109.8 ± 18.8	- -
		FACT-G (score)	Intervention Control	84.7 ± 11.6 84.5 ± 14.1	85.6 ± 13.0 86.5 ± 15.0	- -
[35]Blair (2021)	Tech support, tech support plus health coaching and waitlist control group	Survey (SF-36)	Intervention (tech support)	60.2 (49.6, 70.8) (BP) 62.8 (54.3, 71.3) (GH) 78.1 (70.4, 85.7) (MH) 68.1 (58.1, 78.0) (PF) 79.6 (68.6, 90.7) (RE) 68.1 (55.7, 80.4) (RP) 80.6 (69.8, 91.3) (SF) 61.8 (52.1, 71.5) (V)	61.6 (49.3, 73.9) (BP) 64.7 (55.6, 73.7) (GH) 77.3 (68.8, 85.8) (MH) 72.0 (61.0, 82.9) (PF) 83.8 (71.0, 96.5) (RE) 69.6 (55.9, 83.3) (RP) 80.9 (69.2, 92.7) (SF) 61.7 (51.0, 72.4) (V)	- - - - - - - -
			Intervention (tech support + health coaching)	62.1 (51.2, 73.0) (BP) 70.2 (61.4, 79.0) (GH) 75.3 (67.4, 83.2) (MH) 76.5 (66.2, 86.8) (PF) 82.4 (71.0, 93.8) (RE) 69.5 (56.8, 82.2) (RP) 81.6 (70.5, 92.7) (SF) 56.3 (46.3, 66.2) (V)	68.4 (56.7, 80.1) (BP) 73.9 (65.1, 82.7) (GH) 79.4 (71.3, 87.5) (MH) 76.8 (66.4, 87.2) (PF) 87.5 (75.9, 99.2) (RE) 73.5 (60.7, 86.4) (RP) 84.3 (73.0, 95.7) (SF) 60.8 (50.6, 71.1) (V)	- - - - - - - -
			Control	59.1 (48.5, 69.6) (BP) 71.5 (63.0, 80.0) (GH) 75.6 (67.9, 83.2) (MH)	64.2 (53.6, 74.8) (BP) 70.1 (61.5, 78.6) (GH) 80.1 (72.4, 87.7) (MH)	- - -

[34] Post-intervention is 16 weeks.
[35] Post-intervention is 13 weeks.

				75.6 (65.6, 85.5) (PF) 80.6 (69.5, 91.6) (RE) 70.1 (57.8, 82.5) (RP) 88.2 (77.4, 99.0) (SF) 65.3 (55.6, 75.0) (V)	75.0 (65.0, 85.0) (PF) 89.4 (78.3, 100) (RE) 69.8 (57.5, 82.1) (RP) 82.6 (71.9, 93.4) (SF) 65.3 (55.6, 75.0) (V)	- - - - -
[36]Spector (2014)	Intervention group	Questionnaire (FACT-B total score)	Intervention	117.9 ± 14.5	125.5 ± 9.3	-
		Questionnaire (FACT-B TOI)	Intervention	71.8 ± 11.8	↑78.6 ± 6.2	-
		Questionnaire (FACT-B BCS)	Intervention	25.1 ± 5.5	↑28.3 ± 3.7	-
[37]Courneya (2003)	GP+EX or GP group	Questionnaire (FACT-G Functional wellbeing)	Intervention Control	15.23 ± 4.96 16.95 ± 5.04	$↑16.58 ± 5.30 16.39 ± 5.45	- -
[38]Delrieu (2020)	Intervention group	Questionnaire (EORTC-QLQ-C30 total global health status)	Intervention	62.7 ± 20.6	63.5 ± 23.2	-
		Symptom scales (appetite loss)	Intervention	20.8 ± 27.2	↓9.9 ± 21.1	-
[39]Lam (2020)	PRT or usual care group	Survey (SF-36)	Intervention	55.3 ± 1.8 (V) 54.1 ± 2.4 (MH) 54.4 ± 2.1 (MCS)	$56.2 ± 1.9 (V) • 50.8 ± 2.4 (MH) $56.3 ± 2.1 (MCS)	- - -
			Control	59.3 ± 2.0 (V) 58.7 ± 1.2 (MH) 58.2 ± 1.2 (MCS)	54.7 ± 3.2 (V) 57.2 ± 2.1 (MH) 55.4 ± 2.1 (MCS)	- - -
[40]Villumsen (2019)	Intervention and usual care group	Questionnaire (EORTC-QLQ-C30	Intervention Control	67.0 ± 20.2 67.4 ± 23.4	81.4 ± 16.9 72.5 ± 20.4	- -

[36] Post-intervention is 16 weeks.
[37] Post-intervention is 10 weeks.
[38] Post-intervention is 6 months.
[39] Post-intervention is 12 months. Paper reported increase in MH subscale in intervention group but from the data shown, a decrease can be seen therefore significant group difference reported is inaccurate between groups • .
[40] Post-intervention is 12 weeks.

		Global Health Status)				
		Questionnaire (FACT-P)	Intervention Control	118.7 ± 14.2 119.4 ± 17.4	123.1 ± 13.9 120.7 ± 18.0	- -
[41]Ochi (2021)	Exercise or control group	Questionnaire (EQ-5D total score)	Intervention Control	0.95 ± 0.62 0.94 ± 0.83	0.92 ± 0.07 0.88 ± 0.09	- -
[42]Evans (2021)	Intervention or wait-list control group	Questionnaire (EORTC-QLQ-C30)	Intervention Control	62.7 ± 22.3 71.9 ± 15.0	68.4 ± 22.0 64.5 ± 22.2	- -

[41] Post-intervention is 12 weeks.
[42] Post-intervention is 9 weeks.

Table 11- Characteristics and results of studies that evaluated the effects of home-based exercise interventions.

Study	Treatment	Cancer	Study design	*n*	Sex	Age	Duration (week)	Intervention	Intensity	Frequency	Supervision/Monitoring	Methods	Outcomes
Pinto (2013) [263]	Post primary and adjuvant treatment	CRC	RCT (1:1)	46	M, F	57	12	Aerobic exercise	64-76% HRmax	Gradually 2-5/week	Unsupervised. Accelerometer, home PA log, 1 phone call/week	7-day PAR, CHAMPS; Submaximal tread walk test; FACT-C, SF-36 PF	PA, CRF, QoL
Basen-Engquist (2014) [163]	Post-treatment	EDMC	Single-arm intervention	100	F	57	24	Aerobic exercise	NS	Gradually 5 or more days/week	Unsupervised. 20-30 min phone calls/week (counselling), print materials, pedometer	Computer (iPAQ), Accelerometer ActiGraph GT1M, diary; Submaximal cycle ergometer test; SF-36, QLACS	PA, CRF, QoL
Edbrook (2019) [281]	Radical and palliative treatment	LC	RCT (1:1)	92	M	64	8	Combined aerobic and resistance exercise	Aiming for 4, 'somewhat hard' on modified Borg Dyspnoea Scale	Aerobic exercise 2 sessions/week + resistance exercise 2-3 sessions/week	Unsupervised. Home visits or 2 phone calls/week, exercise diary	Accelerometer SWA, IPAQ; 6MWT, quadriceps force, handgrip strength; FACT-L	PA, CRF/strength, QoL
Cornette (2016) [280]	During neoadjuvant or adjuvant treatment	BC	RCT (1:1)	44	F	51	27	Combined aerobic and resistance exercise	1-VT	Minimum 3/week (resistance exercise 1/week)	Unsupervised. HR monitor, exercise diary, 1 phone call/week	IPAQ; Submaximal cycle ergometer, 6MWT, Globus system; EORTC QLQ-C30	PA, CRF/strength, QoL
McNeil (2019) [284]	Post adjuvant treatment except HT	BC	Pilot RCT (1:1:1)	45	F	59	12	Aerobic exercise	40-50% HRR or 60-80% HRR	NS	Unsupervised. HR monitor, diary, follow up phone call/email every 3 weeks,	Accelerometer GT3X+; Submaximal. Balke treadmill test; SF-12, FACT-B	PA, CRF, QoL
Courneya (2003) [262]	During adjuvant treatment	CRC	RCT (2:1)	102	M, F	61	16	Aerobic exercise	Gradually from 50-60% or 65-75% HRmax	3-5/week	Unsupervised. Weekly phone calls	LSI; FACT-C, FACT-G; Submaximal Balke treadmill test	PA, CRF, QoL
Blair (2021) [164]	Post primary treatment	BC, PC, other	Pilot RCT (1:1:1)	54	M, F	67	13	Aerobic exercise	NS	Daily	Unsupervised. 5 phone calls, diary	Accelerometer activPAL3; SPPB; SF-36	PA, strength, QoL

Spector (2014) [282]	Post primary treatment, except Herceptin	BC	Pilot intervention	13	F	51	16	Combined aerobic and resistance exercise	40-65% HRR	NS	Unsupervised. Pedometer, HR monitor, exercise logbook, tailored newsletters, weekly phone calls (motivational interviewing sessions)	Accelerometer Actical, IPAQ; Submaximal cycle ergometer test; Biodex isokinetic dynamometer; FACT-B	PA, CRF/strength, QoL
Courneya (2003) [285]	During adjuvant treatment	BC, CC, OVC, STC, Melanoma, Hodgkin's, non-Hodgkin's lymphoma, brain, LC, other	RCT (1:1)	108	M, F	52	10	Aerobic exercise	65-75% HRmax	3-5/week	Unsupervised. GP classes, phone calls when didn't attend classes	LSI; FACT-G; Submaximal Balke treadmill test	PA, CRF, QoL
Delrieu (2020) [283]	During adjuvant treatment and HT therapy	BC	Intervention	49	F	55	24	Aerobic exercise	NS	NS	Unsupervised. Wrist activity tracker, in person or phone call check ins weekly	IPAQ; 6MWT, hand and back-leg dynamometer; EORTC QLQ-C30	PA, CRF/strength, QoL
Lam (2020) [162]	During ADT	PC	RCT (1:1)	25	M	71	52	Resistance exercise	NS	3/week	Unsupervised. Supervised sessions every 12 weeks to demonstrate next stage of exercises, online instructional videos and printed training manual, training logbook, monthly phone calls	Pedometer G-sensor, diary; Submaximal cycle ergometer test, isometric dynamometer; SF-36	PA, CRF/strength, QoL
Villumsen (2019) [276]	During ADT	PC	RCT (1:1)	46	M	69	12	Combined aerobic and resistance exercise	NS	3/week	Unsupervised. Exercise diary, phone calls every second week	GLTEQ; 6MWT, power rig; EORTC QLQ-C30, FACT-P	PA, strength, QoL
Ochi (2021) [286]	Post initial adjuvant treatment except HT	BC	RCT (1:1)	50	F	50	12	Aerobic	NS	3/week	Unsupervised. Counselling/exercise guidance via personalised email and smartphone app	GPAQ; Submaximal cycle ergometer test, leg press; EQ-5D	PA, CRF/strength, QoL
Evans (2021) [287]	During adjuvant and HT	PC	Pilot RCT (1:1)	40	M	70	8	Combined aerobic and resistance exercise	OMNI-RPE resistance and aerobic	Aerobic 2-3 sessions/week, resistance training 2-3 days/week	Unsupervised. Exercise diary, 2 telehealth consultations (week 1 and 4) via Zoom, Skype or phone calls, text	ActiGraph GT3X, GLTEQ; 400MWT, chest press; EORTC-QLQ-C30	PA, CRF/strength, QoL

	scale used to prescribe intensity ranging from 6 to 7 out of 10, instructed to increase or decrease intensity by 5-10% if RPE did not match prescribed OMNI scale	messages or email (weeks 2-3 and 5-8)

HT=hormone therapy , ADT=androgen deprivation therapy, CRC=colorectal cancer, EDMC=endometrial cancer, LC=lung cancer, PC=prostate cancer, CC=colon cancer, OVC=ovarian cancer, STC=stomach cancer, RCT=randomised controlled trial, M=male, F=female, HR=heart rate, HRR=heart rate reserve, VT=ventilatory threshold, NS=not specified, OMNI-RPE=rate of perceived exertion, GP=general practitioner, PA=physical activity, CRC=cardiorespiratory fitness, QoL=quality of life, PAR= Physical Activity Recall, CHAMPS= Community Healthy Activities Model Program for Seniors, IPAQ=International Physical Activity Questionnaire, LSI=Leisure Score Index, GLTEQ=Godin Leisure-Time Exercise Questionnaire, GPAQ=Global Physical Activity Questionnaire, SWA=Sense Wear Armband, SPPB=Short Physical Performance Battery, MWT=minute walk test, SF-36=Short Form-36, QLACS=Quality of Life in Cancer Survivors, FACT-L=Functional Assessment of Cancer Therapy-Lung, EORTC-QLQ-C30= EORTC-Core Quality of Life Questionnaire, SF-12=Short Form-12, FACT-B=Functional Assessment of Cancer Therapy-Breast, FACT-C=Functional Assessment of Cancer Therapy-Colorectal, FACT-G=Functional Assessment of Cancer Therapy-General, FACT-P=Functional Assessment of Cancer Therapy-Prostate, EQ-5D=EuroQoL

9.4 Discussion

The purpose of this review was to explore the effect of home-based PA and exercise interventions on physical activity, physical fitness, and quality of life in cancer survivors. A total of fourteen studies were included in this review, eleven RCT's and three intervention studies. Overall, the effect of home-based PA and exercise interventions on these specific outcomes in this population appears complex and there are a variety of factors that may have influenced our findings.

Regular PA is associated with a lower risk of all-cause mortality, cancer recurrence and several chronic diseases including cardiovascular disease in people who have survived cancer [110]. Despite these beneficial health-related outcomes, the majority of cancer survivors are not regularly active, with estimates ranging from less than 10% during active treatment and 29% to 30% post-treatment of survivors meeting the PA guidelines [110,273]. A wealth of evidence has demonstrated that PA and exercise interventions facilitate improvements in survivors levels of PA [273], specifically home-based PA and exercise interventions [277]. It is therefore surprising that only five out of fourteen studies included in this review reported significant increases in PA [163,164,263,282,284]. The interventions provided in these five studies consisted of predominately aerobic activities/exercise, one of these studies delivered their intervention through a combined approach that included both aerobic and resistance exercise [282]. Within four of these studies walking was generally prescribed as the aerobic activity [163,164,263,282] perhaps because it can be easily administered and generally doesn't require any exercise equipment, making it convenient and accessible. A recent review highlighted walking as a convenient and affordable way for cancer survivors to increase their PA levels [277]. Overall, four [163,164,263,284] out of the eight studies [163,164,262,263,283–286] that provided solely aerobic exercise found significant increases in PA. The duration of the interventions did not seem to have a clear influence on these findings, but perhaps they can be attributed to treatment stage as participants in those four studies were post primary and adjuvant treatments [163,164,263,284]. Whereas participants in three out of the other four studies who did not report an increase in PA were during treatment [262,283,285]. As previously noted above, generally only a very small proportion of survivors are active during treatment. Considering this and our findings, home-based PA and exercise interventions may need to be tailored to treatment stages and the individual if the goal is to elicit improvements such as increases in PA.

All studies included in this review provided some level of support to participants that was similar in terms of frequency, therefore it is difficult to conclude or recommend what level of support is needed to help facilitate a change in PA behaviours. Some of the studies that found significant increases in PA contacted participants by telephone weekly and provided activity/exercise counselling [163,263] and motivational interviewing sessions for exercise [282] to address barriers and facilitators for PA and exercise, to promote adherence. This level of support may have facilitated the significant changes observed over the course of these interventions as it may have improved participants level of perceived competence, and as a result, participants may have been more motivated to engage in PA. This draws on aspects of the self-determination theory of behaviour change [11]. In summary, there may be some influence on outcomes such as improvements in PA if future home-based PA and exercise interventions include an aerobic component, specifically walking, in their design and provide additional support. This may in turn promote adherence, if the aim is to elicit improvements in PA in cohorts of this population.

The increases observed in the five studies [163,164,263,282,284] showed large variations between device-based and self-report measures. Three of these studies used device-based measures [164,282,284] and reported significant increases of ~5 to ~36 min/day MPA/MVPA in intervention groups. The significant group differences observed by two of these studies [164,284], was likely due to either larger increases in the intervention group compared to the control group [284] or increases in the intervention group with no change in the control group [164] in MPA/MVPA. Two of these studies used self-reported measures [263,282] and reported significant increases of ~185 to ~212 min/week in the intervention groups. One of these studies also reported a significant increase in the control group of ~69 min/week [263]. Both the control and intervention groups received PA and colorectal cancer tip sheets, which may have encouraged participants in the control group to be more active. Like that of the device-based measures, the significant group differences observed by three studies post-intervention for self-report measures [262,263,285], was likely due to either larger increases in intervention groups compared to the control groups [262,263] or an increase in intervention group with decrease in control group [285]. One study used a combination of device-based and self-report measures to provide an overall value for minutes of exercise, reporting significant increases of ~2 to ~3 min/day [163]. Overall, there was no clear distinction between those using a combination of device-based and self-report measures or either of the measures alone, of the five studies that did show increases, self-report measures presented much larger increases in PA.

As self-report measures rely on participant recall and interpretation, and can be influenced by social desirability and difficulties in recall [291,292], participants may have over reported their PA and the increases observed may not have been an accurate representation of individuals increases in PA given that the increases observed were much larger than that of device measured PA. Over and under-reporting of PA using validated self-reported measures in this population has been previously highlighted [293][294]. Generally, device-based methods are considered more reliable and helpful for validating and calibrating self-report measures [295]. Therefore, it is encouraging to see that five out of the fourteen studies used both device-based and self-report measures of PA together [162,163,281,282,287]. Two of these studies reported larger increases in PA for self-report measures [281,282] and another two of these studies reported larger increases in PA for device-based measures [162,287]. Overall, there was no clear influence of one mode of measurement on PA. Devices such as accelerometers provide an objective assessment of PA based on raw accelerations and can estimate the duration and intensity of activity bouts [110,291], useful to assess changes in PA intensity and in turn, assess the efficacy of PA interventions [110]. Whereas self-report measures provide information on the setting, domain, and/or type of PA, providing more in-depth information regarding PA and exercise [292]. Considering the variations in the levels of PA reported by self-report and device-based measures in cancer cohorts, future studies may benefit from adopting combined measures approaches utilising device-based and self-report tools which may help to give a more robust, accurate and comprehensive estimate of PA levels and behaviours in this population. In addition, the PA measures utilised by the studies included in this review may not have been designed specifically for this population. For example, cut-point algorithms used to summarise accelerometer data into discrete variables such as sedentary, light, moderate-to-vigorous PA (MVPA) have been developed from younger, healthy populations [294][296][293]. Cancer survivors are often older, have comorbid conditions and ongoing cancer-related side effects that impact functional ability. Cut points developed from young healthy populations may not be representative of physiologically “light” or “moderate” intensity activity in cancer populations [296] and lead to insignificant error or biased results [294]. This highlights the need for established population-relevant cut points and algorithms, which may allow for more accurate interpretation of accelerometer data in this unique population. Furthermore, the self-report measures administered were generic validated measures of PA, to understand PA behaviour better in this population a shift from such measures to more cancer-specific measures of PA may be needed.

Given the discussion around the measurement issues/tools above, it is difficult to comment on the meaningfulness of the PA reported. As part of the recommended guidelines, cancer survivors are encouraged to achieve 150 minutes of moderate intensity PA per week (or equivalent of vigorous PA) and 'avoid inactivity' where possible [100]. PA of 150 minutes or more per week has demonstrated reductions in all-cause mortality in cancer survivors [297]. The significant increases in minutes per week reported by self-reported measures exceeded 150 minutes. Significant increases reported by device-based measures showed variations from ~5 to 36~ minutes per day, if considering the higher end of this range, this would equate to more than 150 minutes across a week. The ACSM (American College of Sports Medicine) recently provided an update demonstrating that the majority of cancer health-related outcomes in the 'strong' evidence category are improved by doing thrice-weekly aerobic activity for 30 minutes including better QoL, improved perceived physical function, and less fatigue [100]. Whilst it is recommended that survivors meet PA guidelines for optimal health benefits, it is also worth noting that small increases in PA are also associated with beneficial effects on health outcomes and risk of all-cause mortality, even when recommended levels are not achieved [5]. Therefore, individuals moving from the category of 'no activity' to 'some levels of' activity may improve some health parameters [298]. Considering the lower end of this range, the smaller increases in PA may have facilitated beneficial health outcomes for survivors. These findings in PA are encouraging and provide some evidence that home-based PA and exercise interventions may be useful to help survivors meet recommended guidelines.

Only four [263,280,281,284] out of the fourteen studies reported follow-up PA data, two of which reported significant increases in PA from baseline to follow-up, ~111 min/week [263] and ~18 min/day MVPA in the intervention groups [284]. Including long-term follow-up periods may be important to provide information on maintenance of PA behaviours in this population. As PA is multi-faceted and complex, if the aim is to affect a lifestyle change by eliciting long-term changes in behaviour [299], follow-up periods may be crucial, especially as survivors need to be habitually active to achieve the long-term health benefits from PA and exercise [5]. In the UK, the Independent Cancer Taskforce strategy document sets out initiatives to achieve world class outcomes in cancer; ensuring survivors have the best possible QoL and improving rates of mortality. Promoting habitual exercise participation could help to accomplish these high priority agendas [273]. Furthermore, follow-up periods are recommended in the MRC (Medical Research Council) guidance and RE-AIM evaluation framework. Maintenance is just one dimension of the RE-AIM framework, a process evaluation framework, and refers to the extent of which the intervention and/or behaviours are sustained at least 6 months following completion of the

intervention [1]. Although only two studies reported significant increases in PA at follow-up, these findings provide some evidence to suggest that home-based PA and exercise interventions may facilitate some level of sustained behaviour change in this population. However, more studies that provide follow-up periods are needed to further support these findings.

The two studies that reported significant increases at follow-up, also reported significant increases in PA post-intervention [263,284]. The other two studies that reported follow-up data did not report any significant increases in PA post-intervention or at follow-up [280,281]. These two studies provided combined aerobic and resistance exercise interventions and participants were during neoadjuvant and adjuvant treatment [280] and radical and palliative treatment [281]. Whereas the studies that reported significant increases in PA post-intervention and at follow-up provided aerobic interventions and participants were post primary and adjuvant treatments [263,284], except for hormone therapy [284]. The participants during treatment may have been suffering from associated side effects such as cancer-related fatigue, one of the most commonly reported side effects during treatment, which significantly interferes with an individual's ability to perform activities of daily living [300]. This may explain why no significant increases in PA were observed. However, it is important to note that levels of PA did not diminish, in fact, one study reported that participants doubled their total PA but did not describe statistical significance in this context [280]. This offers some evidence for these interventions possibly being beneficial in sustaining baseline PA levels or preventing declines in PA in this population, particularly those during treatment.

All studies included in this review provided unsupervised exercise interventions. A previous Cochrane Review reported high adherence with supervised exercise interventions and that supervised models helped survivors to meet recommended PA guidelines [273]. Perhaps more studies reporting improvements in PA would have been evident if a level of supervision was provided by an exercise professional. Prior to the COVID-19 pandemic, telehealth research was already rapidly growing in cancer, cardiac, neurologic, and rehabilitation fields, but not in the main stream delivery of cancer services [301]. During the pandemic several clinical trials in exercise oncology transitioned exercise interventions from supervised to home-based. Group-based, virtually, supervised home-based exercise was the most used format among exercise oncology interventions during the pandemic [302]. Considering that previous in-person supervised exercise programs have been more effective at improving cancer and treatment-related side effects than self-directed home-based exercise interventions [302,303], an improvement and increase of telehealth remote delivery due to the pandemic may facilitate positive outcomes

such as improved PA. Overall, there is some evidence to suggest that home-based PA and exercise interventions may provide benefits to cancer survivors across the cancer care continuum, including improvements in levels of PA. Telehealth interventions that provide some level of additional support, including frequent phone calls and/or supervision may further help to facilitate these outcomes [303]. However, given the lack of significant findings, further work is needed. As a result of the COVID-19 pandemic, there may be an increase in the number of home-based PA and exercise interventions being conducted. One such trial is SafeFit, a multimodal intervention of PA, nutrition, and psychological support delivered virtually by cancer exercise specialists (CES), has been designed to support anyone in the UK with suspicion of or confirmed diagnosis of cancer [304] (see section 10.4 in synthesis). Overall, provisions of such trails and interventions will add to the growing body of literature in this area of research and possibly facilitate more understanding around the outcomes assessed in this review.

Five [263,280,282–284] out of the fourteen studies reviewed reported significant increases in CRF in intervention groups, four of these reported changes in VO_{2peak} and VO_{2max} with increases from baseline to post-intervention, ~1 to ~5 mL min^{-1} kg^{-1} [263,280,282,284] and follow-up, ~2 to ~4 mL min^{-1} kg^{-1} [263,280,284]. These findings may be clinically meaningful as a change of 3.5 mL min^{-1} kg^{-1} in CRF has been associated with significantly lower risk of breast cancer death [305,306]. Furthermore, higher levels of CRF are inversely and independently associated with lower all-type cancer incidence and mortality from cancer in adults [307]. Improvements in parameters such as VO_{2peak} may therefore improve health-related outcomes in survivors. Intervention length ranged from 12 to 27 weeks in these four studies and each intervention consisted of either predominantly aerobic exercise or combined aerobic with resistance exercise. This may explain why increases in CRF were observed in these studies, aerobic exercise has been previously reported to improve CRF in cancer survivors [308]. The significant group differences observed by three of these studies [263,280,284], from examining the data, were because of larger increases in the intervention group compared to the control group [263], increases in the intervention group and decreases in control group [280], and larger increases in intervention groups compared to the control group [284] from baseline to post-intervention and/or follow-up. Therefore, these findings offer some evidence to suggest that home-based PA and exercise interventions may prevent declines in CRF in this population.

Out of the eight studies that assessed muscular strength, only two studies [282,283] reported significant increases strength post-intervention: ~4 upper body peak torque and ~9 lower body peak torque [282] and ~42 N lower

body 1RM [283] post-intervention. A further two studies reported significant group differences [286,287], from examining the data this may be because of an increase in the intervention groups and no change in the control groups from baseline to post-intervention. As suggested previously, these interventions may prevent declines in muscular strength which could be facilitative for this population. Both studies provided support via counselling/exercise guidance to the intervention group [286] and telehealth consultations [287] which may have facilitated these changes. Out of these four studies that reported significant changes, two studies' [282,287] home-based interventions consisted of both aerobic and resistance exercise prescriptions with weekly telephone calls [282] and frequent online consultations, telephone calls, text messages and emails [287]. Given the nature of the interventions and support provided this may potentially explain why changes were observed in muscular strength. However, all studies provided some level of support during intervention periods and given the lack of significant findings reported it is difficult to offer an accurate conclusion. Although one study provided an aerobic home-based intervention, participants received support either in person or via weekly telephone calls for encouragement, again this may have been why increases in strength measures were observed as well as CRF [283]. Furthermore, exercise prescriptions were reviewed and modified [283,287] whereas support appeared more limited in studies that did not report any significant changes [162,164,276,280,281]. One of these studies provided supervised sessions every 12 weeks to demonstrate the next stage of exercises to participants, despite this support, telephone calls were only provided monthly [162], and another only provided 5 telephone calls over the intervention period as a method of support [164]. These findings highlight the potential value of future home-based PA and exercise interventions including frequent support within the delivery to facilitate possible positive health and fitness outcomes.

One out of the fourteen studies reviewed that provided a total score for QoL reported significant increases in both the intervention and control groups [263], ~6 FACT-C (intervention group) and ~5 FACT-C (control group) post-intervention and ~5 FACT-C (intervention group) and ~5 FACT-C (control group) at follow-up. Like that of the other outcomes, it is difficult to comment on the meaningfulness of this result in terms of metrics due to the use of diverse methodologies. Furthermore, given the 'identity change' following a cancer diagnosis and new living experiences for cancer survivors [309], metrics alone may not be enough to offer meaningfulness of QoL data. Employing a more comprehensive assessment of survivors' QoL utilising qualitative methods such as focus groups may provide a better understanding of the meaning and utility of PA during the survivorship period, as PA has been demonstrated to positively impact dimensions of survivors QoL including physical, psychological,

social, and spiritual. Additionally, this qualitative data can be integrated within the larger body of knowledge in this research which is mostly derived from quantitative research [166]. However, although qualitative methods may provide rich data, the methods can be more time consuming [310]. Overall, with an increasing focus on how to improve QoL in this population, an appropriate outcome measure is a priority for research [311]. Another alternative, more convenient and possibly more appropriate measure of QoL in this population is the Impact of Cancer (IOCv2) questionnaire which acknowledges the multidimensional and dynamic impact of cancer [311,312]. Other commonly utilised instruments such as the EORTC-QLQ-C30 and FACT-G, like those included in eight out of the fourteen studies reviewed , may not adequately capture the unique needs of survivors and their QoL [311]. In this review, four studies used the EORTC-QLQ-C30 [276,280,283,287] and four studies used the FACT-G (modified for specific type of cancer) [262,263,276,285] to assess QoL. Many of these validated and frequently used measures of QoL, such as the EORTC-QLQ-C30, focus more predominantly on the physical symptoms rather than psychosocial issues related to treatment for cancer. The FACT-G focusses more on emotional aspects [311]. Furthermore, these questionnaires may not address some of the more subtle aspects of QoL identified by cancer survivors as they were designed to focus more on the early stages of being diagnosed with and treated for cancer [313]. Additionally, most studies in cancer survivorship utilise questionnaires that examine primarily the negative outcomes such as distress, diminished QoL and functional impairments, less is known about positive changes following experience of cancer. The IOCv2 was specifically developed to measure not only the unique negative impacts of cancer, such as worry and body change concerns, but also the positive impact of cancer associated with long-term survivorship, such as increased altruism and positive self-evaluation [311]. To know more about and understand QoL better in this population, it may be beneficial for future studies to consider utilising either qualitative methods alongside quantitative measures or more appropriate measures such as the IOCv2 that encompasses the multi-dimensional aspect of a cancer diagnosis and life following treatment.

The study that reported a significant increase in QoL [263] also reported significant increases in the other two outcomes, PA and PF, assessed in this review in the intervention group. Participants included in this study were post primary and adjuvant treatments which may have influenced these results. Improvements in PA and CRF are associated with improvements in QoL [100], this may have facilitated the changes in QoL observed. Furthermore, the home-based intervention delivered in this study consisted of aerobic exercise which consisted of either walking, cycling or use of home exercise equipment, and participants in both the intervention and control groups

received telephone calls over the twelve weeks to control for frequency of contact and received PA and colorectal cancer survivorship tip sheets. This may explain why significant improvements were also found for PA and treadmill time in the control group [263]. A further four studies reported significant improvements in subscales of questionnaire/survey measures post-intervention in the intervention groups [163,282,283,285], one of which reported stable scores for QoL [283] (see table 3) which further suggests that home-based PA and exercise interventions may help to sustain health-related outcomes by preventing declines had participants not taken part in such interventions. However, more work is needed to support these findings. Furthermore, three of these studies provided solely aerobic exercise interventions [163,283,285] and one provided a combined aerobic and resistance exercise intervention [282]. As previously suggested, interventions that offer an aerobic exercise component and additional support may elicit positive health outcomes, such as improving QoL. However, future work is needed to potentially offer a more accurate representation of these findings as most of the studies did not report significant improvements in QoL.

One study reported a significant group difference for three subscales of the SF-36 and two subscales of the QLACS, despite seeing significant improvements in four dimensions of the SF-36 and nine dimensions of the QLACS in both obese and non-obese survivors. Non-obese survivors demonstrated significantly better QoL in three dimensions of the SF-36 and two dimensions of the QLACS than obese survivors, both groups received the same intervention. In addition, participants included in this study were also post-treatment which may have influenced these findings and explain the lack of significant changes in QoL in the other studies given that the majority were during treatment. [163]. More than 60% of female cancer survivors may gain weight following a cancer diagnosis because of their body's response to treatment and those with higher BMI's have reported decreased physical and mental QoL [314]. Therefore it is important to consider the psychological symptoms associated with obesity and coping with a cancer diagnosis and the impact this may have on QoL [315]. This may provide an explanation for why non-obese cancer survivors reported better QoL compared to those cancer survivors in the obese group [163]. However, it is important that the significant improvements in QoL in the individuals in the obese group do not go unnoticed, especially as greater levels of depression and feelings helplessness have been identified in obese survivors [315]. Taken together, these findings add to the small body of evidence provided by this review of home-based PA and exercise interventions in potentially offering beneficial effects on health outcomes in this population, particularly in obese and non-obese survivors, by improving QoL.

However, further investigation is crucial due to the limited number of studies reporting improvements, especially as improving QoL in this population is of high priority.

Like that of the previous outcomes, reports of adherence were inconsistent and varied across studies making it challenging to distinguish whether adherence was reported for the intervention/exercise prescription or overall study. Previously highlighted in a recent Cochrane review, adherence to exercise interventions is crucial but frequently either poorly reported or not reported at all [273]. Nine out of the fourteen studies reviewed reported adherence to the intervention/exercise prescription [162,164,262,280,281,283–285,287]. Out of the nine studies, three [280,281,287] reported levels of adherence for type of exercise, aerobic exercise ranged from ~65% to ~109% and resistance exercise adherence ranged from ~46% to 78%, retrieved from self-reported measures (exercise dairies). Interestingly, across all three studies, adherence to aerobic exercise was higher than resistance exercise, and in one of these studies reasons for incomplete adherence such as feeling overwhelmed or becoming too sick were reported by participants [280]. Lower adherence to resistance exercise may be explained by the fact that participants were having active treatment therefore may have been experiencing symptoms and side-effects associated with treatment and perhaps struggled to perform resistance exercise but found gentle aerobic exercise such as walking more tolerable during this time. Walking has been cited as the most preferred type of PA by survivors across a variety of cancer types during the treatment and post-treatment stages [135]. One study reported ~90% of participants completed the study [276], another reported an adherence rate of ~86%, although it was not clear if this was to the intervention or overall study [286] and a further three studies did not report adherence [163,263,282]. However, one of these studies noted that ~40-65% met 150 min/week PA post-intervention and ~20-30% at follow-up [263]. The dropout rate was generally reported as low and reasons for attrition were similar across the studies, these included cancer recurrence, disease progression, treatment, death and unable to participate. This is an important aspect for assessing the success of an intervention as high dropout rates may indicate that the intervention may not be suitable for this population [299].

9.5 Strengths and limitations

Some of the disparities in the findings may be due to the wide range of measurement tools used and variables of PA, physical fitness and QoL reported in the fourteen studies reviewed. Considering PA, twelve studies used self-report measures [162,163,262,263,276,280–283,285–287] and seven studies used device-based measures [162–164,281,282,284,287], with five studies using a combination of both [162,163,281,282,287]. This made

comparisons between studies extremely challenging due to the large range of outcomes and variables reported (e.g. MVPA, steps, total PA time, MET's). There is a need for the adoption of standardised measures of PA using validated methods and consistent processing techniques, this may allow for a better understanding of PA in this population and enable more accurate comparisons to be made across studies. Like that of the PA measures and variables reported, comparisons between studies for physical fitness were difficult due to the large range of outcomes reported with no consistent variable reported, this was particularly evident for muscular strength. VO_{2peak} and VO_{2max} appeared to be the most reported CRF variables and 1RM appeared to be the most reported muscular strength variable (see supplementary table 2). Considering QoL, frequently used measures included the SF-36 [162–164] and EORTC-QLQ-C30 [276,280,283,287], perhaps due to their high reliability and validity (see supplementary table 3). Furthermore, most studies were judged as 'high risk' when being assessed for risk of bias, highlighting the lack of information being reported by studies in this area of research. However, the dates of studies included in this review ranged from 2003 to 2021, as research in this area develops particularly considering the COVID-19 pandemic where there may be provision of remote interventions, improvements may be seen in the methodological quality of studies.

9.6 Conclusion

The effect of home-based PA and exercise interventions on PA, PF and QoL appears complex. Given the lack of improvements reported for these three outcomes, further work is needed. However, the findings provide some evidence for the positive effects of home-based PA and exercise interventions on PA, PF and QoL in this population, particularly those with aerobic exercise components and additional support.

9.7 Recommendations

Future studies in this area should adopt more consistent assessment methods for PA including combined approaches of device-based and validated self-report measures. There is also a need for standardisation across future studies in terms of assessment methods, this may help to facilitate future reviews and the potential meta-analyses in this area.

Thesis study map

Study	Aims and key findings	Philosophical positioning (Crotty model chapter 4)
Study 1: Exploring barriers, facilitators and reinforcing factors for PA participation amongst cancer survivors	**Aims:** 1. To explore perceptions of general PA, 2. To identify barriers and facilitators for group-based PA participation, 3. To provide formative information to inform the design of group-based PA/exercise interventions. **Key findings:** • Tiredness/fatigue, family and friends, and gym environment were frequently reported barriers. • Group-based activity was frequently reported as a key facilitator for PA participation. • Other frequently reported facilitators were the perceived physiological and psychological benefits of PA. • Facilitators of group-based activity were the activity program being perceived as a 'safe place' and the cost-free nature of the activity program.	**Epistemology = constructivist paradigm** **Theoretical perspective = constructivist approach** **Methodology = qualitative** **Methods = focus groups**
Study 2: Utilising RE-AIM to evaluate the feasibility of a virtual home-based exercise intervention during the COVID-19 pandemic	**Aims:** 1. To evaluate intervention feasibility by exploring acceptability and satisfaction of a virtual home-based exercise intervention, 2. To explore the effectiveness of the intervention on a variety of participant outcomes including motivation and competence to take part in PA, PA behaviour, quality of life and	**Epistemology = Pragmatism paradigm** **Theoretical perspective = pragmatic and constructivist approach** **Methodology = mixed-methods**

	physical fitness using a mixed-methods approach, 3. To retrospectively explore participant experiences moving from a gym-based to home-based setting during the global COVID-19 pandemic using focus groups. **Key findings:** • Significant improvements in mental health dimension of SF-36 from baseline to post-intervention. • Significant improvements in physical fitness (wall squat duration) from baseline to post-intervention. • High levels of acceptability and satisfaction for the intervention. • Group-based format of intervention and coach were reported as key facilitating factors for adherence to intervention. • Stakeholder recognised coach as fundamental component of intervention's success. • At 6-month follow-up, intervention was still being delivered and over half of the participants were still attending.	**Methods = combination of quantitative and qualitative methods including, questionnaires, surveys, fitness test, focus groups, interviews**
Study 3: Home-based PA and exercise interventions in cancer survivors: a systematic review	**Aims:** 1. To conduct a systematic review of peer-reviewed evidence to explore the effects of home-based PA and exercise interventions on outcomes PA, PF, and QoL in cancer survivors. **Key findings:** • Effect of home-based PA and exercise interventions on PA, PF and QoL appears complex • Some evidence to support the positive effects of home-based PA and exercise interventions on PA, PF and QoL,	**Epistemology = Positivist paradigm** **Theoretical perspective = positivism** **Methodology = experimental research (systematic review of)** **Methods = statistics (within each study reviewed)**

	particularly those with aerobic exercise components and additional support • Large variability in assessments tools used and outcomes reported • Need for standardisation across studies in terms of assessment methods and outcomes/variables reported • Frequency, modality, intensity, duration and prescribing of interventions varied across studies • No supervision or group-based formats included in intervention designs in the included studies • Lack of process evaluation of interventions conducted	

10. SYNTHESIS OF FINDINGS

10.1 Introduction

Over the past three decades, research has documented the benefits of PA and exercise for cancer survivors and is rapidly gaining momentum. However, as already highlighted in this thesis (chapters 5, 7, 8 and 9) the number of cancer survivors engaging in PA and exercise is low with many failing to meet the recommended PA guidelines [111]. Despite an increase in the provision of PA and exercise programs/interventions aimed at promoting PA in this population, uptake to such programs/interventions has been low [6]. There is an urgent need to understand cancer survivors and their relationship with PA and exercise to inform effective intervention design and improve rates of uptake and adherence in this population.

The overall aim of this thesis was to explore PA and exercise participation in adult cancer survivors, with a specific focus on group-based PA and exercise. Study 1 (chapter 7) explored perceptions of general PA in a sample of cancer survivors who were already attending group-based exercise sessions at a Merseyside gym facility. Qualitative methodology was employed (see chapter 4) and identified barriers (fatigue, family and friends, and gym environment) and facilitators (group-based format, and physiological and psychological benefits) for PA and exercise participation. In the planning stages of the original Study 2 pre COVID-19 pandemic, this formative information was used to facilitate and inform the design of a cross-sectional study, and a group-based PA and exercise intervention study that would be conducted as the third study of this thesis. However, it was not possible to conduct the cross-sectional study due to the pandemic. A protocol was then developed for a feasibility study utilising the formative information from Study 1 to facilitate the design, current Study 2 (chapter 8), utilising the RE-AIM planning and evaluation framework. This framework was used to evaluate the feasibility of the virtual home-based exercise intervention by exploring acceptability, satisfaction, and the effectiveness of the intervention on a variety of outcomes including PA, QoL and PF using a mixed-methods approach (see chapter 4). In addition, and with consideration of the literature documenting the need to understand participant experiences of such PA and exercise programs/interventions as well as the COVID-19 pandemic, participant experiences of moving from a gym-based to home-based setting to exercise during the pandemic were retrospectively explored. This rich, qualitative data was utilised to further support the findings from the other measures in Study 2 including the Program Evaluation Survey (PES).

Prior to the 6-week intervention, participants were already engaging in virtual exercise as the Foundation had transitioned their service to an online delivery model using the Zoom platform. This was a match-funded PhD project, and it was important for the Foundation to have the virtual mode of service delivery thoroughly evaluated. Given the numerous lockdown periods and gym closures that were ongoing from 2020, the Foundation needed to be able to continue to deliver their service during this time and had consideration of this mode of delivery long-term depending on the virtual intervention's success. Considering the outcomes measured and explored in Study 2, and the design of the intervention, previous literature appeared limited in this area. Given the novelty of this virtual home-based exercise intervention study, and to broaden our perspective of remote/home-based PA and exercise interventions on specific outcomes including PA, PF and QoL, a systematic review of the literature was conducted for Study 3 (chapter 9). The aim of the review was to explore the evidence of home-based PA and exercise interventions on PA, PF, and QoL in cancer survivors during and post-treatment (see chapter 4). This synthesis summarises the key findings and overall themes from studies 1 to 3, highlights the strengths and limitations of the research, reflects on the challenges faced by the researcher and supervisory team particularly during the COVID-19 pandemic, and presents recommendations for future research and practice. Given the positionality of the researcher/coach, researcher reflections are provided to further illustrate the key findings and themes highlighted in this thesis.

10.2 Summary of key findings

Study 1 first explored barriers, facilitators, and reinforcing factors for PA in a sample of cancer survivors', with a variety of cancer types, currently attending a group-based exercise program based at a gym facility in Merseyside. Some findings, like fatigue as a barrier for PA and exercise, were consistent with previous research [6,125,129]. A unique finding from this Study was the group-based format of the exercise program being a key facilitator for participants engagement in general PA and attendance/adherence to the exercise program. This was reported by all 10 participants who took part in this qualitative study (see chapter 7 results section facilitators and reinforcing factors), for example:

It's [seeing each other] motivating to see each other, isn't it? I really enjoy it. (P7)

This finding is consistent with a recent qualitative study [158]. Social support was the most frequently reported facilitator for centre-based exercise by participants, exercising as a group and the resulting group dynamic was found to be very motivating [158]. These findings are consistent with earlier research where cancer survivors/patients have reported preferences for engaging in PA and exercise with other survivors/patients because of the peer/social support, shared experiences and sense of belonging being together offers as they share similar paths following diagnosis [129]. Given that the group-based format was a key, unique finding in Study 1, and considering the impact the group-based format had on the participants (see chapter 7 results section facilitators and reinforcing factors), it was imperative that it was included in the design of Study 2, the virtual home-based intervention. Study 2 further supported the findings from Study 1 and expanded on the facilitative nature of the group-based format for PA and exercise, only this time in a home-based exercise setting. All 13 participants post-intervention, and 12 participants at follow-up reported the group-based format of the virtual home-based exercise intervention as beneficial and an encouraging factor for them to attend throughout the 6-week intervention period. For example:

Absolutely, the group-based nature was really beneficial as you could see others at all different stages of their cancer treatment, and it spurred me on (P5)

In addition to the facilitative nature of the group-based format, participants in both Studies 1 and 2 explained how supportive the group has been to them during their cancer journey (see chapter 7 and 8 results section). Previous work has demonstrated that when PA and exercise is delivered in such group-based contexts it can also provide opportunities for obtaining support for coping with life following diagnosis [316]. Therefore, the support provided may also have influenced participants engagement with PA and exercise in Study 1 and Study 2.

It's [group-based activity program] given me so much hope, and it's [group-based activity program] been a massive help... (P8)

Being part of the group was definitely beneficial because we probably spurred each other on. There was lots of support and camaraderie. Plus, though we don't know the specifics of each other's cancer experiences, we all have that common bond and empathy for one another (P1)

In Study 1, participants also reported that the group-based exercise program encouraged them to take part in more sports/exercise, new physical activities and motivated them to become more active overall outside of the exercise program. These findings suggest that the group-based exercise program may have facilitated behaviour change towards PA and exercise in this sample of cancer survivors. In turn, this may have encouraged maintenance of PA and exercise behaviours. Social support has been previously recognised as an important component for the adoption and maintenance of PA behaviour [316]. The findings from Study 1 are similar to Schneider's qualitative study were participants reported how exercising as a group motivated them to maintain their PA following completion of the centre-based exercise program [158].

Utilising the RE-AIM framework in study 2 allowed for the evaluation of participants PA and exercise maintenance. At follow-up, 64% of participants reported how the group-based format helped them to maintain their attendance 6 months post-intervention. Over half of participants were still attending the virtual exercise program following completion of the 6-week intervention. As a result of the interventions success as a mode of service delivery it continued and is currently still being delivered two years following the initial 6-week intervention. In addition, 45% of participants reported an increase in PA levels and 55% of participants reported the physical benefits as facilitating factors to maintain PA at follow-up (see chapter 8 discussion section Maintenance). These findings are important because for cancer survivors to achieve the long-term health benefits, they must be habitually active and to be habitually active this requires a level of behaviour change [5]. The findings from Study 1 and 2, and the supporting literature suggest that PA and exercise programs/interventions that include group-based formats may be effective in promoting behaviour change for PA and exercise in this population. Overall, this may lead to improved long-term PA and exercise maintenance [158]. Group-based PA and exercise programs/interventions may therefore facilitate not only participation in regular PA and exercise, but also facilitate sustained behaviour change for PA and exercise in cancer survivors facilitating long-term maintenance of such behaviours. Future programs/interventions are needed that include group-based formats to further support these findings.

In Study 2, all thirteen participants reported the coach as a key facilitator for adherence to the home-based exercise intervention, and consensus for this finding was shared in the additional focus groups. The theme derived highlighted the coach as a key factor supporting the acceptability and satisfaction of the virtual home-based

exercise intervention. In addition, the Stakeholder largely attributed the virtual home-based intervention's success to the coach during the Stakeholder interview which was conducted at follow-up.

I think your [the coach] capacity as a coach to be able to coach a complex group like that remotely is not standard practice. I don't think a lot of people would have the confidence, and I don't think a lot of people genuinely would have the eye to it, because you've got to be able to see where you can, and coach what you can, based off these little boxes on a screen. So, I think throughout all that, and certainly the feedback that we've had, which has only ever been positive, it's been a triumph, really.

The qualitative data obtained from participants captured positive perceptions the participants had for the coach (see chapter 8 results section). More specifically, participants reported how the coach largely influenced their experiences of the intervention, which was attributable to the setting the coach created, both in the gym and virtually at home. Participants expressed how this setting was fostered by the coach's level of professional service delivery, ability to provide extensive knowledge regarding exercise training, particularly resistance training, and by how attentive the coach was in terms of being able to adapt exercises to the individual as well as motivate participants to achieve their full ability during the exercise sessions (see chapter 8 results section). Overall, "encouraging", "motivating" and "confidence" were terms that participants frequently used when referring to the coach and the impact the coach had for their participation in PA and exercise, for example,

…C [coach] was the glue that bound us all together. She understood how much to challenge the group and yet I never felt intimidated or that something was beyond my achievement. C [coach] had a marvellous ability to encourage. She is so thorough in her lesson/activity planning and an excellent communicator and observer. She always made sure we were all achieving exactly what the exercises intended. (P4)

…you [coach] giving us definitely the confidence that we can do things, and to push ourselves that much harder, which I think is really helpful, and as much as you did it in the gym, you still have the ability to do it on the Zoom class as well, which is great. (P12)

It [supervised delivery] was encouraging too. You're very motivating, and you know exactly what you're doing, you're really knowledgeable and you give alternatives if people can't do what you set…you make you feel confident that you can do it. (P7)

…you do instil that confidence…I see myself as superwoman, because of the confidence that you've instilled…people say to me, "Don't you get tired?" but I seem to have this energy all the time…I feel the more I do, the more energy it creates. (P11)

Similar findings have also been reported in a previous qualitative study where participants demonstrated positive perceptions of the instructor and reported that their experiences throughout the program were largely influenced by the instructor and the climate they created in a group-based exercise program and how this contributed to participants motivational experiences [317]. In a more recent qualitative study, a main facilitator for centre-based exercise was the support from trained exercise professionals including specific information about exercising that was specific to cancer survivors, this helped participants to feel safe and understand the benefits of exercise during their cancer journey [158]. The findings from this previous research and the current thesis suggest that coaches/instructors may play a significant role in providing support, nurturing cancer survivors' motivations and decisions to adhere to group-based exercise interventions/programs. Overall, these findings add to this novel body of literature as it has not been previously clear *how* coaches/instructors have contributed to cancer survivors' motivations and reasons for adherence throughout group-based exercise [317]. Identifying specific factors for exercise adherence such as the utilisation of a coach/instructor in the delivery of PA and exercise programs/interventions may inform the design and delivery of interventions/programs [318]. In addition, previous work has also documented cancer survivors preference for structured, supervised exercise because of its motivating and facilitating nature [129,211].

Overall, these findings suggest that the exercise program (Study 1) and home-based intervention may have facilitated behaviour change in these individuals, largely influenced by the group-based format and coach. These findings align with the themes of SDT [13] which were discussed in the introduction section of this thesis. As outlined in the introduction and general methods chapters of this thesis, the practitioner-researchers professional working practice was largely informed by SDT. Therefore, future interventions in the exercise oncology field may benefit from applications of SDT within their design and delivery.

The group-based format may have largely supported the participants experiences of relatedness. As defined earlier, relatedness concerns a sense of belonging and connection, and it is facilitated by conveyance of respect and caring [10]. Furthermore, social contexts catalyse both within- and between-person differences in motivation and personal growth, resulting in people being more self-motivated, energised and integrated in some situations, domains and cultures than in others [13]. The social-contextual conditions provided by the group-based nature of the Foundation's exercise program and virtual home-based intervention may have facilitated participants self-motivation by enhancing their levels of both intrinsic and extrinsic (identified and integrated regulation) motivational processes through satisfying the psychological needs and support for relatedness [13]. This is an important finding as the satisfactions for relatedness may have supported participants uptake, adherence and maintenance to PA and exercise, resulting in a level of behaviour change. From a public health perspective, this is largely beneficial in the active promotion and uptake of PA and exercise in this complex population. From examining the qualitative data regarding the coach obtained from Study 2, the coach and their delivery style of the exercise program and home-based intervention may have largely facilitated participants experiences of competence throughout the home-based exercise intervention and general adherence to the Foundation's exercise program. Overall, the satisfaction of these basic psychological needs may have facilitated participants motivational processes throughout Studies 1 and 2 in this thesis and resulted in levels of behaviour change. This may have an important public health impact in this small cohort of cancer survivors and provides evidence for group-based, structured PA and exercise interventions/programs for facilitating positive behaviour change in this population.

Researcher reflections on the group-based exercise sessions and their role as the coach

After enrolling on this PhD project, I began delivering structured, group-based exercise sessions to the members of the Foundations program for cancer survivors. Some members had been attending the program before I started coaching and the other members joined the program around the same time as myself. Initially, I was apprehensive regarding my delivery style as I had previously observed another coach and their exercise delivery to the group and was aware that we both differed in terms of our style of delivery style. I slowly eased myself in as I began delivering the sessions still including some of the delivery style the members were used to which was largely flexibility and some free weight exercises delivered in a circuit style session. At the beginning of each session, I gathered the group and explained what was going to be covered in the sessions and why. I then preceded to take the group through a dynamic warmup including mobility and activation exercises that would prime them ready for the exercises that would make up the main body of the session. Following the warmup, I demonstrated and explained each exercise with regressions and progressions options to facilitate each members ability. Each session consisted largely of strengthening exercises performed in the fundamental movement patterns including squat, hinge, push, pull, single leg, carry and core exercises followed by cardiovascular conditioning exercises. I was present throughout the entire session, working my way round the group coaching where necessary. At the end of the session, I took the group through a cool down and checked in with each individual and asked for feedback from the group about the session they had just completed. In support of the findings from Study 2 regarding the coach, I think my role may have facilitated the uptake and adherence to not only the intervention but the overall activity program itself. In addition, I also feel that it may have helped foster the relationships among the group as during the sessions I partnered members up together in pairs or small groups and made a conscious to rotate the members together each week. This appeared to facilitate more social interaction and engagement between the members, they also commented on this during the sessions and how they enjoyed working together.

In addition to group-based interventions/programs facilitating improvements in PA and exercise, interventions/programs in this context may also have a beneficial impact on survivors physiological and psychological health. Previous studies have provided evidence from similarly structured group-based exercise programs/interventions highlighting that such programs/interventions may not only be an effective way to encourage cancer survivors to be physically active and engage in regular exercise but can also effectively promote positive physical and psychological health [317]. Throughout Studies 1 and 2, participants frequently reported the positive impact of the group-based activity program and home-based exercise intervention on their physiological and psychological health (see chapters 7 and 8 results section). Considering the SDT themes, these findings may have satisfied and supported participants needs for autonomy (value). Again, facilitating their motivational processes in the uptake and adherence to PA and exercise, resulting in behaviour change. For example:

…I started hormone treatment over six years ago, my bone density is stronger now than when I started treatment. It is two and a half years ago that I started coming to the classes…and I firmly believe the credit is due to this. (P6)

My legs and upper body feel stronger which builds up your confidence, especially after going through cancer treatment where you feel so weak and depleted. (P3)

Improving my physical state, in terms of muscle strength and range of movement, has definitely impacted on my mental health and in terms of energy levels…I have got more energy. (P4)

In addition, findings from the virtual home-based exercise intervention conducted in Study 2 demonstrated statistically significant improvements in mental health scores and physical fitness (see chapter 8 results section). The mental health dimension was the only dimension of the SF-36 that significantly improved when assessed in Study 2 post-intervention. There are two possible explanations for these findings. Firstly, it is important to consider that participants QoL may have already been in a 'good place' prior to and at the beginning of the intervention. These participants had already been engaging in regular PA and exercise as part of the Foundation's exercise program. Secondly, as discussed in Study 3 (see chapter 9 discussion section), metrics alone may not be enough to offer meaningfulness of QoL data or capture an accurate representation of a survivor's QoL at various measurement periods. This may also further explain why a limited number of studies included in the review found

significant improvements in QoL in Study 3 (see chapter 9 results section). The qualitative data obtained, not only in the home-based intervention, Study 2, but also Study 1 captured the positive impact the Foundation's exercise program and home-based intervention had on participants QoL. These findings highlight the importance of studies in the PA and exercise for cancer survivors' literature to consider including qualitative methods, such as focus groups, in their design to optimally assess QoL in this complex population. Regarding the significant improvement in the wall squat test, participants performed the wall squat test together on Zoom. The coach conducted everyone's test individually and provided support and encouragement along with the other participants who were waiting to perform their test. Although the motivational environment created by the coach and other participants may have fostered relatedness and competence which may have facilitated the improvements in the wall squat test post-intervention, this motivational environment may have affected the validity of the wall squat as a measure of lower body strength and influenced the results. In addition, although participants were provided with written and verbal instruction for how to perform the wall squat, given that the test was conducted on Zoom, it is important to consider that participants may not have performed the test correctly which may have also influenced the results. Seven out of the fourteen studies included in the review reported significant increases in physical fitness, five for aerobic fitness and two for muscular strength (see chapter 9 results section). A total of nine studies assessed muscular strength. The lack of significant improvements in muscular strength may be due to the climate the tests were conducted in. However, it is difficult to draw more accurate conclusions due to the variety of methods used to assess PF, as well as PA and QoL in the fourteen studies included in the review, Study 3 (see chapter 9 results and discussion sections, respectively).

It is important to note the safety as regards to the virtual home-based intervention conducted in Study 2. During the COVID-19 pandemic, SafeFit, a multimodal intervention of PA, nutrition, and psychological support delivered virtually by cancer exercise specialists (CES), was designed to support anyone in the UK with suspicion of or confirmed diagnosis of cancer [304] (see section 10.4 in synthesis). Within the SafeFit protocol, a safety protocol is provided for the virtual sessions whereby it is the responsibility of the CES to complete a pre-session screening checklist to monitor condition, medical contacts, medication, and COVID-19 status. In the event of an acute medical event during an exercise session or a confirmed diagnosis or suspicion of COVID-19, as part of the safety protocol, the CES has specific procedures to follow. At the time of intervention delivery in Study 2, the research team was not aware of this protocol and did not have these set procedures in place for any adverse events. Future

work should adhere to and implement such procedures as part of intervention delivery to ensure the safety of participants.

10.3 Engaging oncologists and clinicians

Although not a key theme across the thesis, it is important to acknowledge the data obtained from the focus group discussions in both Studies 1 and 2 where participants explained the conflicting and/or lack of information for PA and exercise they received following their diagnosis (see chapters 7, 8 and direct quotes below). These findings align to the literature where an urgent 'call to action' for oncologists and clinicians has been demonstrated to start building the tools and systems required to engage patients/survivors with PA and exercise recommendations [111,319]. This next section addresses the important role oncologists and clinicians may play in the promotion and uptake of PA and exercise in cancer survivors.

No, there's nothing you can do to help yourself. Nothing at all. No diet and exercise, nothing. (P6)

…when I had my sign-off with the breast care nurse, I mentioned it [the program] to her then to say I was interested, and she said, "Oh yes, I am aware of it", but I think they need to factor that in to that appointment, because you're finished with your treatment, you're getting signed off, you're an absolute shell of your former person, and so it's just a way of saying, "We've got this added support", because sometimes you feel as if the hospital finishes with you, and you're just left high and dry. (P3)

…I was telling this substitute consultant what I was doing at the gym and everything, and about my diet and how I was keeping fit, and he said, "Oh, that won't make any difference. That won't stop it coming back"…I couldn't believe it…I was on a downer for ages after that. (P11).

Researcher reflections on the advice provided by oncologists and their role as the coach

I recall participant 11 telling the group and myself at the gym about this conversation with the substitute oncologist. They were extremely upset, and I remember them explaining the negative impact this had caused to their mental health in the days following their appointment. They said that they were considering taking this advice from the consultant and were going to stop attending the group-based exercise sessions and the efforts they had put in place regarding their diet and frequent PA. Given my role as their coach, I gathered the group, and we had a discussion around the benefits of exercise and what they were doing in terms of leading an active, healthy lifestyle and the obvious impact it was having on their lives to date, particularly this participant's as they had voiced feeling physically and mentally stronger many times during the group-based exercise sessions. At the end of the discussion the participant said she felt supported and knew that what she was doing was helping her on her road to her new life as a cancer survivor. Considering my philosophical positioning and the impact this has had on the research process of this PhD project, I feel it may have positively facilitated this participant's engagement with exercise, as well as the groups following this discussion.

It is well documented across the literature that reasons for a lack of regular engagement in PA and exercise among cancer survivors are multifactorial [111]. However, numerous studies have documented survivors reporting a lack of recommendation for PA and exercise from an oncology clinician as a barrier for PA and exercise engagement [18,111]. A recent qualitative study highlighted that only 46% of cancer survivors reported receiving exercise guidance from healthcare professionals following diagnosis, and was perceived as a key barrier to exercise by a cohort of survivors with a variety of cancer types [320]. In addition, previous work exploring oncologists and oncology care provides knowledge, attitudes and practices towards PA promotion in survivors demonstrated that oncologists reported a modest ability to promote PA, low promotion rates and limited knowledge of exercise prescription [159]. In support of the 'call to action' document [111], the findings from this thesis and supporting literature further illustrate the need for more informative processes embedded into the early stages of oncology clinical care. More recently, a framework has been provided for clinical decision making that enables personalised condition assessment, risk stratification, and referral to optimal settings for exercise promotion for cancer

survivors [319]. The framework consists of 5 domains: cardiometabolic status, oncologic factors, aging considerations, behavioural characteristics, and environmental elements. The 5 domains offer a framework for efficient and effective screening that facilitates assessments of elements most relevant to identifying decreasing PA in this complex population and guide clinical decision making for personalised exercise recommendations and referrals adapted to a survivor's existing and evolving needs [319]. To achieve the implementation of this framework, there is firstly a need for enhancements and developments in the oncology clinical setting [319]. Successful implementation into oncology clinical care practices may help to better support cancer survivors for PA and exercise engagement.

Oncologists review their patients regularly, often several years following diagnosis and may be perceived by their patients as figures of authority [153]. As a result, oncologists may be in a unique position and play a valuable role in the promotion of PA and exercise [18,153,319]. Despite this, oncologists may not have access to referral pathways and/or services as well as in-depth knowledge of PA and exercise prescription [153]. Therefore, there is an urgent need to support oncologists in acquiring skills to promote PA and exercise to ensure they have the capability to be able to facilitate PA and exercise prescriptions, promotion of the importance of PA and exercise for health and refer their patients/survivors to the relevant resources and facilitate exercise prescriptions/recommendations. To do so, oncologists, clinicians, and oncology care staff need to be; educated on the value of regular PA and exercise for this population, provided with more clarity on the types, safety, and suitability of exercise for the individual survivor, more aware of available PA and exercise programs and be able to offer direct referrals to relevant programs and/or exercise professionals [111,159]. The contact patients/survivors have with their oncologists may serve as a crucial window of opportunity to facilitate the uptake of PA and exercise in these individuals. This may sustainably increase the number of cancer survivors who engage in exercise and/or keep physically active [111]. Overall, this may help to reduce the global burden of this devastating disease.

10.4 SafeFit Trial

Aside to engaging oncologists and clinicians in the promotion of healthy lifestyle behaviours including PA, cancer patients can now directly refer themselves to a new trial that supports healthy lifestyle behaviours in the UK. In response to the COVID-19 pandemic, SafeFit, a multimodal intervention of PA, nutrition, and psychological

support delivered virtually by cancer exercise specialists (CES), was designed to support anyone in the UK with suspicion of or confirmed diagnosis of cancer [304]. Overall, the aim of this trial is to maintain and improve physical and emotional wellbeing in cancer patients. The trial is for adults (18 years+) and is designed to provided individuals with exercise advice based on their needs that they can complete safely at home, help individuals find different and new ways to keep active and eat healthily, and improve individual's overall wellbeing. CES deliver remote sessions via individual telephone consultations, one-to-one and group video exercise sessions, and group sessions. For anyone with COVID-19, their exercise intervention is paused but they will still receive the other interventions providing nutritional and psychological support [321]. The evidence-based SafeFit trial is to support patients/survivors throughout and beyond the COVID-19 pandemic. Individuals with cancer are increasingly turning to remote services and distanced and home-based interventions have also been shown to be effective in supporting dietary and PA behaviour change in this population. In addition, it is well documented that interventions including a level of supervision increases adherence and long-term maintenance of PA behaviour change. The SafeFit trial is underpinned by behavioural science using evidence-based behaviour change techniques to facilitate engagement and to support self-management and long-term behaviour change in cancer patients. The virtual delivery method allows access to personalised and supportive content offered by the trial from the patient's homes which during the pandemic, helped to reduce the risk of exposure to COVID-19, and also helps to remove frequently reported barriers to in-person interventions as discussed throughout this thesis [304]. Overall, this virtual trail spanning throughout the UK may help to increase the number of cancer patients and survivors engaging in PA and facilitate the promotion of healthy lifestyle behaviours which may positively influence survivorship. The COVID-19 pandemic may have been catastrophic in many ways and affected peoples' livelihoods on a global basis, but it has also led to the development of such programs and trails which are adding to the ever-growing world of exercise oncology research and providing support to this unique population.

10.5 Strengths and limitations

Study specific strengths and limitations were discussed in the relevant chapters, but key strengths and limitations will be briefly summarised here.

A key strength of this PhD project was the accessibility of the PhD researcher, who was also the match-funder's exercise program coach which allowed for direct communication and interaction with participants throughout the PhD project process. Their role appeared to facilitate thorough engagement across the PhD project process, particularly in Studies 1 and 2 and the focus groups discussions. It is important to recognise any biases this role may have caused to the research. In terms of positionality, the researcher had their own views of exercise and gym settings, an invested interest in the participants as their coach and knew participants through the rapport and relationships established throughout the PhD project. To minimise any biases and ensure a robust and rigorous interpretation of the qualitative data for example, themes that emerged were discussed with the HCPC practitioner psychologist by employing between them a process of member checking [187].

In addition, albeit not originally planned in the early development stages of the PhD project, the qualitative stance adopted has served a thorough exploration of PA and exercise among a small cohort of cancer survivors utilising focus groups. Given the 'identity change' following a cancer diagnosis and new living experiences for cancer survivors, employing a more comprehensive assessment utilising qualitative methods may have provided a better understanding of the meaning and utility of PA and exercise during the survivorship period and impact on survivors QoL [309]. PA and exercise have been demonstrated to positively impact dimensions of survivors QoL including physical, psychological, social, and spiritual [309]. Importantly, this qualitative data can be integrated within the larger body of knowledge in this area of research which is mostly derived from quantitative research as demonstrated by findings from the systematic review, Study 3 [166].

The research conducted in this thesis utilised two planning and evaluation frameworks, Precede-Procede and RE-AIM, to inform the research process in Studies 1 and 2. Planning and evaluation frameworks provide structured guidance that facilitates a systematic approach to comprehensively evaluate population needs, the implementation and/or effectiveness or outcomes of a program [322]. Considering the exercise program (Study 1, chapter 7) and virtual home-based exercise intervention (Study 2, chapter 8), understanding if, when, and how these programs/interventions are effective is important to justify policy, program, and funding decisions, and to inform and improve future decisions in research and practice. To achieve this, there is a need for appropriate and comprehensive program/intervention evaluation. Furthermore, the planning and evaluations conducted in Study 1 and 2 were applied to programs in real-world setting generating practice-based evidence which contributes to, and is a fundamental part of evidence-based public health [322]. Overall, comprehensively evaluating

interventions is recognised as an integral part of health research by the Medical Research Council (MRC) to improve the sustainable adoption and implementation of effective evidence-based interventions [240]. In addition, the PRISMA guidelines were utilised to inform the review process in Study 3, PRISMA provides a suitable framework for conducting systematic reviews to answer specific questions [2]. Utilising this framework ensured the process was systematic, transparent, and repeatable.

Key limitations of the studies presented in this thesis are sample size, selection bias and generalisability. The sample size for Studies 1 and 2 were based upon the number of survivors taking part in the Foundation's exercise program. Study 1 included 10 participants, similar qualitative studies have demonstrated similar sample sizes of 11-26 participants [18,129,158,323]. Study 2 included a total of 13 participants. These 13 participants were already taking part in exercise virtually with the PhD researcher/coach as part of the UTS Foundation's exercise program during the pandemic. The virtual home-based exercise intervention was advertised on the Foundation's social media platforms. However, it is not known why more participants did not enquire to take part. Initially, setting up participants with the Zoom platform was challenging as technology use was challenging for some. I designed a guidance document (see appendix 14) and emailed this to the participants to help with this set up process. The technology/virtual element may have been burdensome to other potential participants who were not already taking part in the exercise program. During the recruitment and planning stages for Study 1, it appeared that obtaining a larger sample size would be challenging due to the low number of members joining the Foundation's program. The Stakeholder highlighted issues with recruitment to the program in the Stakeholder interview that was conducted in Study 2. In addition, participants in both Studies 1 and 2 reported how they came to hear of the program through largely friends and family. In the planning stages for the original cross-sectional study, the PhD researcher reached out to Clatterbridge Cancer Charity and the MacMillan staff there to advertise the Foundation's exercise program, to facilitate an improvement the number of survivors taking part in the Foundation's program, and to maximise the number of participants recruited for study 2. Communication initially went well, and a networking meeting was set up for the PhD researcher to attend with various oncologists, clinicians, and care staff. However, the pandemic then occurred and further communication was not feasible.

Considering the sample sizes of the studies included in this thesis along with similar, previous research, this appears to be a hard-to-reach population and highlights a key issue for the promotion and uptake of PA and exercise in this population. During the focus groups conducted in Study 2, participants provided suggestions for

advertising in terms of what they would find appealing as a survivor. Testimonials from current members was suggested as a means of advertising and recruitment as participants highlighted how sharing their own experiences of the intervention could be beneficial for someone to give them who is hesitant about joining and to "give them confidence in joining" (P3), for example:

…in encouraging people, it would be really useful to have examples of people who have really gone through it [intervention] or were using it because that kind of makes it more real for you, and if you're a bit hesitant about whether you'd fit in or how the group progresses, I think it's so useful to talk to someone who's already been through the process. (P4)

Studies 1 to 2 focussed on adult cancer survivors (>18 years), the mean age of participants in study 1 was 47 ± 10 years and 53 ± 11 years in Study 2. One of the main reasons for recruiting adult survivors was because this was the age group of the individuals attending the Foundation's exercise program for cancer survivors. The program is only offered to adult cancer survivors. Therefore, this age group is not representative of all ages. Participants in Study 1 indicated on consent forms that they would be willing to take part in any future research conducted as part of the PhD project research process. It is likely that they expressed their willingness to be recruited because of being interested in the topic of their own PA and exercise behaviour and therefore, selection bias may have been present. These participants were already engaging in the Foundation's exercise program and should not be considered representative of the wider cancer population.

10. 6 Reflections

Finally, conducting this research has personally been a very challenging, but rewarding experience. I have had the opportunity to work alongside a team of diverse, and highly skilled supervisors. Their expertise and guidance have largely facilitated the completion of this thesis, particularly during the COVID-19 pandemic. At the beginning of the pandemic when the first lockdown period was announced, I vividly remember the uncertainty around whether I would complete this PhD project. Learning that all non-COVID-19 related public health research would be postponed was difficult to come to terms with. Much work had gone into the planning stages regarding the ethics application for the cross-sectional study (original study 2) and laboratory training for techniques including vascular ultrasound and venous blood sampling. However, reflecting now despite not being able to put

any of these techniques into practice, I realise that this process was in fact fundamental to my development as a researcher. Although this thesis adopted a largely qualitative stance, I complete this project with both qualitative and quantitative skillsets. In addition, my own thoughts and ideas about cancer survivors PA and exercise, shaped mainly by my own experiences as a Personal Trainer, were challenged throughout the research process by members of my supervisory team, and the participants in my studies. For this I am grateful as it has shaped me into the researcher I am today as I submit this thesis.

On a more personal note, it has been an honour and privilege to work with such a wonderful group of individuals, the participants who took part in two of my studies, and who I have coached throughout my almost 4 years on this PhD project. Although this has not come without its challenges as some of these individuals are no longer with us. I am thankful for the support I have had from my supervisory team, and additional support provided outside of the supervisory team from a psychologist based at the School of Psychology in LJMU to manage these difficult times. Coaching this group of cancer survivors has been the highlight of my week across my PhD journey. Their progress week to week has been outstanding and testament to structured, progressive resistance exercise, further driven by their discipline and determination to show up to the weekly exercise sessions. I am extremely grateful to have been part of their journey as they have navigated their new life as a cancer survivor. They have helped shaped me into the individual I am today, showing me that life is worth living to the fullest and that even in the darkest times, there is hope - I dedicate this work to them.

10.7 Conclusions

The group-based format and the coach emerged as two key findings from this thesis. Both were recognised as key facilitating factors for participants engagement with PA and exercise by the participants themselves. In addition, the coach was recognised as a core component for the successful delivery of the virtual home-based exercise intervention during the pandemic by the Stakeholder. The findings from this thesis offer important, formative information to this growing body of research. The findings may inform effective intervention/program design of future PA and exercise studies for cancer survivors, particularly those conducted in home-based settings, important given the lack of significant findings in Study 3. The studies included in the review, Study 3, did not include group-based formats or coaches However, the was much variability in the assessment tools used and outcomes reported which highlights the need for more standardisation in assessments and outcomes reported across future studies. The findings from this thesis are timely given the recent COVID-19 pandemic where there may be an expansion of home-based interventions/programs. A combination of structured and supervised exercise led by an exercise professional and group-based format, with both facility and home-based elements may be most effective in the promotion, engagement and maintenance of PA and exercise in this population. Future studies including such elements in their design are needed. Overall, the group-based format and coach largely facilitated participants uptake and adherence to PA and exercise, provided improvements in physiological and psychological health, and importantly, provided support to participants in managing and coping with their new life following diagnosis as a cancer survivor.

10.8 Recommendations

Considering the findings presented in this thesis, the following recommendations are made for 1) future research and 2) UTS and the exercise program delivery model, practitioners, and public health.

Recommendations for future research

- Given the small sample sizes in Studies 1 and 2, future studies are needed to explore what the key barriers are for those survivors not participating in PA and exercise interventions/programs or studies exploring cancer survivors' relationships with PA and exercise. The focus groups conducted in this thesis enabled

a rich insight into survivors' perceptions, barriers and facilitators for PA and exercise engagement. Therefore, focus groups may serve as a useful method to gather such information from more inactive survivor populations or those not willing to take part in interventions/programs or studies. Considering the shared experiences and commonalities among cancer survivors, reported by the participants throughout Studies 1 and 2, focus groups may also be a more effective data collection tool as opposed to individual interviews due to the nature of discussion in a group-setting.

- More feasibility studies are needed employing a mixed-method approach utilising quantitative tools such as questionnaires and qualitative tools such as focus groups and interviews. Combining both methods may offer a more in-depth exploration of the effect of PA and exercise interventions/programs on survivors PA behaviour including their motivations and competence to engage in PA and exercise, and physical fitness. Furthermore, a mixed-method approach may help to better highlight the effect such interventions/programs may or may not have on survivors' wellbeing and QoL, metrics alone may not be enough to explore meaningful effects on such outcomes.
- There is an urgent requirement for more studies evaluating the impact of PA and exercise interventions/programs delivered to this population, employing a suitable evaluation framework such as the RE-AIM framework utilised in Study 2 of this thesis. The RE-AIM framework allows for evaluation at both the individual and organisational level. Overall, this may provide more information on the types of PA and exercise interventions/programs that are most effective for long-term PA promotion and engagement, and health benefits, particularly for improving QoL in this population. Furthermore, this would also allow service providers to evaluate the impact of their service and what implementations are needed to facilitate long-term success (see recommendations for UTS and other PA and exercise delivery services section ahead). In addition, exercise oncology intervention studies utilising the Self-Determination Theory in their design and delivery may benefit in terms of intervention success and effectiveness.
- More standardisation is needed across future PA and exercise intervention/program studies including randomised controlled trials and longitudinal designs, regarding assessment methods and outcomes reported. In Study 3, the systematic review, most studies were judged as 'high risk' due to the variability in reporting of measures and outcomes including PA, PF and QoL. This made comparisons across studies extremely challenging and the hindered the ability to draw meaningful conclusions from the data. If researchers adopt more standardisations in assessment methods and outcomes reported for PA, PF, and

QoL in PA and exercise intervention/program studies, this may help to facilitate opportunities for future meta-analysis in this area of research.

Recommendations for UTS, and other PA and exercise delivery services

- UTS and other PA and exercise delivery services should consider including group-based formats in their program design to facilitate uptake and adherence to such programs. In addition, improvements in uptake and adherence may facilitate behaviour change for PA and exercise in this population and facilitate long-term PA and exercise engagement and maintenance.
- UTS and other PA and exercise delivery services should consider including coaches/exercise professionals in their program design to deliver and supervise PA and exercise sessions to further facilitate adherence to such programs and positive long-term behaviour change for PA and exercise. In addition, coaches/exercise professionals should use Self-Determination Theory to inform their work as standard practice in these specific settings.
- UTS and other PA and exercise delivery services should consider offering structured exercise training programs to either individual survivors or groups of survivors. In addition, these exercise training programs should be adapted and tailored to the individual.
- UTS and other PA and exercise delivery services should consider offering a combination of both facility- and virtual home-based interventions/programs. In addition, UTS and other PA and exercise delivery services could also provide participants with PA and exercise recommendations/goals to be performed outside of the structured, supervised sessions.
- UTS and other PA and exercise delivery services should evaluate the impact of PA and exercise programs and potential changes in participants PA and exercise behaviour over time as a result of engaging in the programs. Employing a mixed-methods approach utilising both quantitative and qualitative methods may serve as the most meaningful way to thoroughly evaluate PA and exercise programs.
- UTS and other PA and exercise delivery services should place an emphasis on actively advertising PA and exercise programs. Utilising current participants testimonials may serve as an extremely effective way of advertising these programs to the wider cancer survivor population. In addition, this information could also be provided to oncologists and oncology care organisations to assist in the promotion of PA and exercise. This may help to educate oncologists and in turn facilitate the first steps of behaviour change for PA and exercise if oncologists are promoting PA and exercise in routine clinical care.

- UTS and other PA and exercise delivery services should explore setting up referral pathways with oncology care organisations. This may help to increase the number of potential participants accessing and utilising such programs. Overall, this may thoroughly aid increasing the number of cancer survivors engaging in PA and exercise.

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12. APPENDICES

Appendix 1: Study 1-Participant information sheet

LIVERPOOL JOHN MOORES UNIVERSITY
Participant Information Sheet For Individuals with Cancer

LJMU's Research Ethics Committee Approval Reference: 19SPS015

YOU WILL BE GIVEN A COPY OF THIS INFORMATION SHEET

Title of Study: 'A formative study exploring individuals with cancer perceptions of physical activity: The barriers, reinforcing and enabling factors for physical activity engagement utilising the Precede-Procede model.'

School/Faculty: Sport and Exercise Sciences

Name and Contact Details and status of the Principal Investigator:
Megan Hewitt PhD researcher
M.Hewitt@2013.ljmu.ac.uk

Name and Contact Details of the Investigators: Dr. Ellen Dawson E.Dawson@ljmu.ac.uk , Dr. Lynne Boddy L.M.Boddy@ljmu.ac.uk , Dr. Zoe Knowles Z.R.Knowles@ljmu.ac.uk and Professor Claire Stewart C.E.Stewart@ljmu.ac.uk.

You are being invited to take part in a research study. Before you decide it is important for you to understand why the study us being done and what participation will involve. Please take time to read the following information carefully and discuss it with others if you wish. Ask us if there is anything that is not clear or if you would like more information. Take your time to decide whether or not you wish to take part. Thank you for reading this.

1. What is the purpose of the study?

The aim is of this study is to explore cancer patients' thoughts about and feelings towards physical activity. We would like to explore the barriers, enabling and reinforcing factors, perceptions and attitudes towards physical activity that influence physical activity participation.

2. Why have I been invited to participate?

You have been invited because you take part in the Underground Training Station Foundation group-based activity sessions for individuals with cancer and survivors. You may be eligible to take part in this study if:

- You have been diagnosed with cancer and have either undergone treatment or are currently undergoing treatment
- Are aged 18 years+
- Able to take part in physical activity

You will be unable to take part in this study if:

- You have no cancer diagnosis or are pre treatment
- Are less than 18 years of age

- Are unable to take part in physical activity

3. Do I have to take part?

No, it is up to you to decide whether or not to take part, your participation is entirely voluntary and refusal to participate will involve no penalty or loss of benefits you may have gained. If you do decide to take part you will be given this information sheet to keep and be asked to sign a consent form and complete a demographic and screening form. You can withdraw at any time by informing the principle investigator without giving a reason and without it affecting your rights, any future treatment that you may receive and the services you receive at the Underground Training Station Foundation.

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

- Taking part in this study will require you to discuss a range of topics including health, physical activity, sedentary behaviour and the Underground Training Station Foundation program as an individual with cancer.
- If you decide to take part, you will be asked to return a signed consent form to the principle investigator. You will also be asked to complete a demographic and screening information form solely for the research purposes of this study, this data will be used to identify the sample population and at what stage of during treatment or post-treatment you are. If there are any questions that you do not understand or feel uncomfortable answering, please feel free to leave the questions blank. Please return this form to the principle investigator. The information contained on the demographic form will allow us to group participants into focus groups and describe the population when we are analysing our results.
- You will be required to visit the Underground Training Station and will be asked to take part in one focus group. This session will be digitally audio recorded and will last approximately 45 minutes.
- Depending on the information you provide on the demographic and screening form, you will either be allocated into a 'during treatment' focus group or 'post treatment' focus group. There will be 4 focus groups each involving 6 participants. The principle investigator will talk you through the study procedures and give you the chance to ask any questions.
- At the beginning of the focus group a short introduction will be included to explain the context of the PhD project and you will be informed of the focus group guide and made aware that the sessions will be digitally audio recorded. Group etiquette will be addressed at the beginning of the session allowing yourself and each participant to contribute fairly to the discussion.
- Prior to starting the focus groups, you may already know some of the other participants from attending the activity sessions. However, the focus groups will consist of a formal, structured discussion led by the principle investigator. During the focus group, the principle investigator will ask a series of questions, covering different topic areas including health, physical activity, sedentary behaviour and the Underground Training Station Foundation program. We would like you to answer the questions asked during the focus group and discuss them with the other participants in your group as you feel appropriate to do so. However, you can choose not to answer a question and do not have to offer an explanation as to why. The focus of the discussion among the focus group will evolve around your perceptions to physical activity, highlighting your perceived barriers, enabling and reinforcing factors and attitudes to physical activity.
- Here is an example question that may be asked during the focus group: Can you describe your experiences of the activity sessions this past week on the Underground Training Station Foundation cancer program?
- Some of the questions asked during the focus group may cause disclosure of personal information and you may experience feelings of distress. If you feel that any of the questions have caused you emotional discomfort, please feel free to discuss this with the lead researcher (Megan Hewitt). They will also signpost you to the necessary support services by providing contact information (at the end of this information sheet) for Macmillan, Samaritans, Maggie's and Sunflowers or you can contact your own personal support nurse if you have one.

- If you take part in this study, we will ask you to agree to be contacted to take part in future research studies carried out on this PhD project. In this case, you would be provided with all of the necessary information. Your participation would be entirely voluntary and you would be able to withdraw at any time.

5. Will I be recorded and how will the recorded media be used?

Semi-structured focus groups will be audio recorded on a password protected audio recording device and as soon as possible the recording will be transferred to secure storage and deleted from the recording device.

The audio recordings will be used only for analysis to produce results for this study. No other use will be made of them without your written permission, and no one outside the project will be allowed access to the original recordings.

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

There are no disadvantages to taking part in this study. All potential risks will be minimised and managed by the principle investigator and you, the participant, if any are to occur. If you experience an adverse event or potential feelings of distress or sadness, you may report this to the principle investigator or a member of the research team (their email addresses can be found at the top of this participant information sheet) at any stage of the study. Remember you can leave the focus group at any stage and withdraw freely from the study.

If you are personally affected by participation in this research, you may wish to seek support/advice from a medical professional.

7. What are the possible benefits of taking part?

There are no direct benefits to you from being involved in this study. The research undertaken in this project will allow you to contribute and be part of a novel research project. The findings from this project will provide information about participation in physical activity, specific preferences and what you enjoy about physical activity. The impact of group-based activity sessions will also be highlighted. It is hoped that these findings will provide new information to health practitioners and inform specific recommendations for physical activity in individuals with cancer and survivors, such as yourself, and expand the existing evidence already documented in the United Kingdom.

8. What will happen to the data provided and how will my taking part in this project be kept confidential?

The information you provide as part of the study is the **research study data**. Any research study data from which you can be identified (e.g. from identifiers such as your name, date of birth, audio recording etc.), is known as **personal data**.

- This study does include more sensitive categories of personal data (**sensitive data**) for example, the demographic and screening questionnaire requires you to answer questions about your cancer diagnosis. Though this is not the focus of the study, if sensitive issues are discussed all information will be treated confidentially as with personal data.

- Personal data does not include data that cannot be identified to an individual (e.g. data collected anonymously or where identifiers have been removed).

- Personal data will be stored confidentially for as long as it is necessary to verify and defend, when required, the process and outcomes of research. The time period may be a number of years. Personal data will only be accessible to the principle investigator of the research team.

- Personal data collected from you will be recorded using a linked code – the link from the code to your identity will be stored securely and separately from the coded data

- We will not tell anyone that you have taken part in the focus group, although there is of course a possibility that another member of the group might recognise you. We will also not name you in any of our reports or publications. In addition, all participants in the focus group will be asked to respect the confidentiality of their fellow participants.

- You will not be identifiable in any ensuing reports or publications.

- We will use pseudonyms in transcripts and reports to help protect the identity of individuals and organisations unless you tell us that you would like to be attributed to information/direct quotes etc.

- The semi-structured focus group audio recordings will be inputted into specific software where it will be analysed to produce a transcript.

- Anonymised data might be used for additional or subsequent research studies and we might share anonymised data with other investigators (e.g. in online databases). All personal information that could identify you will be removed or changed before information is shared with other researchers or results are made public.

9. What will happen to the results of the research project?

The investigator intends to use the results from this study to publish peer-reviewed outputs, conference presentations, reports and present the results PhD thesis.

10. Who is organising and funding/commissioning the study?

This study is organised by Liverpool John Moores University and match funded by the Underground Training Station Foundation and Liverpool John Moores University. The Underground Training Station Foundation are interested in improving their program and establish the health benefits the program provides.

Who has reviewed this study?

This study has been reviewed by, and received ethics clearance through, the Liverpool John Moores University Research Ethics Committee (Reference number: 19SPS015).

11. What if something goes wrong?

If you have a concern about any aspect of this study, please contact the principle investigator, Megan Hewitt and/or Dr Ellen Dawson who will do their best to answer your query. The researcher should acknowledge your concern within 10 working days and give you an indication of how they intend to deal with it. If you wish to make a complaint, please contact the chair of the Liverpool John Moores University Research Ethics Committee (researchethics@ljmu.ac.uk) and your communication will be re-directed to an independent person as appropriate.

12. Data Protection Notice

The data controller for this study will be Liverpool John Moores University (LJMU). The LJMU Data Protection Office provides oversight of LJMU activities involving the processing of personal data, and can be contacted at secretariat@ljmu.ac.uk. This means that we are responsible for looking after your information and using it properly. LJMU's Data Protection Officer can also be contacted at secretariat@ljmu.ac.uk**.** The University will process your personal data for the purpose of research. Research is a task that we perform in the public interest.

Your rights to access, change or move your information are limited, as we need to manage your information in specific ways in order for the research to be reliable and accurate. If you withdraw from the study, we will keep the information about you that we have already obtained.
You can find out more about how we use your information by contacting secretariat@ljmu.ac.uk.

If you are concerned about how your personal data is being processed, please contact LJMU in the first instance at secretariat@ljmu.ac.uk. If you remain unsatisfied, you may wish to contact the Information Commissioner's Office (ICO). Contact details, and details of data subject rights, are available on the ICO website at: https://ico.org.uk/for-organisations/data-protection-reform/overview-of-the-gdpr/individuals-rights/

13. Support services contact information:

Macmillan cancer support: 0808 808 00 00 (8am-8pm 7 days/week)
Samaritans helpline: 116 123 (24 hours 7 days/week)
Maggie's Merseyside: 0151 334 4301 (9am-5pm Monday to Friday), clatterbridge@mqaggiescentres.org
Sunflowers Liverpool: 0151 726 8934 (10am-4pm Monday to Friday), bookings@liverpoolsunflowers.com

14. Contact for further information

Megan Hewitt
PhD researcher
Liverpool John Moores University
5 Primrose Hill
Liverpool
L3 2EX
M.Hewitt@2013.ljmu.ac.uk
0151 424 4066

Thank you for reading this information sheet and for considering to take part in this study.

Appendix 2: Study 1-Participant consent form

LIVERPOOL JOHN MOORES UNIVERSITY
CONSENT FORM

Title of Project: A formative study exploring individuals with cancer perceptions of physical activity: The barriers, reinforcing and enabling factors for physical activity engagement utilising the Precede-Procede model.

Researcher: Megan Hewitt Liverpool John Moores University.

1.	I confirm that I have read and understand the information provided for the above study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily	☐
2.	I understand that my participation is voluntary and that I am free to withdraw at any time, without giving a reason and that this will not affect my legal rights.	☐
3.	I understand that any personal information collected during the study will be anonymised and remain confidential	☐
4.	I agree to take part in the above study *(semi-structured focus groups)*	☐
5.	I understand that the focus group will be audio recorded and I am happy to proceed	☐
6.	I understand that parts of our conversation may be used verbatim in future publications or presentations but that such quotes will be anonymised.	☐
7.	I understand that the questions asked during the semi-structured focus group will require the sharing of information regarding personal experiences which may cause myself to experience feelings of distress	☐
8.	I am happy to be contacted about future research	☐

Name of Participant Date Signature

Name of Researcher Date Signature
Megan Hewitt

Appendix 3: Study 1-Gatekeeper information sheet

LIVERPOOL JOHN MOORES UNIVERSITY
GATEKEEPER INFORMATION SHEET

Title of Project: 'A formative study exploring individuals with cancer perceptions of physical activity: The barriers, reinforcing and enabling factors for physical activity engagement utilising the Precede-Procede model.'

Name of Researchers and School/Faculty: Megan Hewitt (PhD student), Dr. Ellen Dawson E.Dawson@ljmu.ac.uk , Dr. Lynne Boddy L.M.Boddy@ljmu.ac.uk , Dr. Zoe Knowles Z.R.Knowles@ljmu.ac.uk and Professor Claire Stewart C.E.Stewart@ljmu.ac.uk . Sport and Exercise Sciences Liverpool John Moores University (LJMU).

1. What is the reason for this letter?

We are hoping to recruit individuals with cancer attending the Underground Training Station (UTS) Foundation cancer program. The reason for this letter is to provide you with the relevant information about this study and what it involves. Before you give consent to participate in this study, it is important that you completely understand why this research is being conducted and what it will require you to do. Please take time to read this information sheet and if you have any questions please do not hesitate to contact the researcher (Megan Hewitt) leading this study. We would also ask that you provide a signed gatekeeper consent form granting us permission to use your facility to carry out the procedures outlined in this information sheet.

2. What is the purpose of the study/rationale for the project?

Research has suggested there any many benefits and challenges to individuals with cancer participating in physical activity. The aim is of this study is to explore cancer patients' perceptions of physical activity and the barriers, reinforcing and enabling factors for physical activity engagement utilising the Precede-Procede model. The objectives are to explore perceived barriers, enabling and reinforcing factors, perceptions and attitudes towards physical activity that influence physical activity participation. Currently, these factors, perceptions and attitudes towards physical activity that influence physical activity participation are unknown. The formative information collected will be used to inform decision making with respect to the design of two further studies in individuals with cancer and survivors.

3. What we are asking you to do?

As a potential gatekeeper, we are asking you to email our recruitment poster and we would like to ask for your help identifying participants in relation to them meeting the stated criteria to take part in the study. To take part in the study, the criteria includes: individuals with cancer, any type of cancer, adults (18+), during or post-treatment and attend the Underground Training Station to participate in regular physical activity sessions. Individuals cannot take part if they are: less than 18 years of age, pre-treatment or no cancer diagnosis and unable to participate in physical activity. Where appropriate, you may be asked to discuss the study with potential participants, as it will be advertised via posters in your facility. We are also asking you to grant permission for us to use your facility the Underground Training Station for data collection purposes and to recruit participants from your Underground Training Station Foundation program utilised by individuals with cancer on a weekly basis to take part in our study.

4. Why do we need access to your facilities/staff/students?

We will need to access your facilities/individuals with cancer to answer the research aim and objectives of this study. We are hoping to recruit participants from your Underground Training Station Foundation cancer program to take part in our research study titled above. Recruitment of these individuals will allow the researchers to gain an in-depth understanding about perceived barriers, enabling and reinforcing factors, perceptions and attitudes towards physical activity that influence physical activity participation in this population. We would appreciate the use of your facility for data collection purposes. The data collection tool used will be semi-structured focus groups. These are sessions that will last approximately 45 minutes per group (4 groups) and will involve discussion amongst the participants and researcher to answer the objectives of the research study.

5. If you are willing to assist in the study what happens next?

If you are willing to assist in the study, please sign and return the *Gatekeeper Consent Form* to the researcher (Megan Hewitt). Once this has been received, the researcher can begin participant recruitment for the study and once all potential participants have provided consent, data collection can commence. You will also be asked to help finalise a date with the researcher for when the semi-structured focus groups can commence. We will advertise the project using posters and emails. Potential participants will then be provided with Participant Information Sheets, consent forms and a demographic and screening questionnaire. Participants that meet the inclusion criteria will then be invited to take part in focus groups.

6. How we will use the Information/gathered from the demographic and screening questionnaire and the focus groups?

The information gathered from the demographic and screening form will allow for us to check whether participants meet the inclusion or exclusion criteria for the research study. Findings from the focus groups will be disseminated as peer-reviewed outputs, conference presentations, reports and part of a PhD thesis which will be accessible to the participants, researchers and involved organisations (LJMU & UTS).

7. Will the name of my organisation taking part in the study be kept confidential?

Please note that confidentiality may not be guaranteed. The researcher will work with you in an attempt to minimise and manage the potential for indirect identification of your organisation.

The researcher will keep confidential anything they learn or observe related to illegal activity unless related to the abuse of children or vulnerable adults, money laundering or acts of terrorism.

The recordings from the semi-structured focus groups will be stored on a secure password protected computer at LJMU that only the researchers will have access to. The data will then be transcribed and analysed, with all transcripts kept on a password protected computer in a secure office at LJMU to ensure your organisation's data security. No personal names of participants will be used in the write up of this study to ensure anonymity.

In certain exceptional circumstances where you or others may be at significant risk of harm, the researcher may need to report this to an appropriate authority. This would usually be discussed with you first. Examples of those exceptional circumstances when confidential information may have to be disclosed are:

- The investigator believes the participant is at serious risk of harm, either from yourself or others
- The investigator suspects a child may be at risk of harm
- You pose a serious risk of harm to, or threaten or abuse others
- As a statutory requirement e.g. reporting certain infectious diseases
- Under a court order requiring the University to divulge information
- We are passed information relating to an act of terrorism
- There is a suicide risk

8. What will taking part involve? What should I do now?

Your taking part will involve allowing us to recruit participants from your Underground Training Station Foundation cancer program. It will also grant us permission to use your facility for data collection purposes. We would therefore need to use a suitable room in the facility that would allow us to conduct the focus groups.

If you are happy for the research to take place at the Underground Training Station, please can you sign and return the *Gatekeeper Consent Form* provided.

Should you have any comments or questions regarding this research, please contact the lead researcher: Megan Hewitt, M.Hewitt@2013.ljmu.ac.uk 0151 424 4066

This study has received ethical approval from LJMU's Research Ethics Committee *(19SPS015, 20/02/19)*

Contact Details of Researcher: Megan Hewitt, M.Hewitt@2013.ljmu.ac.uk 0151 424 4066

Contact Details of Academic Supervisor: Dr Ellen Dawson, E.Dawson@ljmu.ac.uk 0151 904 6264

If you have any concerns regarding your involvement in this research, please discuss these with the researcher in the first instance. If you wish to make a complaint, please contact researchethics@ljmu.ac.uk and your communication will be re-directed to an independent person as appropriate.

Appendix 4: Study 1-Gatekeeper consent form

LIVERPOOL JOHN MOORES UNIVERSITY
GATEKEEPER CONSENT FORM

Title of Project: A formative study exploring individuals with cancer perceptions of physical activity: The barriers, reinforcing and enabling factors for physical activity engagement utilising the Precede-Procede model.

Name of Researchers: Megan Hewitt (PhD student), Dr Ellen Dawson, Dr Lynne Boddy, Dr Zoe Knowles and Professor Claire Stewart- Liverpool John Moores University.

Please tick to confirm your understanding of the study and that you are happy for your organisation to take part and your facilities to be used to host parts of the project.

The project involves recruitment of individuals with cancer accessing your Foundation program to take part in semi-structured focus groups at your facility. These sessions will last approximately 45 minutes.

1. I confirm that I have read and understand the information provided for the above study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily. ☐
2. I understand that participation of our organisation and students/members in the research is voluntary and that they are free to withdraw at any time, without giving a reason and that this will not affect legal rights. ☐
3. I understand that any personal information collected during the study will be anonymised and remain confidential. ☐
4. I agree for our organisation and students/members to take part in the above study. ☐
5. I agree to conform to the data protection act ☐
6. I agree to email the recruitment material to potential participants who are registered on the Underground Training Station Foundation program ☐

Name of Gatekeeper: Date: Signature:

Name of Researcher: Megan Hewitt Date: Signature:

Appendix 5: Study 1-Demographic and screening information questionnaire

DEMOGRAPHIC AND SCREENING INFORMATION QUESTIONNAIRE

Title of Project: A formative study exploring individuals with cancer perceptions of physical activity: The barriers, reinforcing and enabling factors for physical activity engagement utilising the Precede-Procede model.

Researcher: Megan Hewitt
Liverpool John Moores University.
M.Hewitt@2013.ljmu.ac.uk

Participant ID:

Personal information

Age (years)	
Gender	
Postcode	

Screening information

Please can you provide details on the following:

1) When were you diagnosed with cancer? Please provide the date, month and year.

2) When diagnosed, what type of cancer were you diagnosed with? Please provide the name and stage, for example; Stage 1

3) After diagnosis, what treatment was prescribed to you? For example; surgery, chemotherapy, radiotherapy.

4) Please state whether you are currently having treatment for cancer or are post-treatment.

5) Please list any prescribed medication you received during or post-treatment.

UTS Foundation program information

6) How long have you been attending the UTS Foundation program?

7) How many sessions do you take part in during the week at the UTS Foundation?

Thank you for taking the time to complete this demographic and screening information questionnaire.

Appendix 6: Study 1-Focus group guide

Semi-structured focus group list of questions

Title of the research program: 'The impact of Physical Activity and Exercise Training on Physiological and Psychosocial Outcomes in Individuals with Cancer.'

Thesis overarching aims: 1) to identify the preferences, enabling factors and the barriers to physical activity in this population 2) the relationships between physical activity and markers of health including: cardiovascular risk, markers of inflammation, body size and composition and well-being 3) the impact of a small group-based activity sessions on these measures.

Thesis objectives:

- Study 1: To explore perceived barriers, enabling and reinforcing factors, perceptions and attitudes towards physical activity that influence physical activity participation. To use the formative information collected to inform decision making with respect to the design of studies 2 and 3.
- Study 2: To assess physical activity and sedentary behaviour in adult individuals with cancer using objective measures (i.e. accelerometers). To explore the relationship between physical activity and physiological and psychosocial markers of health. To explore the feasibility and acceptability of data collection methods within this population.
- Study 3: To evaluate the effect activity group-based activity intervention on health markers. To assess the impact and feasibility of the group-based activity session.

Study 1 research question: 'A formative study exploring individuals with cancer perceptions of physical activity: The barriers, reinforcing and enabling factors for physical activity engagement utilising the Precede-Procede model.'

Typical introduction: The purpose of this focus group is for you as a group to interact and share your experiences of the Underground Training Station Foundation program which will be done through a guided discussion. The session will last approximately 45 minutes and it is expected that as a group, you all allow for individual contribution and are respectful when other individuals are speaking. It is also helpful to think about whether you agree or disagree with statements being made as we are also looking for some consensus raising where appropriate. As the principle investigator, I will guide you through the session and ask each specific question and then hand over to you as a group. The purpose of this research is to explore perceptions of physical activity and the barriers, reinforcing and enabling factors you experience for physical activity participation on the Underground Training Station Foundation program. There are no right or wrong answers and we have to

accept that our own opinions may differ from that of other focus group members. I will be recording via this device and keeping an eye on time moving matters along when needed so we can finish on time. If at any time you feel uncomfortable or do not wish to answer a question then that is fine. You may leave the focus group at any time without a reason. If so, I will find you a place to sit and wait and will have someone check on you before you leave. You can go to the toilet or get refreshments too before you leave the centre if you wish. You may also speak freely with the Underground Training Station Foundation program coordinators at any stage or wait and I can speak to you at the end of the focus group if you wish. I will also provide you will all necessary support service information if required.

Orienting statement on topic area: The first topic we will discuss is 'health'. The term health can mean different things to different people. I will ask one question at a time and we will take a few minutes to discuss each question among the group.

1. What do you think the term 'health' means?
   Thank you for your responses. As I have said the term, health can mean different things to different people. The World Health Organisation (WHO) defines 'health' as 'a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity.'
2. Are there any specific factors that encourage you to stay healthy?
3. What encourages you to adopt unhealthy behaviours?

We have now discussed health and what it means, thank you for answering the questions related to health, we will now move to the next topic to discuss.

Orienting statement on topic area: The second topic we are going to discuss is 'physical activity'. There may be differences among the group between your understanding of physical activity. Like before, I will ask one question at a time and we will take a few minutes to discuss each question among the group.

1. What are your perceptions of physical activity? Can you tell me what it is?
   Thank you for your responses, the term physical activity is defined as 'any bodily movement produced by contraction of skeletal muscle that substantially increases energy expenditure'.
2. Do you believe that physical activity is needed to maintain a healthy lifestyle?
3. Are there specific factors that facilitate you to participate in physical activity?
4. Can you give me examples of specific barriers that stop you from participating in physical activity?
5. Do you believe there are benefits from participating in physical activity? Can you give me some examples?
6. Across the week, how long, in minutes, do you spend physically active?
   Thank you for your responses, according to research it is recommended that cancer patients be as physically active as their abilities allow, achieving at least 150 minutes of moderate-intensity or 75 minutes of vigorous-intensity aerobic activity or an equivalent combination and include strength exercises.

We have now discussed physical activity, what it means and the recommended guidelines. Thank you for answering the questions related to physical activity, we will now move to our next topic.

Orienting statement on topic area: The third topic we are going to discuss is 'sedentary behaviour'. There may be differences among the group between your understanding of sedentary behaviour. Like before, I will ask one question at a time and we will take a few minutes to discuss each question among the group.

1. What are your perceptions of 'sedentary behaviour'? Can you tell me what it is?
   Thank you for your responses, the term sedentary behaviour is defined as 'any waking behaviour characterised by an energy expenditure of ≤1.5 metabolic equivalents (METS) while in a sitting, reclining or lying posture'.
2. Can you give me examples of what encourages you to be sedentary?
3. Can you give me examples of what you think you could do to reduce your time spent sedentary?
4. Do you believe there are benefits of reducing the amount of time you spend sedentary?

We have now discussed sedentary behaviour and what it means, thank you for answering the questions related to sedentary behaviour. We will now move to our final topic.

Orienting statement on topic area: The final topic we are going to discuss is your involvement in the Underground Training Station Foundation program. As individuals you may share different or the same views and experiences of the UTS Foundation program. Again, I will ask one question at a time and we will take a few minutes to discuss each question among the group.

1. How long have you been a member of the Underground Training Station Foundation cancer program?
2. Can you give me examples of your motives to join the Underground Training Station Foundation cancer program? What were your perceptions of the program?
3. Do you believe attending more than one session per week is beneficial?
4. Can you describe your experiences of the activity sessions this past week on the Underground Training Station Foundation cancer program?
5. Can you give me any examples of how the Underground Training Station Foundation cancer program has influenced you to make any lifestyle changes?
6. What are some of the challenges you face during the activity sessions at the Underground Training Station Foundation?
7. Can you give me examples of enabling factors that facilitate attendance to the Underground Training Station Foundation cancer program?
8. What factors reinforce your attendance to the Underground Training Station Foundation activity sessions?
9. Are there any specific barriers that prevent attendance to the Underground Training Station Foundation program?

10. What feelings did you experience on arrival at the Underground Training Station Foundation prior to taking part in your activity sessions this week?
11. As the activity sessions are group-based, does this influence your participation in the Underground Training Station Foundation cancer program?

Thank you for sharing and discussing your views and experiences of the Underground Training Station Foundation cancer program.

This is the end of the focus group questions, thank you taking the time to answer and discuss as a group the list of questions. If you have any questions, please feel free to contact me using the contact details provided on the participant information sheet.

Appendix 7: Letter of support from UTS

Dr. Colin Robertson
The UTS Foundation
Newhall Lane
Hoylake
CH47 4BP

T. 0151 294 3172
E. utscolin@gmail.com
W: http://utsfoundation.com/
Charity No. 1169421

22nd January 2019

RE: Megan Hewitt – Research Ethics

To whom it may concern,

Please accept this letter as an official document of agreement and support for the above referenced PhD student to collect data at the UTS Foundation.

We are aware that the data collection methods will range from interview, questionnaire, case study, and several objective/physical means of measurement, and we have been fully informed with regards to the purpose of these studies.

Please do not hesitate to contact me should you require any further information in support of this research ethics application.

Best regards,

Dr. Colin Robertson

Executive Trustee, the UTS Foundation.

Appendix 8: Study 2-Participant information sheet

LIVERPOOL JOHN MOORES UNIVERSITY
Participant Information Sheet for Cancer Survivors

LJMU's Research Ethics Committee Approval Reference: 20/SPS/023

YOU WILL BE GIVEN A COPY OF THIS INFORMATION SHEET

Title of Project: Exploring the feasibility of an online activity program for cancer survivors during the COVID-19 pandemic: the transition from a gym-based to a virtual home-based setting. You are being invited to take part in the research study titled above because you are a member of the Underground Training Station's Foundation program for cancer survivors. Before you decide it is important for you to understand why the study us being done and what participation will involve. Please take time to read the following information carefully and discuss it with others if you wish such as family and friends. Please ask us if there is anything that is not clear or if you would like more information. Take time to decide whether or not you wish to take part. Thank you for taking the time to read this.

15. Who will conduct the study?

Study Team: Megan Hewitt (PhD candidate), Dr. Ellen Dawson E.Dawson@ljmu.ac.uk, Dr. Lynne Boddy L.M.Boddy@ljmu.ac.uk, Professor Zoe Knowles Z.R.Knowles@ljmu.ac.uk, Professor Claire Stewart C.E.Stewart@ljmu.ac.uk and Dr Dominic Doran D.A.Doran@ljmu.ac.uk.

Principal Investigator: Megan Hewitt

Co-investigator: Dr Ellen Dawson

School/Faculty within LJMU: School of Sport and Exercise Sciences. Faculty of Science.

Collaborating Institutions: Underground Training Station Foundation

16. What is the purpose of the study?

The purpose of this study is to evaluate the home-based, online activity program offered by the Underground Training Station Foundation and to explore the effect of the program on physical activity and health outcomes

in cancer survivors in a home-based setting as a result of the current COVID-19 pandemic. This study is part of a PhD project in collaboration with Liverpool John Moores University and the Underground Training Station.

17. Why have I been invited to participate?

You have been invited to take part because you are currently a member of the Underground Training Station's Foundation program for cancer survivors. You may be eligible to take part in this study if you meet the following inclusion criteria below. Other members of the Foundation will also be invited to take part if they meet the following inclusion criteria as members of the Foundation.

The inclusion criteria are:

- You are a member of the Underground Training Station's Foundation cancer program
- You have been diagnosed with cancer
- You are either during or post-treatment
- Aged 18 years+
- Able to participant in physical activity

The exclusion criteria are:

- Not a member of the Underground Training Station's Foundation cancer program
- You have no cancer diagnosis
- Pre-treatment
- Less than 18 years of age
- Unable to participate in physical activity and exercise.

18. Do I have to take part?

No. It is up to you to decide whether or not to take part, your participation is entirely voluntary and refusal to agree to participate will involve no penalty or loss of benefits you may have been entitled too. You will have 7 days to decide if you would like to take part. If you do decide to take part, you will be given this information sheet to keep and be asked to sign a consent form which you will return **electronically** to the principle investigator. You can withdraw at any time by informing the investigators without giving a reason and without it affecting your rights/any future treatment/service you receive as a member of the Underground Training Station's Foundation program.

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

Once you have provided consent, we will talk you through the study procedures and give you the chance to ask any questions before the completing procedures. As a result of the COVID-19 pandemic, this study will

be entirely home-based and as you are currently taking part in online activity sessions via Zoom provided by the Foundation. We want to evaluate the Foundation service you take part in to better this service and explore the effects of the activity program on your health outcomes.

- The study will last for 6 weeks and will also include a follow-up assessment 6 months after completion. During the 6-week period you will take part in a 1-hour activity session, every Monday at 10am. Members are already taking part in these session as they were provided to ensure members could continue being physically active during the COVID-19 pandemic, therefore they are the regular weekly sessions that you are already attending but will include some of the following procedures listed below. These sessions are coached by the principle investigator of this study and Foundation coach, Megan.

- Taking part in this study will require you to answer a series of questionnaires and surveys, take part in a fitness assessment and focus group discussion from the comfort of your own home. All assessments at the beginning of the study and post-study will be conducted via Zoom (an app) online. An instruction manual will be provided for how to download and use the app. All procedures will be conducted by the principle investigator, Megan Hewitt.

- Once you have provided consent, you will be asked to complete demographic and screening questionnaires solely for the research purposes of this study. These questionnaires will be emailed to yourself by the principle investigator. This data will be used to identify the sample population and at what stage of during treatment or post-treatment you are. If there are any questions that you do not understand or feel uncomfortable answering, please feel free to leave the questions blank. Please return these questionnaires to the principle investigator **electronically**. The information contained on the demographic and screening questionnaires will allow us to describe the population when we are analysing our results.

- You will complete one fitness assessment via Zoom with the principle investigator at baseline (the beginning of the study) and post-study.

- This fitness assessment will consist of a wall sit and you will be guided through the process by the principle investigator. You will also be provided with a demonstration video beforehand so that you can see the test in action and what it requires. The test will take approximately 5 minutes to set up and conduct. Please see the below written guide:

Wall sit Instructions:

-Stand comfortably with feet shoulder width apart, approximately 2 feet from the wall

-Back against a vertical wall

-Slide your back down the wall to assume the position with both your knees and hips at a 90-degree angle (right angle)

-Move your feet further from the wall if required

-Ensure feet are flat on the ground

-Back against the wall, looking straight ahead, arms across chest

-The timing starts when the correct position is assumed

-The timing will end as soon as you can no longer hold the position

-The researcher will record your time at baseline (beginning of study) and post online-activity program

- You will complete a questionnaire to assess your quality of life at baseline (the beginning of the study) and post-study. This questionnaire is the Short Form (SF)-36 Health Survey and consists of 36 questions. This will take approximately 15 minutes to complete. Below is an example question.

SF-36 example question:

In general, would you say your health is:

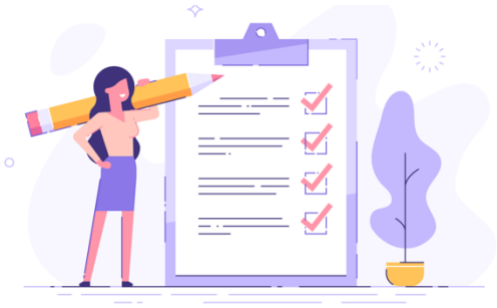
1-Excellent

2-Very good

3-Good

4-Fair

5-Poor



- You will complete a questionnaire to assess your motivation to either engage or not engage in physical activity at baseline (the beginning of the study) and post-study. This questionnaire is the BREQ-3 and consists of 24 questions. This will take approximately 15 minutes to complete. Below is an example question.

BREQ-3 example question:

	Not true for me		Sometimes true for me		Very true for me
I exercise because other people say I should	0	1	2	3	4

- You will complete a Perceived Competence Scale to assess your feelings towards engaging in physical activity at baseline (the beginning of the study) and post-study. This will take approximately 5 minutes to complete.

For example; I feel confident in my ability to be physically active

1	2	3	4	5	6	7
Not at all true			Somewhat true			Very true

- On completion of the 6-week online activity program you will complete a program evaluation survey to explore how you were recruited to take part in the study, your perceptions of physical activity behaviour, barriers and facilitators for taking part in the program and your acceptability and satisfaction of the program. This will take approximately 15 minutes to complete.

- You will return completed questionnaires and surveys to the principle investigator via email at, M.Hewitt@2013.ljmu.ac.uk.

- You will take part in a focus group discussion with the other members to explore your experiences of the activity program once the 6 weeks have been completed. You will also take part in a second focus group discussion with the other members at a 6-month follow-up period to explore your perceptions of maintaining physical activity behaviour and the barriers and facilitators you may experience to do so. These discussions will be audio recorded and will take 60 minutes to complete. Group etiquette will be addressed at the beginning of the focus groups allowing yourself and each participant to contribute fairly to the discussion, you will also be informed of the focus group guides. We would like you to answer the questions asked during the focus groups and discuss them with the other participants in your group as you feel appropriate to do so. However, you can choose not to answer a question and do not have to offer an explanation as to why.

20. Will I be recorded and how will the recorded media be used?

Focus groups will be audio recorded on a password protected audio recording device and as soon as possible the recording will be transferred to secure storage and deleted from the recording device.

The audio recordings will be used only for analysis to produce results for this study. No other use will be made of them without your written permission, and no one outside the project will be allowed access to the original recordings

The online activity program sessions will also be recorded to fulfil the requirements of the data collection procedures for this study. These will be observed by a member of the research team.

You are free to decline to be audio/video recorded. The audio/video recording is essential to your participation, but you should be comfortable with the recording process and you are free to stop the recording at any time

The audio and/or video recordings of your activities made during this study will be used only for analysis. No other use will be made of them without your written permission.

21. Are there any possible disadvantages or risks from taking part?

There are no disadvantages to taking part in this study and all potential risks will be minimised and managed by the principle investigator, Megan Hewitt, however this is minimal. If you experience any adverse events or emotional upset, please report this immediately to the principle investigator, Megan's contact details can be found at the end of this information sheet. Remember, you are free to withdraw from the study at any time.

If you feel uncomfortable answering any questions included on the questionnaires, surveys or during the focus groups, you do not have to answer them and this will not affect your participation in the study.

If you are personally affected by participation in this study, you may wish to seek support/advice from a medical professional such as your GP.

22. What are the possible benefits of taking part?

Whilst there will be no direct benefits to you for taking part in this study, it is hoped that this work will provide formative information to the Underground Training Station Foundation to further improve the service delivered, therefore impacting yourself as a member of the Foundation in a positive way.

23. What will happen to the data provided and how will my taking part in this project be kept confidential?

The information you provide as part of the study is the **study data**. Any study data from which you can be identified (e.g. from identifiers such as your name, date of birth, audio recording etc.), is known as **personal**

data. This includes more sensitive categories of personal data (**sensitive data**) such as your race; ethnic origin; politics; religion; trade union membership; genetics; biometrics (where used for ID purposes); health; sex life; or sexual orientation.

When you agree to take part in a study, we will use your personal data in the ways needed to conduct and analyse the study and if necessary, to verify and defend, when required, the process and outcomes of the study. Personal data will be accessible to the study team.

In addition, responsible members of Liverpool John Moores University may be given access to personal data for monitoring and/or audit of the study to ensure that the study is complying with applicable regulations.

When we do not need to use personal data, it will be deleted or identifiers will be removed. Personal data does not include data that cannot be identified to an individual (e.g. data collected anonymously or where identifiers have been removed). However, your consent form, contact details, audio recordings etc. will be retained for 5 years.

Personal data collected from you will be recorded using a linked code – the link from the code to your identity will be stored securely and separately from the coded data.

Each questionnaire/survey will contain a unique participant code.

We will not tell anyone that you have taken part in the focus group, although there is of course a possibility that another member of the group might recognise you. We will also not name you in any of our reports or publications. In addition, all participants in the focus group will be asked to respect the confidentiality of their fellow participants. You will not be identifiable in any ensuing reports or publications.

We will use pseudonyms in transcripts and reports to help protect the identity of individuals and organisations unless you tell us that you would like to be attributed to information/direct quotes etc.

With your consent, we would like to store your contact details so that we may contact you about future opportunities to participate in studies.

The focus group recordings will be sent to an independent company who will produce a transcript with a unique participant ID.

24. Limits to confidentiality

Please note that confidentiality may not be guaranteed; for example, due to the limited size of the participant sample, the position of the participant or information included in reports, participants might be indirectly identifiable in transcripts and reports. The investigator will work with the participant in an attempt to minimise and manage the potential for indirect identification of participants.

The Investigator will keep confidential anything they learn or observe related to illegal activity unless related to the abuse of children or vulnerable adults, money laundering or acts of terrorism.

The investigator has a professional obligation to inform relevant agencies if they learn about any of the above.

In certain exceptional circumstances where you or others may be at significant risk of harm, the investigator may need to report this to an appropriate authority. This would usually be discussed with you first. Examples of those exceptional circumstances when confidential information may have to be disclosed are:

- The investigator believes you are at serious risk of harm, either from yourself or others
- The investigator suspects a child may be at risk of harm
- You pose a serious risk of harm to, or threaten or abuse others
- As a statutory requirement e.g. reporting certain infectious diseases
- Under a court order requiring the University to divulge information
- We are passed information relating to an act of terrorism

25. What will happen to the results of the study?

The investigator intends to use the results from this study to form part of a PhD thesis and to publish peer-reviewed outputs, conference presentations and reports.

26. Who is organising and funding/commissioning the study?

This study is organised by Liverpool John Moores University and match-funded by the Underground Training Station Foundation and Liverpool John Moores University. The Underground Training Station Foundation are interested in improving their program provided to cancer survivors.

27. Who has reviewed this study?

This study has been reviewed by, and received ethics clearance through, the Liverpool John Moores University Research Ethics Committee (Reference number: 20/SPS/023).

28. What if something goes wrong?

If you have a concern about any aspect of this study, please contact the relevant investigator (Megan Hewitt) or the academic supervisor Dr Ellen Dawson. Contact details can be viewed at the end of this information sheet and they will do their best to answer your query. The investigator should acknowledge your concern within 10 working days and give you an indication of how they intend to deal with it. If you wish to make a

complaint, please contact the chair of the Liverpool John Moores University Research Ethics Committee (researchethics@ljmu.ac.uk) and your communication will be re-directed to an independent person as appropriate.

29. Data Protection Notice

Liverpool John Moores University is the sponsor for this study based in the United Kingdom. We will be using information from you in order to undertake this study and will act as the data controller for this study. This means that we are responsible for looking after your information and using it properly. Liverpool John Moores University will process your personal data for the purpose of research. Research is a task that we perform in the public interest. Liverpool John Moores University will keep identifiable information about you for 5 years after the study has finished.

Your rights to access, change or move your information are limited, as we need to manage your information in specific ways in order for the study to be reliable and accurate. If you withdraw from the study, we will keep the information about you that we have already obtained. To safeguard your rights, we will use the minimum personally-identifiable information possible.

You can find out more about how we use your information at URL and/or by contacting secretariat@ljmu.ac.uk.

If you are concerned about how your personal data is being processed, please contact LJMU in the first instance at secretariat@ljmu.ac.uk. If you remain unsatisfied, you may wish to contact the Information Commissioner's Office (ICO). Contact details, and details of data subject rights, are available on the ICO website at: https://ico.org.uk/for-organisations/data-protection-reform/overview-of-the-gdpr/individuals-rights/

30. Contact for further information

Contact Details of Researcher: Megan Hewitt, M.Hewitt@2013.ljmu.ac.uk 0151 424 4066

Contact Details of Academic Supervisor: Dr Ellen Dawson, E.Dawson@ljmu.ac.uk 0151 904 6264

Thank you for reading this information sheet and for considering to take part in this study.

Appendix 9: Study 2-Participant consent form

LIVERPOOL JOHN MOORES UNIVERSITY
PARTICIPANT CONSENT FORM

Title of Project: Exploring the feasibility of an online activity program for cancer survivors during the COVID-19 pandemic: the transition from a gym-based to a virtual home-based setting.

Name of Researcher and School/Faculty: Megan Hewitt (PhD candidate), School of Sport and Exercise Sciences.

9. I confirm that I have read and understand the information provided for the above study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily ☐

10. I understand that my participation is voluntary and that I am free to withdraw at any time, without giving a reason and that this will not affect my legal rights. ☐

11. I understand that any personal information collected during the study will be anonymised and remain confidential ☐

12. I agree to take part in the above study (evaluation study using questionnaires and focus groups) ☐

13. I understand that the focus group will be audio / video recorded and the activity sessions will also be video recorded, and I am happy to proceed ☐

14. I understand that parts of our conversation may be used verbatim in future publications or presentations but that such quotes will be anonymised. ☐

Name of Participant:

Date **Signature**

Name of Researcher: Megan Hewitt

Date **Signature** M. Hewitt

Appendix 10: Study 2-Participant demographic questionnaire

Participant Demographic and Contact Information Questionnaire

Title of Project: Exploring the feasibility of an online activity program for cancer survivors during the COVID-19 pandemic: the transition from a gym-based to a virtual home-based setting.

Researcher contact details:

Megan Hewitt

M.Hewitt@2013.ljmu.ac.uk

Participant code: _____

Have you read the participant information sheet, and do you consent to completing this questionnaire? Y / N

Today's date: _____

Q1. Name: ……

Q2. Please provide you age and date of birth: ……

Q3. What are the first three digits of your home postcode? ……

Q4. What is your phone number? ……

Q5. What is your email address? ……

Q6. What is your current employment status? ……

Thank you for taking the time to complete this demographic questionnaire.

Appendix 11: Study 2-Participant screening questionnaire

Participant Screening Questionnaire

Title of Project: Exploring the feasibility of an online activity program for cancer survivors during the COVID-19 pandemic: the transition from a gym-based to a virtual home-based setting.

Researcher contact details:

Megan Hewitt

M.Hewitt@2013.ljmu.ac.uk

Participant code: _____

Have you read the participant information sheet, and do you consent to completing this questionnaire? Y / N

Please can you provide the relevant information on the following, reported as accurately as possible.

1) Please provide the date, month and year that you received your cancer diagnosis.

   …….

2) Please provide the name and stage of your cancer diagnosis? For example, breast cancer stage 0, I, II, III or IV

   …….

3) What is your current treatment status? Undergoing treatment or post-treatment?

   …….

4) What treatment have you been or were prescribed for your cancer? For example; surgery, chemotherapy, radiotherapy or a combination of both

   …….

Thank you for taking the time to complete this screening questionnaire

Appendix 12: Study 2-Gatekeeper information sheet

LIVERPOOL JOHN MOORES UNIVERSITY
GATEKEEPER INFORMATION SHEET

Title of Project: Exploring the feasibility of an online activity program for cancer survivors during the COVID-19 pandemic: the transition from a gym-based to a virtual home-based setting.

Name of Researcher and School/Faculty: Megan Hewitt (PhD candidate), School of Sport and Exercise Sciences.

9. What is the reason for this letter?

We would like to recruit cancer survivors attending your program at the Underground Training Station (UTS) Foundation. The reason for this letter is to provide you with the relevant information about the current study and what it involves. Before you give consent to act as gatekeeper for this study as a representative for the Foundation, it is important that you completely understand why this research is being conducted and your role will require. Please take time to read this information sheet and if you have any questions please do not hesitate to contact the lead researcher, Megan Hewitt PhD candidate. We would also ask that you provide a signed gatekeeper consent form.

10. What is the purpose of the study/rationale for the project?

The purpose of this study is to explore the feasibility of an online activity program for cancer survivors during the COVID-19 pandemic: the transition from a gym-based to a virtual home-based setting and to provide evidence of how the program effects participants (members) health outcomes and behaviour for physical activity.

11. **What we are asking you to do?**

Acting as the gatekeeper, we would be grateful if you could email members of the Foundation with the recruitment email generated by the lead researcher with the participant information sheet attached. The lead researcher already has access to some of the members email addresses from those who attend the Monday activity sessions therefore can also distribute the required recruitment material to those members if necessary. It would also be helpful if you could post an advertisement poster on the UTS Foundation Social media account for members to see. Which the lead researcher will also provide. If potential participants have been identified by or contact yourself, we would ask that you would ask their

permission to share their contact details with the lead researcher or the potential participant can contact the lead researcher directly and you can provide the lead researcher's contact details which are included at the end of this information sheet.

12. Why do we need access to your members?

- We need access to your members as they attend your Foundation program and are already taking part in the activity program. They also meet the following inclusion criteria; a member of the Underground Training Station's Foundation cancer program, have been diagnosed with cancer, either during or post-treatment, aged 18 years+ and able to participate in physical activity. This will help us to achieve the aims and objectives of this study.

13. If you are willing to assist in the study what happens next?

If you are willing to assist in the study, please sign and return **electronically** the **Gatekeeper Consent Form** to the lead researcher. Once this has been received, the researcher can begin participant recruitment for the study and once all potential participants have provided consent, data collection can commence.

14. How we will use the Information/questionnaire?

The information gathered from the data collection procedures and findings from the data collected will be disseminated as peer-reviewed outputs, conference presentations, reports and part of a PhD thesis (second study) which will be accessible to the participants, researchers and involved organisations (LJMU & UTS).

15. Will the name of my organisation taking part in the study be kept confidential?'

Please note that confidentiality may not be guaranteed. The researcher will work with you in an attempt to minimise and manage the potential for indirect identification of your organisation.

The researcher will keep confidential anything they learn or observe related to illegal activity unless related to the abuse of children or vulnerable adults, money laundering or acts of terrorism.

All information collected will be stored securely on an LJMU M:drive with password protected Microsoft Office sheets. No personal names of participants will be used in the write up of this study to ensure anonymity.

In certain exceptional circumstances where you or others may be at significant risk of harm, the researcher may need to report this to an appropriate authority. This would usually be discussed with you first. Examples of those exceptional circumstances when confidential information may have to be disclosed are:

- The investigator believes the participant is at serious risk of harm, either from yourself or others
- The investigator suspects a child may be at risk of harm
- You pose a serious risk of harm to, or threaten or abuse others
- As a statutory requirement e.g. reporting certain infectious diseases
- Under a court order requiring the University to divulge information
- We are passed information relating to an act of terrorism
- There is a suicide risk

16. What will taking part involve? What should I do now?

- Sign and return the **Gatekeeper Consent Form** provided.

Should you have any comments or questions regarding this research, you may contact the researchers:
(Megan Hewitt (PhD candidate) M.Hewitt@2013.ljmu.ac.uk , Dr. Ellen Dawson E.Dawson@ljmu.ac.uk, Dr. Lynne Boddy L.M.Boddy@ljmu.ac.uk, Professor Zoe Knowles Z.R.Knowles@ljmu.ac.uk, Professor Claire Stewart C.E.Stewart@ljmu.ac.uk and Dr Dominic Doran D.A.Doran@ljmu.ac.uk).

This study has received ethical approval from LJMU's Research Ethics Committee (reference 20/SPS/023, 19/05/2020)

Contact Details of Researcher: Megan Hewitt, M.Hewitt@2013.ljmu.ac.uk 0151 424 4066

Contact Details of Academic Supervisor: Dr Ellen Dawson, E.Dawson@ljmu.ac.uk 0151 904 6264

If you have any concerns regarding your involvement in this research, please discuss these with the researcher in the first instance. If you wish to make a complaint, please contact researchethics@ljmu.ac.uk and your communication will be re-directed to an independent person as appropriate.

Appendix 13: Study 2-Gatekeeper consent form

LIVERPOOL JOHN MOORES UNIVERSITY
GATEKEEPER CONSENT FORM

Title of Project: Exploring the feasibility of an online activity program for cancer survivors during the COVID-19 pandemic: the transition from a gym-based to a virtual home-based setting.

Name of Researchers: Megan Hewitt (PhD candidate), Dr. Ellen Dawson E.Dawson@ljmu.ac.uk, Dr. Lynne Boddy L.M.Boddy@ljmu.ac.uk, Professor Zoe Knowles Z.R.Knowles@ljmu.ac.uk, Professor Claire Stewart C.E.Stewart@ljmu.ac.uk and Dr Dominic Doran D.A.Doran@ljmu.ac.uk.

Please tick to confirm your understanding of the study and that you are happy for your organisation to take part.

1. I confirm that I have read and understand the information provided for the above study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily. ☐

2. I understand that participation of our organisation and members in the research is voluntary and that they are free to withdraw at any time, without giving a reason and that this will not affect legal rights. ☐

3. I understand that any personal information collected during the study will be anonymised and remain confidential. ☐

4. I agree for our organisation and members to take part in the above study. ☐

5. I agree to conform to the data protection act ☐

Name of Gatekeeper: Colin Robertson

Date: **Signature:**

Name of Researcher: Megan Hewitt

Date: **Signature:**

Appendix 14: Study 2-Zoom guide

GETTING READY FOR HOME ONLINE VIDEO COACHING

In order to benefit from remote video coaching, it is important that the technology doesn't get in the way during your session. Therefore, it is good advice to spend some time before your first session to check your set up, learn how your devices work and become familiar with the software used.

ZOOM

We will be using Zoom as the platform for our calls.

https://zoom.us/

This programme does not require that you create an account but you will have to download the software. You will probably want to use a laptop or tablet as the screen will be bigger but a smartphone will also work well. You can download the software to your computer by following the above link or the app for your smartphone or tablet from your relevant App Store:

SIGNING IN FOR YOUR SESSION

I will send you a Zoom meeting request via email with a direct link to the Zoom meeting session. Click on this link and it will take you to our meeting. Please make sure that you open the link on the platform that you wish to complete the session on (i.e. Laptop, Tablet or Phone)

TECHNOLOGY SET UP

It is a good idea to have your device set up in a place that allows its camera to get a good view of your working area. It will be helpful to me to be able to see your whole body as you work. Therefore, you may consider placing your device on a tripod or a stand so you can easily adjust and move it around as necessary. If you have a selfie stick, it may be that the holder part is able to be detached and screwed onto a regular camera tripod.

Also check that the lighting is good and if there is a window that the camera doesn't face it during daytime because this is likely to mean that you will not be seen due to the bright backlight. I may ask you to reposition the camera at times, just so that I can get a better view of your technique.

Please ensure that the device that you are using is either fully charged or connected to the mains. YOUR WORKOUT SPACE I plan your sessions around the space available to you, but as a minimum, we need around a 1.5m square space that is clear and safe for you to work in. Please make sure furniture is pushed back, out of the way and any ornaments or objects are moved out of harm's way since we wouldn't want to knock anything over accidentally. If you have a home gym, please be in there!

Please ensure that you get a good internet connection in your workout space - whether it be 4G or WIFI.

EQUIPMENT Depending on the workout, you will need to have to hand the equipment you need. An exercise mat will help make things more comfortable for you (carpet burns are a thing!). You may have purchased some home equipment as suggested from Amazon etc. and we will possibly get creative and make some use out of your home interiors. Please make sure you have a water bottle handy and you are wearing appropriate clothing - just as you would in the gym.

ENVIRONMENT Please make sure that others in your household know that you will be working out and ask them if they could refrain from entering your workout space during your session. It's also a good idea to keep pets out of the room since they can be very curious and like to get involved!

Feel free to put some background music on during the session - not too loud!

Appendix 15: Study 2-Focus group guide post-intervention

FOCUS GROUP GUIDE
(to be completed after completion of 6-week online activity program)

EXPLORING THE FEASIBILITY OF AN ONLINE ACTIVITY PROGRAM FOR CANCER SURVIVORS DURING THE COVID-19 PANDEMIC: THE TRANSITION FROM A GYM-BASED TO A VIRTUAL HOME-BASED SETTING.

Objectives:

1) To examine program feasibility by exploring acceptability and satisfaction of an online activity program for cancer survivors
2) To assess the effectiveness of the program on participants health outcomes including quality of life and physical activity behaviour
3) To retrospectively explore participants experiences of the online activity program using focus groups: the transition from gym-based to home-based activity

The purpose of this focus group is for you as a group, to interact and share your experiences with one another of the 6-week online activity program you have just completed as members of the Underground Training Station Foundation, to explore any effects the online activity program has had on your health, fitness and wellbeing and to provide your thoughts and feelings of moving from a gym-based to home-based setting during the covid-19 pandemic to exercise. This will be done through guided discussion. Your responses will help to shape future versions of the program if the Foundation staff decide to deliver another home-based online program. The session will last approximately 45 minutes and it is expected that as a group, you each allow for individual contribution and are respectful when other individuals are speaking. It will also be helpful if you think about whether you agree or disagree with statements made as I am looking to explore consensus where appropriate. As the researcher, I will guide you through the session, asking each question and then hand over to you as a group to answer as you wish. As we are using the Zoom platform, I would ask that each participant mute themselves throughout the discussion. If you would like to answer a question or engage with conversation amongst the group, please raise your hand and I will address you to unmute and speak. It is important to highlight there are no right or wrong

answers and we should accept that our own opinions may differ from that of other focus group members. I will be recording the focus group here on Zoom and also on this back up device (dictaphone) and keeping an eye on time moving matters along when needed or when I think we have reached saturation point on a question so we can finish on time. If connection is lost, please re-join the meeting using the invite that was sent to you. If you have difficulties doing so, please send me an email and we will look to resolve the problem. I would like to make you aware that you can leave the focus group at any time and without reason to do so. If you would like any further information on the topics discussed, please feel free to ask and I will do my best to answer your questions.

<table>
<tr><th>Interview question</th><th>Justification</th></tr>
<tr><td>For the purpose of the recording…
• Can you introduce yourself, who you are and something you consider to be an interesting fact about yourself?

I would like to start by asking you about your prior experiences of the Foundation program and to help make sense of your answers further ahead …
• The program was purposely set up in a group exercise format. How did you feel about that having been informed in your initial consultation before participating in the sessions?
• Can you tell me, if at all, has exercising as a group been motivational as regards to taking part during your time as a member and in offering your answer perhaps provide examples?
• Can you indicate whether overall the group format had a negative, neutral or positive influence on your participation to keep attending each week using the 5-point Likert scale?

<table><tr><td>Very negative</td><td>Negative</td><td>Neutral</td><td>Positive</td><td>Very positive</td></tr><tr><td></td><td></td><td></td><td></td><td></td></tr></table></td><td>Background</td></tr>
<tr><td></td><td></td></tr>
<tr><td>This next section focusses on what the virtual home-based program set out to achieve and its purpose for you as members of the Foundation’s program for cancer survivors on the Wirral…

In March this year (2020), cancer survivors were advised to shield, and gym facilities closed due to COVID-19. The Foundation staff recognised that as members of the Foundation, you wouldn’t be able to take part in your normal weekly, coached activity sessions.</td><td>Participant experiences</td></tr>
</table>

In light of this, the Foundation staff wanted to ensure that as members, you were able to receive the usual service offered by the Foundation as far as was practically possible, and in a safe format adapted to the current circumstances. The online home-based program was developed in line with the following 3 aims:

1) to provide members with the usual service from the Foundation

2) to keep members exercising and engaging with each other on a weekly basis

3) to keep members participating in the program from the safety of their own home during COVID-19.

I would like to know how well we did with developing the online home-based program in line with the 3 aims stated. I would also like to know if the program met your expectations.

- Can you tell me if you think the aim to provide members with the usual, but adapted, service was achieved or not?
  - Please tell me more about how/why
  - If not, why do you think this?
- Can you tell me if you think exercising and engaging as a group each week was achieved or not?
  - Please tell me more about how/why
  - If not, why do you think this?
- Can you tell me how safe or not you felt participating in the program from your home during the COVID-19 pandemic?
  - Please tell me more about how/why
  - If not, why do you think this?
- Can you tell me if the online program was what you expected it to be or was it something different?
  - Please tell me more about how/why
  - If not, why do you think this?

The online activity program is the first of its kind to be developed and delivered by the UTS Foundation as part of their cancer survivor program. It is important the we learn from your experiences, your roles as participants in this focus group is to help shape future versions of the program. I would like to know any potential effects the program had on your health, fitness and participation in physical activity. Some of you

may have experienced different outcomes as some of you are having active treatment and others are post-treatment for their cancer. The World Health Organisation (WHO) defines health as 'a state of complete physical, mental and social wellbeing and not merely the absence of disease or infirmity'. Health can mean something different to each person, please feel free to use your own words. • Physical health and mental health have a strong relationship with physical health influencing mental health and vice versa. Can you tell me if the program has had any effect, if at all any, overall, on your physical and mental health and in offering your answer perhaps provide examples? - Please tell me more about how/why - If not, why do you think this? • Social wellbeing is 'the ability to communicate, develop meaningful relationships with others, and maintain a support network.' Can you tell me if the program has had any effect, if at all any, on your social wellbeing and in offering your answer perhaps provide examples? - Please tell me more about how/why - If not, why do you think this? Physical fitness is defined as 'a set of attributes including cardiorespiratory endurance (how well your heart, lungs and muscles work together for an extended period of time), skeletal muscle endurance (ability for muscles to work for an extended period of time), strength and power, flexibility, agility, balance, reaction time and body composition, that people have or achieve that relate to the ability to perform physical activity'. Fitness can mean something different to each person, please feel free to use your own words. • Can you tell me if the program has had any effect, if at all any, on your cardiorespiratory endurance/fitness and in offering your answer perhaps provide examples? • Can you tell me if the program has had any effect, if at all any, on your muscular endurance/function and strength and in offering your answer perhaps provide examples? • Can you tell me if the program has had any effect, if at all any, on your ability to perform daily living tasks such as climbing stairs, gardening and housework?	

- Using the 5-point Likert scale, would you agree or disagree that a certain level of fitness is important for your health?

Strongly disagree	Disagree	Neutral	Agree	Strongly agree

Physical activity is defined as 'any bodily movement produced by contraction of skeletal muscle that substantially increases energy expenditure'. Physical activity can mean something different to each person, please feel free to use your own words.

- Did the program influence, if at all, your physical activity during the 6-weeks and in offering your answer perhaps provide examples?
- Have you been more or less active after completing the 6-week program and in offering your answer perhaps provide examples?
- Using the 5-point Likert scale, would you agree or disagree that being physically active is important for your health?

Strongly disagree	Disagree	Neutral	Agree	Strongly agree

For future versions of the program, it is important that we learn from your experiences of the format used in the program you took part in as participants. As well as being the PhD researcher, I am also the lead coach for the Foundation program. I would like to explore your experiences of the format including delivery style, day and time the program took place.

- The program has always been coach led in the gym-based setting. I delivered both the gym-based and online home-based sessions. Can you tell me if this was or not, an encouraging factor for you to attend the online program?
  - Please tell me more about how/why
  - If not, why do you think this?
- The program was coached and fully structured for 6 weeks with written programming; the sessions have always been programmed when delivered in the gym. The 6-week program was split into 2, 3-week programs which consisted of a

combination of both resistance and aerobic training. Can you tell me how this combination of training styles worked for you and in offering your answer perhaps provide examples? - Please tell me more about how/why - If not, why do you think this? • The program was scheduled every Monday at 10am because this was the time and day the gym-based sessions took place. Can you tell me how convenient or not this scheduling was for you each Monday morning and in offering your answer perhaps provide examples? - Please tell me more about how/why - If not, why do you think this? • The online activity program recruited participants via emails and the coach also informed members via the group WhatsApp and face-to-face virtually during the Zoom activity sessions pre the 6-week activity program. As a cancer survivor, what would you suggest is appealing as regards to recruitment and advertising material to others who do not yet know about the program? - Please tell me more about what and why - What wouldn't work and why? *I would like to explore how you think the home-based online activity program could be improved for the future. It is important that we learn from your experiences. You may have views on the delivery of sessions, coaching and structure, day and time, advertising or any other area related to the online activity program.* • Is there anything that you think may prevent the program from being successful? • With these in mind, can you think of any ways in which the online activity program can be improved?	
This next section focusses on the transition from a gym-based to virtual home-based setting, as members you have been attending the gym with face-to-face coaching whereas the home-based program required you to participate in exercise at home with minimal kit, virtual coaching and engagement with the group…	*Participant experiences*

I would like to explore your thoughts and feelings at the end of the 6-week activity program after moving from a gym-based to a home-based setting to exercise which encompassed exercising with minimal kit, being coached virtually and exercising and engaging virtually with the other group members.
 	
• Can you tell me how this transition worked for you and in offering your answer perhaps provide examples?
  - Please tell me more about how/why?
  - If not, why do you think this?
 	
Attending the program in the gym meant that you had access to an abundance of kit. However, at home you did not, and I encouraged everyone to use objects in their homes for certain exercises such as ruck sacks for deadlifts, squats and bent over rows or kitchen worktops for elevated press ups. It is important that we learn from your experiences of this in a virtual setting.
 	
• Can you tell me if the workouts were more or less challenging in the home setting with minimal kit compared to in the gym setting and in offering your answer perhaps provide examples?
 	
Attending the program in the gym meant that you received face-to-face coaching during the sessions. In the home setting the coach, myself, coached the sessions virtually on Zoom. The level of coaching provided has always been a fundamental element of the gym-based program and a vital component of the UTS brand ethos. It is important that we learn from your experiences of this in a virtual setting compared to a face-to-face setting.
 	
• Can you tell me how this worked for you in terms of the level of coaching provided including coach engagement for the warmup, demonstrations and main body of the sessions compared to in the gym setting?
 	
The program has always been delivered in the gym as a group format. This has also been previously reported as a key facilitator for participation from members. The Foundation staff wanted to ensure the online activity program incorporated this key element. It is important that we learn from your experiences of this element in a virtual setting.	

- Can you tell me how exercising and engaging with the group in a virtual setting worked for you in terms of social interaction during the sessions and in offering your answer perhaps provide examples?
- Can you tell me if the group format, if at all, influenced your initial participation in the 6-week home-based program?
- Can you tell me, if at all, how the group format influenced your participation during the 6 weeks and in offering your answer perhaps provide examples?
- Using the 5-point Likert scale below, would you agree or disagree that the group format was a fundamental part for encouraging participation throughout the 6-week program.

Strongly disagree	Disagree	Neutral	Agree	Strongly agree

As individuals, our ability to take part in physical activity and exercise may vary. Some of you are still having active treatment and some of you have finished treatment. This can affect how you feel and perform during physical activity and exercise as a result of treatment and cancer-specific side effects such as fatigue. I am interested in how participants felt as regards to being competent or able to do the home-based sessions compared to what they normally did in the gym.

- Can you tell me if you felt more or less competent in the home-based sessions compared to the gym-based sessions and in offering your answer perhaps provide examples?
    - Please tell me more about how/why
    - If not, why do you think this?

I would like to explore the potential impact the home-based program has had on you as members of the Foundation during the COVID-19 pandemic as regards to your wellbeing. Cancer survivors were advised to shield by the UK government which meant staying indoors and reducing the number of people you interacted with. Wellbeing includes the presence of positive emotions and moods such as happiness, the absence of negative emotions such as depression, satisfaction with life,

fulfilment and positive functioning or in simple terms, by judging life positively and feeling good.

- Can you tell me if the online program has had an impact, if any, on your wellbeing, during the pandemic and in offering your answer perhaps provide examples?
  - Please tell me more about how/why
  - If not, why do you think this?
- Using the 5-point Likert scale below, would you agree or disagree the potential impact has been negative, neutral or positive?

Very negative	Negative	Neutral	Positive	Very positive

This is the end of the focus group guide.

Appendix 16: Study 2-Focus group guide follow-up

FOCUS GROUP GUIDE
(to be completed at 6-month follow-up)

EXPLORING THE FEASIBILITY OF AN ONLINE ACTIVITY PROGRAM FOR CANCER SURVIVORS DURING THE COVID-19 PANDEMIC: THE TRANSITION FROM A GYM-BASED TO A VIRTUAL HOME-BASED SETTING.

Objectives:

1) To examine program feasibility by exploring acceptability and satisfaction of an online activity program for cancer survivors
2) To assess the effectiveness of the program on participants health outcomes including quality of life and physical activity behaviour
3) To qualitatively explore participants experiences of the online activity program using focus groups: the transition from gym-based to home-based activity

This focus group guide was solely intended to guide the members discussion around perceptions of maintaining their physical activity behaviour. Whilst the intention of the focus group was principally to discuss this, the intention was also to let the members discuss the barriers and facilitators they experience for maintaining this physical activity behaviour.

The purpose of this focus group is for you as a group, to interact and share your experiences with one another of your physical activity as members of the Underground Training Station Foundation, over this past 6 months having completed the 6-week online activity program in August last year (2020). This will be done through guided discussion. The session will last approximately 45 minutes and it is expected that as a group, you each allow for individual contribution and are respectful when other individuals are speaking. It will also be helpful if you think about whether you agree or disagree with statements made as I am looking to explore consensus where appropriate. As the researcher, I will guide you through the session, asking each question and then hand over to you as a group to answer as you wish. As we are using the Zoom platform, I would ask that each participant mute themselves throughout the discussion. If you would like to answer a question or engage with conversation amongst the group, please raise your hand and I will address you to unmute and speak. It is important to highlight there are

no right or wrong answers and we should accept that our own opinions may differ from that of other focus group members. I will be recording the focus group here on Zoom and also on this back up device (dictaphone) and keeping an eye on time moving matters along when needed or when I think we have reached saturation point on a question so we can finish on time. If connection is lost, please re-join the meeting using the invite that was sent to you. If you have difficulties doing so, please send me an email and we will look to resolve the problem. I would like to make you aware that you can leave the focus group at any time and without reason to do so. If you would like any further information on the topics discussed, please feel free to ask and I will do my best to answer your questions.

Interview question	**Justification**
For the purpose of the recording… • Can you introduce yourself, who you are and an interesting fact about yourself? I would like to start by asking you about your prior experiences of the Foundation program and to help us make sense of your answers… • Can you tell me how long you have been a member of the Foundation? • Can you tell me what being a member of the Foundation means to you?	*Background*
This next section focusses on maintaining physical activity behaviour… • Can you tell me if the home-based program has influenced, if at all, your physical activity behaviour by perhaps being more or less active regularly over this past 6 months? And in offering your answers perhaps provide an example? Prompt: type of activity, exercise, routine, frequency • Can you tell me if the experience you gained, if at all any, from taking part in home-based program, has influenced your attitude towards physical activity over this past 6 months? And in offering your answers perhaps provide an example? Prompt: type of activity, ability, more or less confident, more or less motivated	***Maintenance:*** *Perceptions of maintaining physical activity*
This next section focusses on what factors may encourage you to maintain being physically active or what factors may prevent you from being physically active regularly… • Can you tell me what encouraged you to maintain, if at all, physical activity on a regular basis during the home-based program and over this past 6 months? In offering your answers perhaps provide an example. Prompt: health, fitness, environment, group	***Maintenance:*** *Facilitators and barriers to maintaining physical activity*

• Can you tell me if there were any factors that prevented you from maintaining, if at all, physical activity regularly during the home-based program and over this past 6 months? In offering your answers perhaps provide an example. Prompt: treatment, commitments, time • Can you tell me if you are still taking part or not in the home-based program? Can you tell me why? Prompt: environment, physical activity, exercise, health	

Appendix 17: Study 2-Stakeholder interview guide

STAKEHOLDER INTERVIEW GUIDE
(to be completed at 6-month follow-up)

EXPLORING THE FEASIBILITY OF AN ONLINE ACTIVITY PROGRAM FOR CANCER SURVIVORS DURING THE COVID-19 PANDEMIC: THE TRANSITION FROM A GYM-BASED TO A VIRTUAL HOME-BASED SETTING.

Objectives:

4) To examine program feasibility by exploring acceptability and satisfaction of an online home-based activity program for cancer survivors
5) To assess the effectiveness of the program on participants health outcomes including quality of life and physical activity behaviour
6) To qualitatively explore participants experiences of the online activity program using focus groups: the transition from gym-based to home-based activity

This interview guide was solely intended to guide the stories and experiences of the stakeholders themselves. Whilst the intention of the interview was principally to discuss the sustainability of the online home-based program, delivery and its impact on the Foundation members, the intention was also to let the stakeholder discuss their thoughts and provide reflections on their experiences.

The purpose of this interview is for you, the stakeholder, to share your thoughts and experiences of the online home-based program provided to the members of your foundation who are cancer survivors during the COVID-19 pandemic. This will be done through guided discussion and the session will last approximately 45 minutes. As the researcher, I will guide you through the session using the question guide. I will be recording the interview here on Zoom and also on this back up device (dictaphone) and keeping an eye on time moving matters along when needed or when I think we have reached saturation point on a question so we can finish on time. If connection is lost, please re-join the meeting using the invite that was sent to you. If you have difficulties doing so, please send me an email and we will look to resolve the problem.

Interview question	Justification

For the purpose of the recording… • Can you introduce yourself? • Can you describe your primary and current role? • Can you tell me what impact, if any, the COVID-19 pandemic has had on the service delivery of the Foundation program for cancer survivors? I would like to start by asking you about the online home-based program and what it is… • What is your understanding of the program? - Prompt: what it delivers, who it is targeted at, where/how it is delivered. • What impact, if at all any, do you think the home-based program has had on the members of the Foundation? - Prompt: positive, negative, COVID	*Background: this gives a good account of what they already know and may help to frame future answers.*
The home-based program delivers structured exercise sessions (combination of both aerobic and resistance style training) each Monday morning at 10am to individuals living with cancer (members of the Foundation) who are able to take part in exercise and be physically active. Both those individuals who are having active treatment or post treatment can engage with the program. The program is delivered virtually via the Zoom platform and is fully supervised. This next section addresses the continuation of the program and its sustainability over the long-term… • Can you tell me if the home-based program is still being delivered, how and why, if that is the case? - Please tell me more - If not, why do you think that is?	*Maintenance: continuation of program*

• Can you tell me about the feasibility and practicality of the program as a method of service delivery for the Foundation? - Please tell me more - If not, why do you think that is? • Can you tell me if there have been any challenges you, as director of the Foundation, have faced or not with the program? - Please tell me more - If not, why do you think that is? • Can you tell me if you deem the home-based program a success or not? Perhaps on reflection of the original delivered program objectives? - Please tell me more - If not, why do you think that is? • Can you tell me if referrals of potential new members have been made to the program on initial assessment consultations and what has the uptake been like in regard to numbers joining? • From now on and when we return to 'normal', can you tell me how the program will be advertised? Have there been successful methods used to date? - Prompt: social media, marketing, testimonials and feedback from members • Can you tell me if there are any improvements you see fit for the program in order to make future practices more successful? Are these improvements listed in terms of priority?	

- Prompt: recruitment, staff uptake/upskilling, delivery, structure, advertising • In regard to future business plans, can you tell me if the home-based program may be delivered over the long-term? - If yes, please tell me more - If not, why do you think this?	

Appendix 18: Study 1-ethics

19SPS015 Megan Hewitt, PGR (SPS) - A formative study exploring cancer patients' perceptions of physical activity (PA): The barriers, reinforcing and enabling factors for PA engagement utilising the Precede-Procede model. (Ellen Dawson/Lynne Boddy)

UREC decision: Approved

Liverpool John Moores University Research Ethics Committee (REC) has reviewed the above application and I am pleased to inform you that ethical approval has been granted and the study can commence.

Approval is given on the understanding that:

- any adverse reactions/events which take place during the course of the project are reported to the Committee immediately by emailing researchethics@ljmu.ac.uk;
- any unforeseen ethical issues arising during the course of the project will be reported to the Committee immediately emailing researchethics@ljmu.ac.uk;
- the LJMU logo is used for all documentation relating to participant recruitment and participation eg poster, information sheets, consent forms, questionnaires. The LJMU logo can be accessed at http://www2.ljmu.ac.uk/corporatecommunications/60486.htm;
- The study consent forms, data, information etc. will be accessible on request to any supervisory team and/or to responsible members of Liverpool John Moores University for monitoring, auditing and data authenticity purposes.

Where any substantive amendments are proposed to the protocol or study procedures further ethical approval must be sought (https://www2.ljmu.ac.uk/RGSO/93205.htm)

Applicants should note that where relevant appropriate gatekeeper / management permission must be obtained prior to the study commencing at the study site concerned.

Please note that ethical approval is given for a period of five years from the date granted and therefore the expiry date for this project will be 5 years from this date. An application for extension of approval must be submitted if the project continues after this date.

Yours sincerely

Mandy Williams, Research Support Officer
(Research Ethics and Governance)
Research and Innovation Services
Kingsway House, Hatton Garden, Liverpool L3 2AJ
t: 01519046467 e: a.f.williams@ljmu.ac.uk

Appendix 19: Study 2-ethics

U UREC minimal Risk Registration

To: UREC minimal Risk Registration; Hewitt, Megan

Cc: Knowles, Zoe; Dawson, Ellen

Tue 19/05/2020 14:24

HewittMeganMinRiskRegFor... 121 KB

Thank you for registering your study as minimal risk.

Student name: Megan Hewitt

Supervisor/Co-I – Ellen Dawson

Title of study: An evaluation of the Underground Training Station (UTS) Foundation's program for cancer survivors and the programs effect on physical activity and health outcomes in cancer survivors: A home-based study as a result of the COVID-19 pandemic.

Minimal risk UREC approval reference number: 20/SPS/023
Approval is given on the understanding that:

- The study is conducted in accordance with the Minimal Ethical Risk Guiding Principles
- Any adverse reactions/events which take place during the course of the project are reported to the Committee immediately by emailing researchethics@ljmu.ac.uk;
- Any unforeseen ethical issues arising during the course of the project will be reported to the Committee immediately emailing researchethics@ljmu.ac.uk;
- The LJMU logo is used for all documentation relating to participant recruitment and participation e.g. poster, information sheets, consent forms, questionnaires. The study consent forms, data, information etc. will be accessible on request to a student's supervisory team and/or to responsible members of Liverpool John Moores University for monitoring, auditing and data authenticity purposes.
- Where any substantive amendments are proposed to the protocol or study procedures that change the associated risk from minimal to low risk (use the decision tool to establish the associated risk), the investigators must complete an ethics application form describing all aspects of the study and submit for ethical review and approval as required.
- Where relevant appropriate gatekeeper / management permission must be obtained prior to the study commencing at the study site concerned.

Please note that approval is given for a period of five years from the date granted and therefore the expiry date for this project will be 5 years from 19/05/2020. An application for extension of approval must be submitted if the project continues after this date.

Best wishes
UREC