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Promoting physical activity during and after curative cancer treatment

Assessment, experiences and effect of behaviour change support

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Abstract
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Aims: The overall aim of this thesis was to increase knowledge about the promotion of physical activity (PA) in patients during and after curative cancer treatment. **Methods:** Study I investigated agreement between a 7-day diary and the SenseWear Armband mini (SWA) when assessing PA and sedentary time in 65 participants with breast cancer. Agreement was examined with Bland-Altman plots. Studies II-IV used data from an RCT, where participants about to start curative treatment for breast, prostate or colorectal cancer, were randomised to six months of high or low-to-moderate intensity exercise (supervised group-based resistance- and home-based endurance training), *with* or *without* self-regulatory behaviour change techniques (BCTs; e.g. goal-setting and action planning). In study II, participants randomised to the groups *with* self-regulatory BCTs answered a questionnaire (n=229) and took part in semi-structured interviews (n=18) after exercise programme completion. The interviews were analysed with thematic analysis. In Study III, all participants (n=577) randomised were included. Exercise adherence during the intervention was assessed with attendance records, training logs and heart rate monitors. Regression analyses were performed to determine the effect of self-regulatory BCTs on exercise adherence. In Study IV, participants (n=301) who provided data about their PA level at 12-month follow-up were included. Regression analyses were performed to determine the effect of self-regulatory BCTs on PA maintenance and potential baseline predictors. **Results:** There were mean differences and wide limits of agreement between the 7-day diary and the SWA when assessing PA and sedentary time. Participants described different incentives to exercise, which fostered feelings of autonomy, competence and relatedness and helped them find motivation to exercise during cancer treatment. Social support from coaches, feedback, self-registration of exercise and scheduled sessions at a public gym were useful for exercising. There was no effect of the self-regulatory BCTs on exercise adherence during the intervention; however, a positive effect was found on PA maintenance at 12-month follow-up. Baseline predictors of PA maintenance at 12-month follow-up were health-related quality of life, exercise motivation, expectations of exercise and being a former or current smoker/ snus user. **Conclusions:** A 7-day diary and the SWA have limited agreement and cannot be used interchangeably in patients with breast cancer. Individual incentives and a positive and supportive environment are crucial to increase exercise motivation in patients undergoing curative cancer treatment, and can be promoted using specific support (i.e. social support, feedback, self-registration of exercise and scheduled exercise sessions). The addition of self-regulatory BCTs is not likely to improve exercise adherence in patients undergoing curative treatment for breast, prostate or colorectal cancer and participating in structured, well-controlled exercise interventions, but may improve long-term PA maintenance in this population. Patients with low health-related quality of life, low exercise motivation, high expectations of exercise or with a history of tobacco use at the start of their cancer treatment may be those most in need of such support to maintain PA.

Keywords: Adherence, Behavioural medicine, Exercise, Incentives, Maintenance, Oncology

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To my family

"*It always seems impossible until it's done.*" — Nelson Mandela

List of Papers

This thesis is based on the following papers, which are referred to in the text by their Roman numerals.

I. Mazzoni AS, Nordin K, Berntsen S, Demmelmaier I, Igelström H. Comparison between logbook-reported and objectively-assessed physical activity and sedentary time in breast cancer patients: an agreement study. BMC Sports Sci Med Rehabil. 2017;9:8.

II. Mazzoni AS, Carlsson M, Berntsen S, Nordin K, Demmelmaier I. "Finding my own motivation" - A mixed methods study of exercise and behaviour change support during oncological treatment. Int J Behav Med. 2019;26(5):499-511.

III. Mazzoni AS, Brooke H, Berntsen S, Nordin K, Demmelmaier I. Exercise adherence and effect of self-regulatory behaviour change techniques in patients undergoing curative cancer treatment: secondary analysis from the Phys-Can randomized controlled trial. Integr Cancer Ther. 2020;19:1534735420946834.

IV. Mazzoni AS, Brooke H, Berntsen S, Nordin K, Demmelmaier I. Effect of self-regulatory behaviour change techniques and predictors of physical activity maintenance in cancer survivors: a 12-month follow-up of the Phys-Can RCT. Manuscript.

Contents

Abbreviations

ACSM	American College of Sports Medicine
BCT	Behaviour change technique
BMI	Body mass index
CI	Confidence Intervals
COREQ	Consolidated criteria for reporting qualitative research
EBSS	Exercise Barrier Self-Efficacy Scale
EORTC QLQ	European Organisation for Research and Treatment of Cancer
FITT	Frequency, Intensity, Time and Type
HADS-A	Hospital Anxiety and Depression scale (Anxiety subscale)
HI	High intensity
HRmax	Maximum heart rate
HRQoL	Health-related quality of life
HRR	Heart rate reserve
LMI	Low-to-moderate intensity
MET	Metabolic Equivalent
MFI	Multidimensional Fatigue Inventory
MPA	Moderate-intensity physical activity
MVPA	Moderate-to-vigorous intensity physical activity
OR	Odds ratio
PA	Physical activity
Phys-Can	Physical Training and Cancer
PROM	Patient-reported outcome measure
RCT	Randomised controlled trial
RM	Repetition maximum
RPE	Rating of perceived exertion
SD	Standard deviation
ST	Sedentary time
SWA	SenseWear Armband mini
$\dot{V}O_2max$	Maximal oxygen uptake
VPA	Vigorous-intensity physical activity

Preface

During my four years working as a physiotherapist, physical activity has always had a central role in treating my patients. I gave my patients different kinds of exercise programmes to help them to relieve their symptoms or in the best case to be free from their health issues. However, I saw many of them struggle to follow my advices on physical activity, without really understanding why they struggled and how I could help them. My inability to understand and help aroused my curiosity and pushed me to learn more about physical activity and its promotion. I realised that just giving my patients exercise programmes and instructions on how many times they should perform the exercises was not enough. I also realised that I needed to have a broader view and consider physical activity from a behavioural perspective, i.e. taking into account different aspects (e.g. biological, psychological and social factors) to be able to understand and have an impact on my patients' ability to perform physical activity.

Later, when I started with the Phys-Can research project, first as a research assistant and then as a PhD student, I had the opportunity to learn more about physical activity in the context of cancer. I also had the opportunity to learn more about physical activity from two different, but complementary, perspectives. The first one is a biomedical and physiological perspective where physical activity and its effects on health can be quantified and measured. This approach is important, for example, to be able to evaluate the associations between physical activity and different health outcomes. The second perspective is a biopsychosocial perspective, implying that physical activity is a concept consisting of many different behaviours that are multifactorial and should be understood from biological, psychological, behavioural and contextual aspects. This holistic approach is essential to understand what factors explain physical activity, but also to understand what factors can be targeted to have an impact on patients' physical activity levels, both in the short and long term.

This thesis is about promoting physical activity in patients during and after cancer treatment and embraces these two perspectives. I genuinely hope that what I have learned during this journey will be useful to others (i.e. patients, healthcare professionals, researchers, etc).

Introduction

The importance of physical activity (PA) for improved health in persons of all ages has emerged over the past decades [1, 2]. Research clearly demonstrates that regular PA can improve, for example, cardiorespiratory and muscular fitness, bone health and body composition and can prevent many chronic diseases such as depression, obesity, heart diseases and various types of cancer [1, 2]. Research also indicates that regular PA plays an important role in the management of many chronic diseases such as cancer, reducing several disease-related symptoms, improving quality of life, and even extending survival [2].

Historically, patients diagnosed with cancer were advised by their clinicians to rest and to avoid PA [3, 4]. However, research in exercise oncology (i.e. the field that examines the associations between cancer variables and PA [5]) in the 1990s and 2000s challenged this advice [6]. The accumulated evidence has resulted in PA receiving a prominent place in the field. It is now widely recognised that individuals diagnosed with cancer should be physically active both during and after their treatment, and several international recommendations have therefore been published during the past 10 years [3, 6]. However, a decline in PA is usually seen the months to years following a cancer diagnosis [7]. This problematic phenomenon has led to an urgent need to answer questions about how to promote PA in adults diagnosed with cancer, both in the short and the long term [5].

This thesis includes four studies and focuses on PA promotion in patients during and after curative treatment for breast, prostate or colorectal cancer. The introduction consists of four main parts. First, PA and its related concepts are presented in a broader context. Second, a description of cancer, treatments and symptom burden is provided. Third, PA is described in the context of cancer survivorship. Fourth, health behaviour change theories and strategies that can be used to facilitate PA in cancer survivors are presented, as well as the current research gaps that will be addressed in the rest of the thesis.

Physical activity

Definitions

Since PA is a key construct in this thesis, it is essential to first define PA and its related concepts from a physiological perspective.

PA is defined as any bodily movement produced by skeletal muscles that increases energy expenditure above resting levels and includes the full range of human movements [8]. On the other hand, *exercise* is a subset of PA, defined as planned, structured, and repetitive bodily movements performed to improve or maintain physical fitness [8], and consists of aerobic training (cardio-respiratory endurance), resistance training (muscular endurance and strength), flexibility training (stretching) and balance training [9]. The term *PA* is more inclusive and will be used in this thesis unless specifically referring to exercise interventions, as recommended by Rogers et al [10].

Another concept related to PA is *physical inactivity*, defined as insufficient PA levels to meet current PA recommendations [11]. Physical inactivity is often incorrectly used interchangeably with s*edentary behaviour*, defined as any waking activity characterised by low levels of energy expenditure while in a sitting, reclining or lying posture [11]. Sedentary activities therefore include activities undertaken during daytime, for example, while watching TV, engaging in computer use or other forms of screen-based entertainment, as well as reading or sitting in transportation [12]. Hence, physical inactivity and sedentary behaviour are not synonymous.

Physical activity categorisations

PA can be categorised in many ways. For example, PA can be divided into occupational, household, transport and leisure-time activities [13]. Thus, PA includes all types of activities that substantially increase energy expenditure and that are undertaken while working, travelling, playing, carrying out household tasks, or engaging in recreational activities [13].

PA can also be categorised based on the intensity of the activity. Different methods can be used, e.g. absolute or relative intensity [9]. The *absolute intensity* of an activity is the amount of energy required to perform the activity and is usually measured in kcal/kg/min or Metabolic Equivalents (METs). MET is a metabolic unit used to estimate the amount of oxygen consumed by the body during a specific activity, and is defined as the ratio of the metabolic rate during the activity to a reference metabolic rate at rest (1 MET= 3.5 ml O_2/kg/min or 1 kcal/kg/h) [9]. Different MET values can be assigned to dif-

ferent activities to indicate their intensity [14]. PA is therefore usually classified as light intensity with an energy expenditure between 1.6-2.9 METs (e.g. casual walking), moderate intensity (MPA) with an energy expenditure between 3.0-5.9 METs (e.g. brisk walking) and vigorous intensity (VPA) with an energy expenditure at 6.0 METs or more (e.g. running) [1]. PA can also be quantified in terms of METs and minutes spent in different activity levels per day, or MET-minutes per day. At the low end of the intensity range, sedentary activities are characterised by an energy expenditure at 1.5 METs or less [11]. PA intensity can also be measured in *relative intensity*, referring to a person's level of effort relative to his or her maximum capacity. Relative intensity can therefore be expressed as a percentage of a person's maximal oxygen uptake ($\dot{V}O_2max$), heart rate reserve (HRR) or perceived exertion using a self-rating scale such as the Borg's rating of perceived exertion 6 to 20 scale (Borg's RPE 6-20 [15]) [9]. Specific to resistance training, the relative intensity is usually expressed as repetition maximum (RM), where 1 RM is the maximum amount of weight that a person can possibly lift for one repetition [9].

PA can be further categorised in terms of frequency, time and type of activity, referring to how often and how long PA is performed as well as what PA is performed (i.e. the mode) [9]. Together with intensity, those four dimensions constitute the so called *FITT-principles.* The volume of the performed PA can be calculated as the product of the FITT-principles [9].

Assessment of physical activity and sedentary time

Different measurement methods can be used to assess PA and sedentary time (ST) in real-life settings [16, 17]. In public health research, data collection usually involves subjective or self-report instruments such as questionnaires, diaries and recalls, with questionnaires being most frequently used [16]. Self-reports are inexpensive, easy to use and to administer but have various limitations [16, 17]. In particular, they have difficulties in establishing the true frequency, duration and intensity of the activities because of the increased risk for recall and response bias that such reports induce, often related to social desirability and the cognitive demands of recall [16, 17]. Consequently, self-reports tend to over-estimate PA and under-estimate ST. However, daily diaries are a type of self-reports that are able to capture responses within hours after completing the activities [18, 19]. Although they require an intensive effort from the participants to provide detailed information about their activities during the day [20], they are often recommended for a more accurate assessment and for capturing detailed descriptions of PA [16].

On the other hand, the use of objective instruments such as accelerometers has increased exponentially over the past two decades in epidemiological studies and are believed to give a more accurate assessment of PA and ST in real-life

settings than self-reports [16, 21]. Accelerometers are small electronic devices that are usually placed on the hip in the mid-axillary line or on the back of the upper arm triceps, and can measure the magnitude of the body in one (uniaxial), two (biaxial) or three (triaxial) planes [22]. They can capture activities across the movement continuum (i.e. sleep, sedentary and physical activities) in 'real time' and can estimate the number and length of activity bouts at different intensities throughout the day and the week [16]. They provide thus accurate information about the patterns of PA and ST, and an objective estimate of energy expenditure. They also allow a direct comparison between collected data and PA recommendations [22], and remove issues of recall and response bias [17]. Although accelerometers have many advantages, they also have several limitations [22], including their cost [17] and inability to provide contextual information (e.g. settings and type of activities) [16]. Further, they are usually not sensitive enough to differentiate light-intensity activities from sedentary activities, and depending on their emplacement on the body, do not always detect activities involving only upper or lower body movements [17, 18].

Benefits of physical activity and risks of sedentary time

In epidemiological studies, both subjective and objective measurement methods have been used to examine the relationship between PA, ST and health. Regardless of the method used, there is strong evidence that participating in regular PA, at both moderate and vigorous intensity, provides many health benefits in various populations, including populations at risk of developing chronic diseases or living with current chronic conditions or disabilities [1, 4, 23, 24]. Research clearly demonstrates that regular PA can improve cardiorespiratory and muscular fitness, bone health and body composition. Thus, PA is important in the prevention and management of many chronic diseases such as depression, obesity, heart disease, stroke, type 2 diabetes and different types of cancer [1, 25, 26].

On the other hand, sedentary behaviours have emerged as a new risk factor for health in the last decade. Research demonstrates that time spent in sedentary behaviours can lead to a multitude of negative health consequences such as an increased risk for cardiovascular diseases [27, 28], type 2 diabetes [27, 28] cancer [27] and all-cause mortality [27, 28].

Recommendations for the general population

Given the importance of PA and ST on health, it is recommended that adults engage in at least 150 minutes per week of MPA or 75 minutes per week of VPA, preferably spread throughout the week [1]. It is also specified that bouts of any duration of moderate-to-vigorous PA (MVPA) can be included in the

daily accumulated total volume of PA. Furthermore, healthy adults should perform resistance training twice a week, and limit ST [1].

Cancer

Cancer is one of the leading causes of morbidity and mortality worldwide, affecting millions of persons each year [29]. In 2018, approximately 18 million new cases and 10 million deaths occurred due to cancer [29], and the global burden is projected to increase dramatically during the next decade [30]. In Sweden, breast and prostate cancer are the most common cancer types diagnosed in women and men respectively, while colorectal cancer is the third most common cancer diagnosed in both genders [31]. Although the incidence of these cancer types is growing constantly, the survival rates increase due to early detection and improved treatments [31]. Indeed, the five-year survival rate following a cancer diagnosis is approximately 68% today, which reflects a 30% improvement over the past four decades [32].

Curative cancer treatment

Cancer is a group of diseases that can affect any organ or tissue of the body, characterised by an uncontrolled growth and division of abnormal cells invading healthy tissues [30]. Depending on the cancer localisation, type and stage, treatment with curative intent (i.e. aiming at curing the disease) can be provided. There are different combinations of curative treatment. For the most frequent cancers, treatment may include surgery, chemotherapy, radiation and/or hormone therapy [33, 34]. Surgery is usually the primary treatment used to remove the tumour. Chemotherapy, radiation and/or hormone therapy can be given prior to surgery as *neoadjuvant treatment* to shrink the tumour, and/or after surgery as *adjuvant treatment* in order to reduce the risk of cancer recurrence [30, 33, 34].

Treatment-related side effects

Although the improved efficacy of cancer treatment has been demonstrated, cancer and its treatment often cause multiple physical and psychological side effects that can persist for years [33-35]. Cancer-related fatigue [36], depression and anxiety [37, 38], pain [39], cognitive impairments [40, 41] and reduced cardiopulmonary function [42] are among the most common side effects, leading to difficulty returning to work, poor autonomy and poor quality of life [43]. The symptom burden is considerable, affecting a majority of patients. For example, in a recent systematic review and meta-analysis involving 145 000 adults with heterogeneous cancer types, the pooled prevalence of cancer-related fatigue was estimated to 52%, with approximately 40% of patients

suffering from moderate-to-severe cancer-related fatigue [36]. Results from longitudinal studies have also indicated that between 35% and 75% of adults suffer from cognitive impairments (i.e. problems with memory, executive functioning and attention/concentration), both during and after cancer treatment [41]. Furthermore, the risk of developing heart diseases is increased due to some cancer treatments [44], and cardiovascular mortality has emerged as one of the major causes of death in cancer survivors, affecting approximately 10% of this population [45]. Although the proportion of cancer survivors experiencing side effects varies greatly in study reports due to methodological aspects (i.e. different methods to assess side effects) and study samples' characteristics (e.g. different cancer treatments), it is estimated that all patients will be affected by one or more side effects during the course of their treatment or survivorship [46].

Cancer survivors

Many definitions of cancer survivors have been proposed over the past decades [47], and because this thesis focuses on this population, a clear definition needs to be determined. Historically, the term *cancer survivors* was used to describe family members who survived the loss of a loved one to cancer at the time cancer was considered incurable [48]. As cancer treatments became more effective, the term *cancer survivors* has been used to describe patients who had cancer but had remained free from the disease for at least five years [47]. Another common definition is "individuals with a diagnosis of cancer who have completed primary treatment or the major aspects of treatment for cancer" [49]. However, several organisations such as the National Coalition for Cancer Survivorship and the National Cancer Institute's Office of Cancer Survivorship have redefined the term *cancer survivors* recently, as individuals with cancer from the time of diagnosis and throughout their lifespan [50, 51]. Their definition, which is now widely used in the literature, also includes family, friends and caregivers. This holistic definition aims at encouraging clinicians to consider the care of survivors and their relatives as an integral part of the cancer care continuum, i.e. from diagnosis to years post-diagnosis. Three distinct phases are usually associated with cancer survivorship, including the time from diagnosis to the end of primary treatment, the transition from treatment to survivorship, and long-term survivorship [52]. In this thesis, the term *cancer survivors* will be used to refer to patients who have been diagnosed with cancer, from the time of diagnosis through the remainder of life. More specifically, to differentiate patients undergoing (neo-) adjuvant cancer treatment from those who have completed their treatment, the term *patients undergoing curative cancer treatment* will be used. However, it is important to acknowledge that debate about how to define cancer survivors or whether to use this term at all is still ongoing. It is also important to acknowledge that the term *cancer survivors* may be viewed differently by patients based on their

own experiences, and thus that patients may not always identify themselves as cancer survivors [53].

Physical activity in cancer survivors

Given the increasing number of cancer survivors worldwide, an urgent need regarding how to manage the multiple persistent side effects caused by cancer and its treatment has emerged over the past decades [54]. The role of PA in cancer survivors, both during and after treatment, has been intensively studied and identified as one of the key health behaviours that needs to be in focus [6, 54]. An overview of the current knowledge and evidence regarding PA and cancer is presented in the next few paragraphs.

Health benefits

A growing body of evidence indicates that PA, including exercise, is safe and beneficial during and after cancer treatment [6], improving many of the negative side effects of cancer and its treatment. Indeed, results from a large number of randomised controlled trials (RCTs) indicate that regular PA may reduce cancer-related fatigue [6, 55], anxiety [6, 56], depression [6] and improve physical fitness and quality of life [6, 57] in cancer survivors. Furthermore, epidemiological studies suggest that being physically active after a cancer diagnosis may reduce the risk of cancer recurrence [58, 59] and the all-cause mortality up to 45% in this population [54]. Evidence from observational studies also suggest a dose-response relationship between PA levels and cancer outcomes (e.g. higher PA volumes may lead to lower mortality risk) [54, 60, 61].

Moreover, the possible negative health effects caused by ST in cancer survivors such as impaired quality of life [62, 63], increased depression [64] and mortality [65], have long been considered to be independent of PA [65, 66]. However, new evidence has challenged these previous study findings. The results from a large meta-analysis including more than 800 000 heathy adults indicate that the effects of ST on cardiovascular diseases and cancer mortality could be reduced and even eliminated if a certain level of daily MVPA was performed [67]. Similar results have been reported in observational studies with cancer survivors. For example, a study involving 199 breast cancer survivors found that the association between ST and different health outcomes (e.g. pain and fatigue) was eliminated when higher levels of MVPA were performed [68].

The benefits of PA have been observed for multiple types of cancers, but the strongest evidence exists for breast, prostate and colorectal cancer survivors

due to the large number of studies performed involving patients with these diagnosis [6, 54]. Several biological mechanisms are believed to be involved, including weight loss, decreased adiposity, improved immune function, reduced systemic inflammation, modulation of sex hormone levels (e.g. oestrogens and testosterone) and metabolic changes (e.g. improved insulin sensitivity and glucose metabolism) [69, 70]. Although the underlying mechanisms are not yet fully understood, it is now recognised that cancer survivors have much to gain by being physically active regularly. International PA recommendations have therefore been established and are described below.

International recommendations

Since 2003, international PA recommendations for cancer survivors have been developed and regularly updated based on the growing evidence linking PA to health outcomes. In 2010, the American College of Sports Medicine (ACSM) [3] published recommendations for cancer survivors, based on existing recommendations for the general population [71-73]. *For improving general health,* cancer survivors are recommended to engage in moderate intensity aerobic activity for at least 150 minutes per week or 75 minutes per week of vigorous intensity (or a combination, e.g. 90 minutes of aerobic activity at moderate-to-vigorous intensity), in addition to two or more sessions per week of resistance training, including major muscle groups [3]. In 2019, updated recommendations were published, and more specific exercise prescriptions were generated for cancer-related outcomes, including fatigue, health-related quality of life (HRQoL), physical function, anxiety and depression [6]. *For improving these cancer-related outcomes*, cancer survivors are recommended to perform thrice-weekly moderate intensity aerobic activity for at least 30 minutes per session, and/or two sessions per week of resistance training. Cancer survivors are also recommended to avoid being sedentary [6]. A detailed description of these new recommendations is provided in Table 1.

Table 1. *Physical activity recommendations for cancer survivors with application to the FITT-principles* [6]

Rational	**Recommendations**			
Improve specific cancer-related outcomes	Aerobic only	Resistance only	Combination	
Fatigue	▪ 3 times/week ▪ 45% $\dot{V}O_2$max, RPE 12 ▪ 30 min/session	▪ 2 times/week ▪ 60% 1 RM, RPE 12 ▪ 2 sets of 12–15 reps for major muscle groups	Aerobic: ▪ 3 times/week ▪ 45% $\dot{V}O_2$max, RPE 12 ▪ 30 min/session	Resistance: ▪ 2 times/week ▪ 60% 1 RM, RPE 12 ▪ 2 sets of 12–15 reps for major muscle groups
HRQoL	▪ 2 to 3 times/week ▪ 60%–80% HRmax, RPE 11–13 ▪ 30 min/session	▪ 2 to 3 times/week ▪ 60%–75% 1 RM, RPE 13–15 ▪ 2 to 3 sets of 8–15 reps for major muscle groups	Aerobic: ▪ 2 to 3 times/week ▪ 60%–80% HRmax, RPE 11–13 ▪ 20 to 30 min/session	Resistance: ▪ 2 to 3 times/week ▪ 60%–80% 1 RM, RPE 12–14 ▪ 2 sets of 8–15 reps for major muscle groups
Physical function	▪ 3 times/week ▪ 60%–85% $\dot{V}O_2$max, RPE 12–13 ▪ 30–60 min/session	▪ 2 to 3 times/week ▪ 60%–75% 1 RM, RPE 13–15 ▪ 2 sets of 8–12 reps for major muscle groups	Aerobic: ▪ 3 times/week ▪ 60%–85% $\dot{V}O_2$max, RPE 12–13 ▪ 20–40 min/session	Resistance: ▪ 2 to 3 times/week ▪ 60%–75% 1 RM, RPE 13–15 ▪ 2 sets of 8–12 reps for major muscle groups
Anxiety and depression	▪ 2 to 3 times/week ▪ 60%–80% $\dot{V}O_2$max, RPE 13–15 ▪ 30–60 min/session	Insufficient evidence	Aerobic: ▪ 2 to 3 times/week ▪ 60%–80% $\dot{V}O_2$max, RPE 13–15 ▪ 20–40 min/session	Resistance: ▪ 2 to 3 times/week ▪ 65%–85% 1 RM, RPE 13–15 ▪ 2 sets of 8–12 reps for major muscle groups

Abbreviations: FITT= frequency, intensity, time and type, $\dot{V}O_2$max = maximal oxygen uptake, RPE= Rating of Perceived Exertion, RM= repetition maximum, reps= repetitions, HRQoL= health-related quality of life, HRmax= maximum heart rate.

Trajectory and level of physical activity and sedentary time

Despite the health benefits of PA and the recommendations, cancer survivors tend to reduce their level of PA after being diagnosed, as reported by several observational studies [7, 74-77]. For example, results from a German cohort including 1067 breast cancer survivors indicate a decrease in total self-reported PA levels during and after treatment compared with pre-diagnosis levels, from 36 MET-hour/week pre-diagnosis to 14 MET-hour/week during the treatment period, and 34 MET-hour/week one year after surgery [75]. A French cohort study involving 942 cancer survivors with different cancer diagnosis has reported similar patterns [7]. Total self-reported PA levels decreased after diagnosis from 53 MET-hour/week pre-diagnosis to 49 MET-hour/week during the first year after diagnosis. This decrease of PA was then followed by increased levels at three years post-diagnosis but without reaching the pre-diagnosis levels [7].

Cancer survivors not only decrease their level of PA, but also increase the amount of time spent sedentary after being diagnosed [7, 78] and tend to spend more time sedentary compared with healthy controls [79-81]. For example, in a cross-sectional study, self-reported ST in cancer survivors was examined and compared to non-cancer controls, using data from the National Health and Nutrition Examination Survey (NHANES) (2007-2010) [81]. The authors found that the proportion of cancer survivors spending more than eight hours sedentary was approximately 35% compared with 30% for the non-cancer participants [81].

Furthermore, research demonstrates that the majority of cancer survivors do not meet the PA recommendations [82, 83]. For example, data from a national survey in the United States indicate that between 30% and 47% of cancer survivors meet the PA recommendations with large variations between types of cancer [82]. Data from another national survey in England indicate that only 23% of cancer survivors are active to recommended levels and 31% are completely inactive [83]. Research also shows that cancer survivors are less physically active than the general population, both during and after cancer treatment (Figure 1) [84-87]. When looking at aerobic PA and resistance training separately, similar trends are observed. For example, the authors from another national survey in the United States found that the proportion of persons meeting the recommendations for aerobic PA was approximately 35% for cancer survivors and 43% for non-cancer controls [88]. Further, the proportion of persons meeting the recommendations for resistance training was approximately 25% for cancer survivors and 32% for non-cancer controls [88].

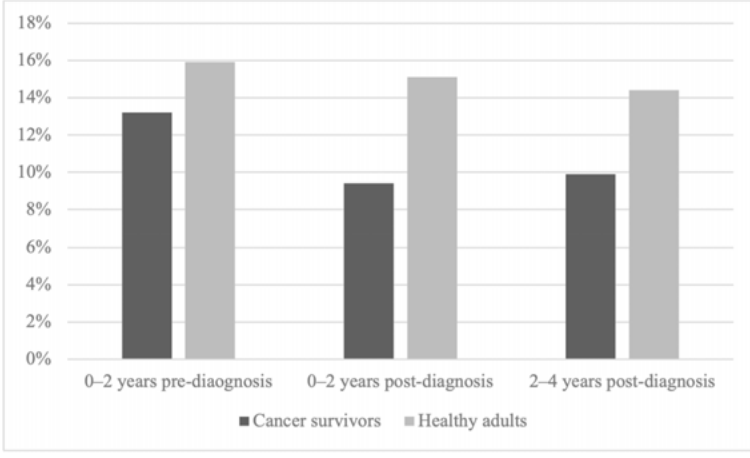

Figure 1. Proportion of cancer survivors moderately or vigorously physically active ≥ once per week at three different time points compared to healthy adults (data from Williams et al. [85])

Reasons for the changes in PA and ST in cancer survivors are multifactorial, but several qualitative and quantitative studies have reported treatment side effects [89-93] and insufficient support from healthcare professionals [93-96] as possible explanations. The low levels of PA in cancer survivors also indicate that engaging in PA during and after cancer treatment is challenging for many cancer survivors. The promotion of PA in this population is therefore crucial.

The importance of assessing physical activity and sedentary time

Assessing PA in cancer survivors is important for many reasons. First, from a research perspective, we need to better understand PA, to identify which interventions work and to correctly evaluate the associations between PA and health outcomes in cancer survivors [97]. This will lead to stronger research evidence, which in turn, may encourage the integration of PA into routine cancer care. Second, from a cancer care perspective, using adequate measurement instruments may provide healthcare professionals with detailed information on their patients' PA levels during and after cancer treatment. This will enhance their ability to detect differences in their patients' physical function, helping them to promote PA [98, 99]. Further, ST should also be included when assessing PA to provide a full picture of a patient's PA behaviours. Indeed, the association found between PA and ST (i.e. PA reducing the negative effects of ST [67, 68]) highlights the importance of capturing both PA and ST to effectively promote health in cancer survivors.

However, assessing PA and ST accurately in cancer survivors remains a challenge because of the complex multi-dimensional nature of these constructs

[22]. Both self-reports and objective instruments are usually used and include well-known advantages and limitations [16]. Daily diaries and accelerometers have several advantages as described earlier, and are therefore recommended for a more accurate assessment of PA and ST in different populations when using a self-report and an objective instrument, respectively. They are therefore of particular interest for assessing PA and ST in cancer survivors [22]. These instruments have a certain amount of measurement error and it is therefore unlikely that they will provide exactly the same results when compared to each other. However, assessing the degree of agreement between these two instruments allows us to determine how much they differ from each other, whether the data provided are comparable or whether they can be used interchangeably [100], providing valuable information on how to optimise their use. To date, few studies have compared daily diaries with accelerometers to assess PA and ST in cancer survivors [101, 102], emphasising a need to examine the level of agreement between the two types of measurement instruments in this population.

Promoting physical activity in cancer survivors

Understanding how to facilitate PA in cancer survivors is one of the top 10 research questions in exercise oncology [5]. A biopsychosocial perspective is needed to understand and explain how to promote PA, both in the short and long term. This holistic approach emphasises that there are interactions between biological, psychological, social and contextual factors, and that those interactions need to be considered to fully understand and explain an individual's PA behaviours [103].

Further, to understand a PA behaviour, we also need to take into consideration the causes of this behaviour (antecedents) and its consequences, implying that a behaviour is performed or not, depending on situations that precedes the behaviour and the consequences (operant learning) [104]. Thus, a PA behaviour can be analysed using operant learning principles that include the identification of antecedent cues (A) for a specific behaviour (B) and the consequences of this behaviour (C). Antecedent cues are factors or situations that trigger a behaviour. If a PA behaviour (e.g. engaging in a daily walk) is then followed by reinforcing or positive stimuli (e.g. well-being), it will be strengthened and more likely to occur again in the future. Conversely, if a PA behaviour results in punishment or undesirable consequences (e.g. pain), it will be weakened and less likely to occur again in the future.

Health behaviour change theories

Partly inspired by the biopsychosocial perspective and the above-mentioned operant learning principles, several health behaviour change theories have been developed to understand PA behaviours (by identifying the constructs that predict PA) and guide PA promotion (by determining how these constructs can be manipulated in interventions to facilitate PA) [105]. Theories such as the social cognitive theory and self-determination theory have been frequently used in exercise interventions with cancer survivors [105]. These theories share several central concepts to promote PA such as *motivation*, *self-efficacy* and *self-regulation* [106]. No single theory provides complete answers on how to understand PA behaviours. Therefore, it is recommended to combine or blend different constructs from different theories in behavioural interventions [105-107]. Since this thesis is partly inspired and guided by the social cognitive theory, self-determination theory and their key concepts, it is important to describe them.

Social cognitive theory

The social cognitive theory is used to understand and explain what factors motivate a person to adopt and maintain a specific behaviour [106, 108]. This theory is based on a dynamic and reciprocal model in which personal, behavioural and environmental factors continually interact. This theory considers that an individual's behaviours can be influenced by several key constructs: 1) *outcome expectations*, i.e. an individual's belief about positive and negative consequences of performing a specific behaviour; 2) *observational learning*, i.e. learning by observing the actions of others and the consequences of those actions; 3) *goals* that individuals set for themselves and the concrete plans and strategies for realising them; and 4) *perceived facilitators/barriers* to the behaviour changes they try to achieve [108].

Self-efficacy and *self-regulation* are also central constructs and seem to be particularly important for influencing behaviours [108]. Self-efficacy is defined as an individual's confidence in his/her ability to perform a specific behaviour and is the foundation of motivation. Individuals who believe they can reach the desired effects by changing a behaviour are more motivated to make these changes even if they face difficulties. Bandura [108] has outlined structural paths of influence and hypothesised that self-efficacy has an indirect effect on behaviours through outcome expectations, perceived facilitators/barriers and goals. All those key constructs influence motivation and are influenced by the environmental factors. Moreover, self-efficacy is posited to influence behaviours directly and through the development and use of self-regulatory skills, defined as an individual's ability to regulate one's behaviour. Self-efficacy is therefore considered as part of the self-regulatory process which occurs through the development or reinforcement of three skills: self-observation, to

be aware of own behaviour; self-evaluation, to evaluate own performance; and self-reaction, to rectify the behaviour if a discrepancy occurs between the current and the intended behaviour [109].

Consequently, according to the social cognitive theory, individuals learn through their own and others' experiences, e.g. by performing a specific PA and by observing others performing the same PA and seeing if the consequences are positive or negative. Further, a PA behaviour change is possible when individuals develop self-regulatory skills, feel that they can execute the PA behaviour (i.e. self-efficacy) and have a reasonable expectation that the PA behaviour will result in a desired health outcome (i.e. outcome expectations) [110]. Several studies have demonstrated that by incorporating key constructs of the social cognitive theory (e.g. self-efficacy) in interventions promoting PA in cancer survivors, levels of PA were increased, both in the short [111-113] and the long term [114].

Self-determination theory

Self-determination theory considers that a person's motivation to engage in a behaviour depends on the satisfaction of her or his basic psychological needs [105, 115]. Those needs are *autonomy* (being the agent of one's own actions), *competence* (being able to achieve challenging tasks and reach goals) and *relatedness* (being connected to and valued by others). Additionally, self-determination theory describes the relationship between individuals' behavioural regulations and their motivational consequences. Motivation to engage in a behaviour is based on a motivational continuum, from *extrinsic motivation* with *external regulation* (i.e. the behaviour is regulated by external incentives) to *intrinsic motivation* with *autonomous regulation* (i.e. the behaviour is self-regulated and fully integrated into personal values and beliefs) [105]. For example, an individual is motivated to go for a 30-minute walk every day to win a walking challenge at her/his workplace (extrinsic motivation; the individual exercises in response to an external demand/reward), while another individual is motivated to perform the same activity because walking is fun (intrinsic motivation; the individual exercises for the inherent enjoyment, interest and pleasure derived from accomplishing the activity).

According to self-determination theory, the satisfaction of the three basic psychological needs (autonomy, competence and relatedness) is believed to promote and facilitate motivation through the development of more intrinsic incentives, leading to feelings of inherent satisfaction, enjoyment and personal accomplishment. Thus, when creating an environment that promotes autonomy, competence and relatedness, an individual becomes intrinsically motivated and is more likely to sustain a behaviour change [115]. Here, motivation is a central concept and using strategies that encourage the satisfaction of the

three basic psychological needs (e.g. through social support) may lead to increased motivation to exercise and thereby to a sustainable behaviour change in cancer survivors [116]. Studies have found that incorporating self-determination theory constructs in interventions promoting PA led to increased PA levels [116, 117] and improved health outcomes in cancer survivors [118].

Behaviour change support

Research indicates that cancer survivors during and after cancer treatment may benefit from interventions promoting PA and exercise [119-122]. For example, results from an intervention involving 377 breast cancer survivors indicate that using print materials with pedometers increased PA levels in participants in the intervention groups [123]. Results from another intervention with 46 colorectal cancer survivors show that telephone counselling increased home-based PA levels in the intervention group [112]. Finally, in an intervention involving 222 breast cancer survivors, it was reported that a multicomponent behavioural support, combining counselling sessions with supervised group-based exercise and individual home-based exercise, was effective in increasing PA levels in the intervention group [124].

Such interventions typically incorporate constructs from various behavioural change theories and use strategies to target these constructs and facilitate PA, including behaviour change techniques (BCTs). BCTs are defined as active ingredients or practical components of an intervention designed to change a behaviour [125]. A taxonomy of 93 BCTs has been developed by Michie et al [125] to provide a standardised method of classifying such intervention components. Using this taxonomy, several reviews have reported that most interventions promoting PA use different combinations of BCTs [119-122]. Graded tasks, instructions on how to perform a behaviour and social support figure among the most commonly used BCTs in interventions involving cancer survivors, irrespective of their efficacy in promoting PA [119-122]. On the other hand, self-regulatory BCTs such as goal-setting, self-monitoring and action planning are frequently used in effective studies with different adult populations [121, 126]. They appear to play an important role in enhancing patients' self-regulatory skills (i.e. ability to control/regulate one's behaviour), and may thereby increase the chances of succeeding in facilitating PA in cancer survivors, both in the short (e.g. during cancer treatment) [119, 121] and long term (e.g. months or years after cancer treatment completion) [127]. However, few RCTs have examined the effect of self-regulatory BCTs in promoting short- and long-term PA in cancer survivors, highlighting a need for further research. A more detailed knowledge from a patient perspective is also needed to inform health care and improve clinical practice.

Adherence to exercise interventions

In the context of interventions promoting PA, and more specifically exercise, *exercise adherence* is defined as the extent to which intervention participants follow the exercise prescription during the intervention [128, 129]. In the literature, *adherence* has been used interchangeably with the term *compliance,* although there are important differences. While the term *adherence* implies an active, agreed and voluntary engagement of participants in performing a specific behaviour, *compliance* has a more patriarchal approach, consisting of a passive behaviour in which participants are following exercise instructions from professionals without considerations of contextual factors [130, 131]. From a behavioural perspective, the term *adherence* is preferred and therefore used in this thesis.

To be able to determine what behavioural interventions work in promoting PA and to implement effective behaviour change support in clinical practice, there is a need to report how such support impacts on exercise adherence. A detailed report of exercise adherence in cancer survivors is therefore crucial [121]. However, exercise adherence is usually poorly documented in interventions involving cancer survivors [121, 132, 133], highlighting a need for further investigation. Yet, it is recommended to report exercise adherence based on the FITT-principles. This includes reporting adherence to the prescribed frequency, intensity, time and type of exercise [132]. Dropout rates should also be included to provide insight into the efficacy and feasibility of exercise interventions [129].

Physical activity maintenance

Another important aspect in exercise oncology is *PA maintenance*, defined as a sustained PA behaviour for at least six months after the end of an exercise intervention [134, 135]. As previously described, a majority of cancer survivors struggle to stay physically active, even years after being diagnosed [7, 77, 85]. Many also struggle to maintain their level of PA even after participating in an exercise intervention [136, 137]. Examining the long-term effect of behaviour change support such as self-regulatory BCTs provided in exercise interventions is therefore crucial to better understand how to promote PA in cancer survivors. We also need to better understand what factors may predict sustained PA in order to identify who may benefit most from self-regulatory BCTs and develop more effective interventions for promoting long-term PA in cancer survivors. Several determinants such as demographic factors (e.g. age and education), psychosocial factors (e.g. motivation, exercise self- efficacy, fatigue) and physical factors (e.g. body mass index, cardiovascular fitness) have been identified as potential predictors of PA maintenance, but study findings are mixed [138]. Furthermore, the majority of studies have examined

predictors of short-term maintenance (e.g. six months post-intervention) [138], limiting the possibility to draw conclusions about predictors of PA maintenance in the longer term (12 months or more). Hence, there is a need to study predictors of long-term PA maintenance in cancer survivors.

Rationale for this thesis

In summary, PA including exercise, is safe and beneficial during and after cancer treatment, reducing many of the negative side effects of cancer and its treatment. However, it is really challenging for cancer survivors to be physically active during cancer treatment, and to maintain adequate PA levels in the long term. Given the importance of PA in cancer survivors, it is essential to fill several of the current research gaps and increase knowledge about how to promote PA in this population.

First, there is a need to better understand how to correctly assess PA and ST in cancer survivors. This is essential because it may strengthen research evidence, lead to an integration of PA into routine cancer care, and give healthcare professionals tools for promoting PA. Studies reporting levels of PA and ST in cancer survivors have used self-reports (mainly questionnaires) or objective instruments, introducing well-known bias. Two types of instruments are however recommended for a more accurate assessment of PA and ST: daily diaries as self-reports and accelerometers as objective instruments. To date, few studies have compared these two types of instruments to assess PA and ST in cancer survivors, emphasising a need to examine their level of agreement, which will provide useful information about how to optimise their use.

Second, there is a need to better understand how to facilitate PA in patients undergoing cancer treatment. Previous studies have examined associations between different BCTs and level of PA, but still little is known about the effect of self-regulatory BCTs on exercise adherence in patients undergoing cancer treatment, highlighting a need for further research. A patient's perspective regarding the use of behaviour change support is also warranted. This to better understand how exercise interventions including this approach may promote and motivate patients to be physically active, and how to implement such support in clinical settings.

Finally, the effect of exercise interventions on long-term PA maintenance in cancer survivors is not well-understood, and little is known about the predictors of long-term PA maintenance. This needs to be studied in order to develop more effective and better tailored strategies to improve PA in cancer survivors in the long term.

Overall and specific aims

The overall aim of this doctoral thesis was to increase knowledge about the promotion of PA in patients during and after curative cancer treatment, focusing on PA assessment, patients' experiences and the effect of behaviour change support.

The specific aims of the studies included in this thesis were:

Study I

To compare a self-report (7-day diary) and an objective instrument (SenseWear Armband mini) for assessing daily time spent in MPA, VPA and ST in patients undergoing curative treatment for breast cancer.

Study II

To explore the motivational experiences of exercise combined with behaviour change support, and to describe how specific BCTs were valued among patients exercising during curative treatment for breast, prostate or colorectal cancer.

Study III

To describe exercise adherence according to the FITT-principles (frequency, intensity, time and type) and dropout rates, and to determine the effect of self-regulatory BCTs on exercise adherence in patients participating in a six-month exercise intervention during curative treatment for breast, prostate or colorectal cancer.

Study IV

To determine the effect of self-regulatory BCTs on long-term PA maintenance and identify baseline predictors of long-term PA maintenance in breast, prostate and colorectal cancer survivors 12 months after participating in an exercise intervention delivered during curative cancer treatment.

Methods

The four studies included in this thesis are based on data collected within the Physical training and Cancer (Phys-Can) project. The Phys-Can project is described in the sections below.

The Phys-Can project

The Phys-Can project includes an observational study and an RCT with a 2x2 factorial design. In both studies, eligible patients, assessed by an oncologist, were aged 18 years or older, newly diagnosed with breast, prostate or colorectal cancer and scheduled to undergo curative (i.e. (neo-)adjuvant) cancer treatment. Patients were excluded if they suffered from cognitive dysfunction (e.g. dementia or serious mental illness), physical impairments and/or other diseases (e.g. cardiovascular or lung diseases) that could affect their ability to perform PA and exercise. All participants were consecutively recruited at University hospitals in three cities in Sweden (Lund/Malmö, Linköping and Uppsala). For both studies, participants were followed over time and assessments were performed at several time points, including at baseline, at six months and at 18 months. These assessments comprised filling out questionnaires, performing a $\dot{V}O_2$max test and measuring PA (see Procedures and data collection for more details).

Phys-Can observational study

The aim of the Phys-Can observational study (n=103) was to monitor how the disease and treatment influence cancer-related fatigue, cardiorespiratory fitness, mental well-being, HRQoL and PA in patients during and after curative cancer treatment. Participants were recruited before the start of the RCT, between September 2014 and February 2016. They were followed up over time and did not receive any intervention.

Phys-Can RCT

The aim of the Phys-Can RCT (n=577) was to compare the effects of exercise intensity and self-regulatory BCTs on cancer-related fatigue in patients undergoing curative cancer treatment [139]. Participants were recruited between

March 2015 and April 2018, and were randomised to one of four intervention groups: 1) high intensity (HI) exercise *with* self-regulatory BCTs, 2) HI *without* self-regulatory BCTs, 3) low-to-moderate intensity (LMI) exercise *with* self-regulatory BCTs, and 4) LMI *without* self-regulatory BCTs.

The intervention was initiated at the beginning of the curative cancer treatment, and started with a six-week familiarisation period to provide the participants with a gradual introduction to the exercise programme and to the behaviour change support.

Exercise programme

The exercise intervention took place for six months and consisted of combined resistance training and endurance training.

Participants were offered twice-weekly resistance training sessions at a public gym, in groups of 5-10 participants and supervised by study coaches (physiotherapists and personal trainers). The programme consisted of a total of six exercises (i.e. seated leg press, chest press, leg extension, seated row, seated leg curl and seated overhead press) (Appendix 1). Participants in the HI groups were instructed to perform three sets of six repetitions at an intensity of six RM during the first weekly session, and three sets of 10 repetitions at 10 RM during the second weekly session. The third set of each exercise was performed until exhaustion. Participants in the LMI groups were instructed to perform three sets of 12 repetitions at 50% of six RM during the first weekly session, and three sets of 20 repetitions at 50% of 10 RM during the second weekly session. To enable progression, all participants performed six and 10 RM tests every six weeks, with subsequent adjustments made to their exercise programme.

Participants performed endurance training on their own (home-based). Participants in the HI groups were instructed to perform twice-weekly HI interval training (e.g. alternating between running and walking). The interval training consisted of two-minute intervals at 80-90% of HRR, followed by two minutes of active rest. The number of intervals was progressively increased (one interval added every four weeks), starting with five intervals the first weeks until 10 intervals were reached. Participants in the LMI groups were instructed to perform 150 minutes per week of continuous training (e.g. bicycling or walking) in bouts of at least 10 minutes at 40-50% of HRR. An individual HRR was calculated for each participant based on the results of the $\dot{V}O_2max$ test performed before randomisation, where participants walked or ran on a treadmill until exhaustion.

Behaviour change support

Behaviour change support was provided to facilitate exercise. More specifically, all participants in the four intervention groups were provided with specific BCTs during the exercise intervention (Table 2). Those BCTs consisted of social support from coaches and peers, a structured environment with scheduled resistance training sessions, feedback on performance and self-registration of resistance and endurance training in logs. Participants randomised to receive self-regulatory BCTs were also guided by study coaches to use additional BCTs, consisting of goal-setting, review of those goals, self-monitoring, action planning and problem solving (Table 2). These self-regulatory BCTs were selected based on previous research [120, 140]. They were used to target key constructs of the social cognitive theory (e.g. goals, self-regulation) and enhance motivation. The self-regulatory BCTs were used during face-to-face behavioural sessions on a maximum of nine occasions, except for self-monitoring that was home-based and performed by the participants after each endurance training session. Participants also developed an individual plan for relapse prevention at the end of the exercise intervention, including goal-setting and coping planning. This plan was individually followed up and revised at three and nine months post-exercise intervention during face-to-face or telephone sessions with the study coaches (Table 2).

Intervention integrity

Before the intervention started, the coaches involved in the study completed a three-day mandatory course, where they were trained to supervise participants randomised to one condition (i.e. either *with* or *without* self-regulatory BCTs). During the intervention, they followed a detailed protocol and kept a week-by-week checklist for each participant, where notes were taken regarding any deviations from the protocol. Further, to ensure a clear delimitation between the conditions, the groups trained on different days and the coaches who provided self-regulatory BCTs only supervised participants randomised to this condition. Finally, research staff visited the gyms repeatedly and arranged group meetings with the coaches to ensure that the intervention was delivered as planned.

The total number of behavioural sessions offered to participants, who were provided with self-regulatory BCT, could vary *during* the exercise intervention depending on each participant's needs (e.g. there were fewer sessions if goals were easily reached every week). The median number of behavioural sessions was five (min 1-max 9) *during* the exercise intervention and two (min 0-max 2) *after* the exercise intervention. None of the intervention groups was offered training sessions after the end of the exercise intervention.

Table 2. *Behaviour change support provided in the Phys-Can RCT*

BCTs	Description	During the exercise intervention	After the exercise intervention
	To all participants		
Social support	*Coaches* encouraged and gave information about why and how to exercise. They provided practical help and guidance. Participants were also encouraged, advised and assisted by their *peers*.	x	
A structured environment	Participants performed the resistance training sessions at *fixed times* and at a *fixed place*. They were also provided with the adequate *gym equipment*.	x	
Feedback on performance	Participants used a *heart rate monitor* during the endurance training sessions. The *heart rate monitor files* were continuously checked by the coaches. Participants regularly performed *muscular strength tests* and *cardiorespiratory fitness tests*.	x	
Self-registration	Participants recorded each resistance and endurance training session in *training logs*.	x	
	To participants in the groups with self-regulatory BCTs		
Goal-setting	Participants formulated specific *weekly behavioural goals* for the home-based endurance training (exercise frequency, intensity, time and/or type).	x	
Review of behavioural goals	Participants r*eviewed their behavioural goal*s with their coaches to check if those goals were reached. Adjustments were made when needed.	x	
Self-monitoring	When recording endurance training sessions in training logs, participants made reflective notes regarding exercise experiences, thoughts and feelings. They also reflected and made notes about facilitators and barriers to exercise in specific situations.	x	
Action planning	Participants made *exercise plans* with their coaches specifying when, where and how to perform endurance training. The plans were based on an initial interview about previous exercise habits.	x	
Problem solving	Participants *analysed their training logs* with the coaches and identified strategies to overcome barriers to exercise. The analyses were performed to identify relationships between antecedents, specific exercise behaviours and consequences. Participants developed a written long-term *plan for relapse prevention* at the end of the exercise intervention.	x	
Follow-up prompts	Participants had brief contacts with their coaches at 3 and 9 months after the end of the exercise intervention. The plan for relapse prevention, including goal-setting and coping planning, was reviewed and revised on this occasion.		x

Abbreviations: Phys-Can= Physical Training and Cancer, RCT= randomised controlled trial, BCTs= behaviour change techniques.

Methodological overview Studies I-IV

Different data from the Phys-Can project and different methods were used in the four included studies. *Study I* was based on a sample from the Phys-Can observational study and used a cross-sectional and descriptive design. *Studies II-IV* were based on samples from the Phys-Can RCT and used a mixed-methods, RCT and longitudinal correlative design, respectively. A methodological overview of the studies is presented in Table 3.

Table 3. *Designs and methods of Studies I-IV*

Study	Design	Sample	Data collection	Data analysis
I	Cross-sectional and descriptive	65 participants with breast cancer from the Phys-Can observational study	SWA and a 7-day diary (for MPA, VPA, ST)	Wilcoxon signed-rank test, Bland-Altman plots and spearman's rank correlation coefficients
II	Mixed-methods (concurrent triangulation) and descriptive	229 participants with breast, prostate or colorectal cancer from the Phys-Can RCT	Semi-structured individual interviews (n=18) and a study-specific questionnaire (n=229)	Thematic analysis and descriptive statistics
III	RCT and descriptive	577 participants with breast, prostate or colorectal cancer from the Phys-Can RCT	Attendance records, training logs and heart rate monitors	Descriptive statistics, multiple linear regression and multiple logistic regression
IV	RCT, longitudinal and correlative	301 participants with breast, prostate or colorectal cancer from the Phys-Can RCT	SWA (for MPA, VPA), a 7-day diary (for resistance training), PROMs, objectively assessed outcome measures and medical records	Descriptive statistics and multiple logistic regression

Abbreviations: SWA= SenseWear armband mini, MPA= moderate-intensity physical activity, VPA= vigorous-intensity physical activity, ST= sedentary time, Phys-Can= Physical Training and Cancer, RCT= randomised controlled trial, PROMs= patient-reported outcome measures.

Participants

Study I

Participants in *Study I* were patients with breast cancer who accepted to participate in the Phys-Can observational study between September 2014 and April 2015, and who performed the baseline assessments. From the 68 eligible participants, 3 (4%) did not complete the PA assessments and were therefore excluded. A total of 65 (96%) had available data regarding MPA and VPA and were included. Among them, 42 participants (65%) had available data regarding ST. Participants' mean age was 58 years (SD 11). All were included after breast surgery, and the majority were scheduled to receive radiation therapy (40%) as primary adjuvant treatment (Table 4).

Table 4. *Baseline characteristics of the participants in Study I (Phys-Can observational study)*

	Study I (n=65)
Age, mean years (SD)	58 (11)
Education, n (%)	
University	31 (51)
Occupation, n (%)	
Working[a]	32 (50)
On sick leave[a]	20 (32)
Retired	22 (36)
Comorbidities, n (%)	
One or more	31 (50)
Self-reported exercise habits, n (%)	
Resistance training since ≥6 month	13 (24)
Endurance training since ≥6 months	38 (61)
Weight status, n (%)	
Normal weight, BMI 18-24.9 kg/m^2	27 (46)
Overweight, BMI 25-29.9 kg/m^2	25 (42)
Obesity, BMI≥ 30 kg/m^2	7 (12)
Exercise self-efficacy (0-10)[b], mean (SD)	5 (2)
$\dot{V}O_2$max, mean mL/kg/min (SD)	29 (7)
Primary adjuvant treatment, n (%)	
Chemotherapy	25 (38)
Radiation therapy	26 (40)
Endocrine therapy	14 (22)

Note: [a] full-time and part-time, [b] Assessed by the Exercise Barrier Self-Efficacy Scale (EBSS), higher scores mean better outcome. n's do not all sum to total due to missing data; % is of those with available data. *Abbreviations*: Phys-Can= Physical Training and Cancer, SD= standard deviation, BMI= body mass index, $\dot{V}O_2$max = maximal oxygen uptake.

Studies II-IV

Participants in *Studies II-IV* were patients with breast, prostate or colorectal cancer included in the Phys-Can RCT between March 2015 and April 2018.

In *Study II*, participants were those randomised to one of the two intervention groups *with* self-regulatory BCTs, and having completed the exercise programme or dropped out after the six-week familiarisation period. From the 243 eligible participants, 229 (94%) agreed to participate in the quantitative part of the study. Participants' mean age was 59 years (SD 12). The majority were women (78%) and received chemotherapy (53 %) as primary (neo-)adjuvant treatment (Table 5). Among these participants, 20 were approached and 18 agreed to participate in the qualitative part of the study. The selection of these 18 participants was based on a maximum variation sampling strategy in order to capture as many different experiences as possible [141]. Dimensions of interest were age, gender, geographical location, level of education, occupation, cancer diagnosis, cancer treatment, previous exercise habits, intervention group, attendance at the resistance training sessions and dropout from the Phys-Can RCT. For more details regarding the baseline characteristics of the questionnaire participants and the interview participants, see Appendix 2.

In *Study III*, all participants randomised to one of the four intervention groups were included (n=577). Participants' mean age was 59 years (SD 12). The majority were diagnosed with breast cancer (79%) and received chemotherapy (53%) as primary (neo-)adjuvant treatment (Table 5). Participants' characteristics in the four intervention groups were similar at baseline (Appendix 3).

In *Study IV*, participants included were those randomised to one of the four intervention groups and who completed the PA assessments at six months (i.e. end of the exercise intervention) and at 12-month follow-up (i.e. one year after the end of the exercise intervention). Participants were excluded if they did not meet the international PA recommendations regarding aerobic PA or resistance training (i.e. at least 150 min/week of MPA *or* 75 min/week of VPA *or* 90 min/week of MVPA, *and/or* two sessions of resistance training/week [3, 6]) at the end of the exercise intervention. From the 316 eligible participants, 15 (5%) did not meet the PA recommendations, resulting in a total of 301 participants (95%) included in the analyses. Participants' mean age was 59 years (SD 12). The majority were diagnosed with breast cancer (78%) and received chemotherapy (52%) as primary (neo-)adjuvant treatment (Table 5). Participants' characteristics were similar in the four intervention groups. The 276 participants (48%) lost to follow-up significantly differed from the follow-up population at baseline in being, for example, less physically active ($p<0.001$), having a higher body mass index (BMI) ($p<0.001$) and a lower $\dot{V}O_2max$ ($p<0.001$). For more details, see Appendix 4.

Table 5. *Baseline characteristics of participants in Studies II-IV (Phys-Can RCT)*

	Study II (n=229)	**Study III (n=577)**	**Study IV (n=301)**
Age, mean years (SD)	59 (12)	59 (12)	59 (12)
Women, n (%)	178 (78)	465 (81)	238 (79)
Education, n (%)			
University or equivalent	139 (61)	346 (60)	198 (66)
Occupation, n (%)			
Working[a]	131 (57)	314 (57)	179 (60)
On sick leave[a]	82 (36)	196 (39)	99 (36)
Retired	94 (41)	214 (41)	107 (38)
Comorbidities, n (%)			
One or more	109 (55)	293 (58)	147 (55)
Self-reported exercise habits, n (%)			
Resistance training since ≥6 months	45 (24)	103 (22)	59 (24)
Endurance training since ≥6 months	81 (43)	187 (38)	100 (39)
Exercise self-efficacy[b] (0-10), mean (SD)	6 (2)	6 (2)	6 (2)
Exercise motivation[c] (0-100), median (IQR)			
Resistance training	80 (38)	80 (37)	81 (37)
LMI endurance training	91 (29)	88 (27)	89 (28)
HI endurance training	64 (50)	61 (53)	65 (46)
Weight status, n (%)			
Normal weight, BMI 18-24.9 kg/m^2	102 (47)	267 (49)	158 (54)
Overweight, BMI 25-29.9 kg/m^2	83 (38)	188 (35)	101 (35)
Obesity, BMI≥ 30 kg/m^2	32 (15)	87 (16)	32 (11)
$\dot{V}O_2$max, mean mL/kg/min (SD)	30 (7)	30 (7)	31 (7)
MVPA, median min/day (IQR)	66 (56)	61 (59)	68 (57)
Diagnosis, n (%)			
Breast cancer	175 (76)	457 (79)	235 (78)
Prostate cancer	45 (20)	97 (17)	56 (19)
Colorectal cancer	9 (4)	23 (4)	10 (3)
Primary (neo-)adjuvant treatment, n (%)			
Chemotherapy	122 (53)	298 (53)	157 (52)
Radiation therapy	83 (36)	185 (32)	100 (33)
Endocrine therapy	24 (11)	75 (13)	44 (15)
Intervention group, n (%)			
HI with BCTs	114 (50)	144 (25)	77 (26)
LMI with BCTs	115 (50)	145 (25)	81 (27)
HI without BCTs	-	144 (25)	71 (24)
LMI without BCTs	-	144 (25)	72 (24)

Note: [a] Full-time and part-time, [b]Assessed by the Exercise Barrier Self-Efficacy Scale (EBSS), higher scores mean better outcome, [c]Mean of 3-item study-specific questionnaire ("How important/confident/ready are you to perform ...? 0='Not at all' to 100='Very'). n's do not all sum to total due to missing data; % is of those with available data. *Abbreviations*: Phys-Can= Physical Training and Cancer, RCT= randomised controlled trial, SD= standard deviation, IQR= interquartile range, LMI= low-to-moderate intensity, HI= high intensity, BMI= body mass index, $\dot{V}O_2$max = maximal oxygen uptake, MVPA= moderate-to-vigorous physical activity, BCTs= self-regulatory behaviour change techniques.

Procedures and data collection

Study I

Baseline data from the Phys-Can observational study were used in *Study I*. Participants received a PA monitor and a diary during a visit at the University hospital. After wearing the monitor 24 hours a day for seven consecutive days and filling out the diary during the same period, participants returned the two instruments by post in prepaid envelopes.

PA monitor

The SenseWear Armband mini (SWA; BodyMedia, Pittsburgh, USA) was used to objectively assess PA and ST, and was worn on the back of the upper triceps (right or left). The SWA has previously been validated in healthy adults [142, 143] and adults with cancer [144]. This monitor combines a three-axis accelerometer with heat sensors. Data are registered and then integrated into proprietary algorithms to provide estimates of energy expenditure (i.e. a MET value is assigned to each minute the monitor is worn). The SenseWear Professional 8.1 Software was used to provide SWA wear time and time spent in different intensity levels. Collected data were considered valid and were included in the analyses if the SWA was worn for at least four days [145], including one weekend day [146] and with a wear time of at least 12 waking hours per day [147]. An excel-file for each valid day was generated and analysed visually. Bouts of PA considered for the analyses were defined as 10 or more consecutive minutes [148] at moderate or vigorous intensity, allowing interruptions of maximum two minutes below threshold intensity [149]. These bouts were then classified as MPA or VPA, using established cut-off values, i.e. 3.0-5.9 METs and ≥6.0 METs, respectively [1]. The participants' daily time spent in MPA and VPA were calculated separately by summing minutes in a valid day where the bouts met the criterion for the relevant intensity. Additionally, all activities undertaken during daytime with an energy expenditure ≤1.5 METs were classified as sedentary activities [11]. In order to delimit ST to only daytime, the time axes of each participants were visually analysed, and nighttime sleep was removed. ST was then calculated by summing all minutes during daytime in a valid day, where the minutes met the criterion for the relevant intensity.

Diary

A 7-day diary was developed for the Phys-Can project, consisting of one log page for each day over seven days. Participants made daily notes regarding all PA bouts performed during at least 10 minutes. They provided information about the duration and type of the PA bouts as well as the intensity with the Borg RPE 6-20 scale [15]. Similar diaries have previously been used in other studies, involving overweight patients with obstructive sleep apnea [150,

151]. Days from the diary were included in the analyses if they corresponded to the same valid days from the SWA. The same MET classification was used as for the SWA-data, and a MET value was determined for each performed PA lasting at least 10 minutes, using the Compendium of Physical Activities developed by Ainsworth et al [14]. Participants' daily time spent in MPA and VPA was calculated separately by summing minutes in a day, where the bouts met the criterion for the relevant intensity. Additionally, participants reported how much time (in hours and minutes) they spent sedentary during the day (excluding sleeping at night-time). ST was then determined according to what was reported by the participants in the diary.

Study II

Data from the Phys-Can RCT were used in *Study II*. The qualitative and quantitative data were collected in parallel, 0-9 months (of which 90% within three months) after participants completed or dropped out from the exercise intervention.

Interviews

Participants were invited by mail to take part in individual semi-structured interviews. An interview guide was developed by the study authors (ASM, MC, SB, KN and ID) to explore participants' motivational experiences of exercise combined with behaviour change support. The interview guide consisted of six main areas with open-ended and follow-up questions (Table 6). When necessary, probing questions such as "Could you tell me more about...?" or "Could you give me a concrete example?" were asked to gain more detailed and rich descriptions. The interviews were conducted by the second author (MC), who is an experienced interviewer and was not involved in the Phys-Can project. The first interview was used as a pilot interview to test and adjust the interview guide. The follow-up questions regarding the experiences of the specific BCTs were then modified, and no more major changes were made. The interviews took place at the interviewer's office or, when this was not possible, by phone. The interviews lasted between 25 and 65 minutes and were audio-recorded. Data collection continued until the authors (ASM, MC, SB, KN and ID) judged that no new key themes emerged. The interviews were then transcribed verbatim by the first and second authors (ASM and MC).

Table 6. *Interview guide used in Study II*

Main area	Examples of questions
1. Expectations before starting in the Phys-Can RCT	What expectations did you have before starting to exercise in the intervention?
2. Exercise experiences	Could you tell me about your experiences of exercising in the intervention?
3. Facilitators to exercise	Describe what made it easier to exercise during the intervention. - What helped you to exercise? - What motivated you to exercise?
4. Barriers to exercise	Describe what made it difficult to exercise during in the intervention. - Describe a situation where you did not manage to overcome obstacles. - Describe a situation where you did manage to overcome obstacles. - How did you manage to overcome these obstacles?
5. Experiences of the specific BCTs	Could you tell me about your experiences of xx? (questions about all the BCTs were asked if not mentioned before, e.g. support from peers, use of the heart rate monitor) - Which BCTs have been most useful to you for exercising? Why? - How did the BCTs help you to exercise? - Which BCTs have been less useful to you for exercising? Why?
6. Reasons for interrupting participation (optional)	Could you tell me about the reasons for interrupting your participation? - What made you drop out of the exercise programme? - What could have made you continue exercising in the intervention?

Abbreviations: Phys-Can= Physical Training and Cancer, RCT= randomised controlled trial, BCTs= behaviour change techniques.

Questionnaire

A 19-item study-specific questionnaire was developed by the study authors (ASM, MC, SB, KN and ID) and designed to determine how the BCTs, provided during the exercise intervention, were valued by the participants for performing exercise (Appendix 5). A similar questionnaire has been used previously in a study involving adults with rheumatoid arthritis [152]. Participants were asked to rate on a scale from 1 to 5 (1= "Not at all valuable, 5= "Very valuable") the value of each BCT such as social support from coaches and peers, self-registration of exercise with training logs and goal-setting. They were also asked to rate on a scale from 1 to 5 (1 = "No, definitely not", 5 = "Yes, definitely") their intention to recommend the exercise programme per-

formed during the intervention to others with a similar condition. The questionnaire was sent to the participants by mail, including two reminders at three weeks and five weeks, respectively.

Study III

Data from the Phys-Can RCT were used in *Study III*. Adherence data were collected from training logs (developed for the Phys-Can project) and a heart rate monitor during the time the exercise intervention was conducted. Exercise adherence was defined as the extent to which participants followed the exercise prescription according to the study protocol in the Phys-Can RCT, and was assessed based on the FITT-principles (resistance and endurance training, respectively) and dropout rates.

Instruments

For resistance training, participants were instructed to record all their sessions in a resistance training log during their performance, providing detailed information about the frequency (number of performed sessions), intensity (weight), time (sets and repetitions) and type (exercises) of the resistance training. This log was then used to assess adherence to resistance training based on the FITT-principles.

For endurance training, participants were instructed to use a heart rate monitor (Polar R400) during the sessions, and to record the sessions in an endurance training log directly after. They provided information about the frequency (number of performed sessions), intensity (heart rate zone and Borg-scale RPE), time (duration) and type (mode) of the home-based sessions. Participants in the HI groups were asked to register any HI exercise (intervals and even continuous exercise if performed), while participants in the LMI groups were asked to register a maximum of 150 minutes of exercise at LMI as well as any HI exercise if performed. A combination of data from the heart rate monitor files and the endurance training log was then used to assess adherence to endurance training based on the FITT-principles. Priority was given to data from the heart rate monitor files. However, data from the endurance training log were used as a complement when files from the heart rate monitor were not available due to technical issues.

For dropout rates, attendance records maintained by the study coaches were used to determine if and when participants permanently discontinued exercise before the end of the six-month exercise intervention.

Calculation of exercise adherence

A brief description of how exercise adherence was calculated is provided below. For more details, see Appendix 6.

Adherence rates were calculated for resistance training and endurance training separately. To determine how participants exercised overall (i.e. total exercise volume) and how many times they performed the exercises, overall adherence rates and adherence rates to frequency were calculated as *performed training divided by prescribed training*. To determine how participants exercised during the performed sessions, adherence rates to intensity, time and type were calculated as *performed training divided by prescribed training during the performed sessions*. For endurance training, adherence to each FITT-principle was only calculated for the HI groups because the study protocol and some technical issues in the data collection did not enable these calculations for the LMI groups.

Dropout rates were calculated as *number of participants who left the Phys-Can RCT or did not exercise during the last month (or more) of the exercise intervention divided by total number of participants in each group*. Participants who dropped out of the study were recorded as 0 adherence to any remaining training session until the end of the prescribed training period.

Study IV

Data from the Phys-Can RCT were used in *Study IV*. PA maintenance was determined using PA data collected at six months (end of the exercise intervention) and at 12-month follow-up (one year after the end of the exercise intervention). PA maintenance was defined as a sustained PA behaviour 12 months after the end of the exercise intervention.

Assessment of physical activity

PA was assessed with the SWA and the 7-day diary described in *Study I*. At each measurement point, participants were asked to wear the SWA 24 hours a day for seven consecutive days and fill out the diary during the same period.

The SWA with the Professional 8.1 Software were used to assess the weekly aerobic PA duration and intensity. To reflect one week of PA, data from the SWA were included in the analyses if the SWA was worn for at least four days [145], including one weekend day [146] and with a wear time of at least 80% per day [153]. MPA and VPA were determined using established cut-off values, i.e. 3.0-5.9 METs and ≥6.0 METs, respectively [1]. Daily time spent in different intensity levels was calculated for each valid day by summing minutes in 24 hours, where the criterion for the relevant intensity was met.

The 7-day diary was used to assess the weekly frequency of the resistance training, which was determined by summing the number of times participants wrote activities such as “resistance training”, “resistance exercises” or “exercises on gym-machines”.

Calculation of physical activity maintenance

PA maintenance was determined based on the change in aerobic PA (MPA, VPA and MVPA, expressed in min/week) and resistance training (expressed in number of sessions/week) between the two measurement points, and was calculated as *level at 12-month follow-up minus level at the end of the exercise intervention*. Due to the small number of participants who performed resistance training at 12-month follow-up, the PA maintenance variable was dichotomised. Participants were categorised either as maintainers (i.e. change in any aerobic PA intensity level ≥ 0 and/or change in resistance training ≥ 0) or non-maintainers (i.e. maintained neither aerobic PA levels nor resistance training).

Assessment of potential predictors

A total of 12 variables, collected at baseline, were used and are presented in Table 7. The choice of predictors potentially associated with PA maintenance was based on previous research [136, 137, 154]. The number of predictors was restricted by the sample size in the smallest group to ensure that there were at least five participants per factor (degree of freedom) included in the analysis [155].

Patient-reported outcome measures were collected from self-reports and consisted of nine variables, i.e. age, living situation, tobacco status, anxiety, cancer-related fatigue, HRQoL, exercise self-efficacy, cancer outcome expectations of exercise and exercise motivation. Objectively assessed outcome measures consisted of two variables, i.e. cardiorespiratory fitness and BMI. Finally, information about the type of (neo-)adjuvant cancer treatment consisted of one variable and was extracted from medical records.

Table 7. *Potential predictors collected at baseline in the Phys-Can RCT*

	Instrument/Method	Category	Score range	Interpretation of higher score
Age	-	-	22-85	-
Living situation	-	Living with a partner vs. Living alone	-	-
Tobacco status	-	Never smoked or used snus vs. Former or current smoker/snus user	-	-
Anxiety	Subscale HADS-A [156]	-	0-21	Worse outcome

Table 7 cont.

Cancer-related fatigue	Subscale general fatigue of MFI-20 [157]	-	4-20	Worse outcome
HRQoL	Subscale global health status of EORTC QLQ-C30 [158]	-	0-100	Better outcome
Exercise self-efficacy	Mean of the 9-item EBSS [159]	-	0-10	Better outcome
Cancer outcome expectations of exercise	Study-specific numerical rating scale ("How confident are you that exercise can reduce the risk of cancer recurrence? 0='Not at all confident' to 10='Very confident')	-	0-10	Better outcome
Exercise motivation	Mean of the 3-item study-specific questionnaire ("How important/confident/ready are you to perform aerobic endurance training at moderate intensity? 0='Not at all' to 100='Very') [160]	-	0-100	Better outcome
Cardiorespiratory fitness	$\dot{V}O_2$max test during walking/running to exhaustion using a modified Balke protocol [161]	-	14-59 (mL/kg/min)	Better outcome
BMI	Calculated by the study staff the same day the $\dot{V}O_2$max test was performed	-	18-40 (kg/m^2)	Worse outcome
Type of cancer treatment	-	Chemotherapy vs. No chemotherapy	-	-

Abbreviations: Phys-Can= Physical Training and Cancer, RCT= randomised controlled trial, HADS-A= Hospital Anxiety and Depression scale (Anxiety subscale), MFI= Multidimensional Fatigue Inventory, HRQoL= health-related quality of life, EORTC QLQ= European Organisation for Research and Treatment of Cancer, EBSS= Exercise Barrier Self-Efficacy Scale, $\dot{V}O_2$max = maximal oxygen uptake, BMI= body mass index.

Data analysis

All statistical analyses were performed using the Statistical Package for Social Sciences SPSS, version 22 (Study I), version 24 (Study II) and version 25 (Studies III-IV). The tests were two sided and considered statistically significant if $p < 0.05$.

Study I

The average daily time spent in MPA, VPA and ST with the 7-day diary and the SWA was presented at group level as mean and standard deviation (SD). A Wilcoxon signed-rank test was performed to compare the differences between the two instruments. Agreement between the 7-day diary and the SWA was assessed using a Bland-Altman plot [162] for MPA, VPA and ST separately, following two steps for each plot. First, the difference in minutes between the two measurement instruments (7-day diary minus SWA) was calculated for each valid day and plotted on the y-axis against the average values in minutes of both instruments ((7-day diary+SWA)/2) on the x-axis. Second, the mean difference between the two instruments and limits of agreements (mean difference ±1.96 SD) were calculated and plotted. The two instruments were considered as having a good level of agreement and interchangeable if the mean difference and the range between the limits of agreement did not exceed 10, 5 and 60 minutes per day regarding MPA, VPA [163, 164] and ST [165], respectively. These cut-off points were defined as the limits of maximum acceptable differences based on research findings, indicating the importance of using instruments that are able to detect such clinical changes [163-165]. Finally, spearman's rank correlation coefficients were also calculated to determine the association between the average and the difference in daily time spent in MPA, VPA and ST between the 7-day diary and the SWA.

Study II

Transcribed data from the interviews were analysed with thematic analysis as described by Braun and Clarke [166]. The analysis started with an inductive approach and assumed, in a later phase, a deductive profile inspired by the key motivational concepts from self-determination theory [115]. The analysis was a back-and-forth procedure with several revisions performed mainly by the first author (ASM), and peer-reviewed by all the co-authors (MC, SB, KN and ID) who had different professional backgrounds and expertise. The analysis was carried out in five steps. First, transcribed interviews were checked against the recordings for accuracy. They were then read several times to become familiar with the data, and initial ideas were noted down. Second, initial codes were generated through NVivo 11 software programme by systematically sorting the entire data set, and then tagging and naming extracts of interest. Third, the different codes were sorted into potential themes and subthemes, and a thematic map was produced. Fourth, the potential themes and subthemes were revised several times and were checked against each other and back to the original data set. Fifth, the deductive approach was used, and the themes and subthemes were further refined, defined and named. The authors also followed the 15-point checklist developed by Braun and Clarke [166] to ensure rigour and quality in the analysis. Response scales from the

questionnaire were analysed with descriptive statistics, including frequencies, medians and interquartile ranges for the entire group.

Study III

Exercise adherence was reported using descriptive statistics, including mean percentages and SD or frequencies and proportions (%). The main effect of self-regulatory BCTs on each FITT-principle (continuous variable in %) and dropout (dichotomised variable, yes/no) was examined using multiple linear regression and multiple logistic regression, respectively. The analyses were conducted according to intention-to-treat and were adjusted for exercise intensity, interaction (exercise intensity x self-regulatory BCTs), study site and cancer diagnosis. All these variables were included in the models using effect coding, except for study site and cancer diagnosis that were included using dummy coding. The results were presented as unstandardised regression coefficients (B) with 95% Confidence Intervals (95% CI). The regression coefficients indicate the mean change in % adherence due to the main effect of the self-regulatory BCTs.

Study IV

PA maintenance at 12-month follow-up was reported using frequencies and proportions (%). The main effect of self-regulatory BCTs on PA maintenance (dichotomised variable, maintainer/non-maintainer) was examined using multiple logistic regression. The analysis was adjusted for exercise intensity, interaction (exercise intensity x self-regulatory BCTs) and study site. All these variables were included in the model using effect coding, except for study site, which was included using dummy coding. The main effect of the self-regulatory BCTs on PA maintenance was presented as unstandardised regression coefficient (B) and odds ratio (OR) with 95% CI. Potential predictors of PA maintenance were examined using multiple logistic regression and were all entered simultaneously in the model. The model also included a variable for the intervention groups to adjust for potential effect of the intervention on the outcome. Dichotomous variables were generated for nominal variables, i.e. living situation (Living with a partner vs. Living alone), tobacco status (Never smoked or used snus vs. Former or current smoker/snus user) and cancer treatment (Chemotherapy vs. No chemotherapy). The variable for the intervention groups had four categories and was included in the model using dummy coding. All the other variables were treated as continuous variables with OR reported per whole unit of the measure (e.g. 1 year, 1 kg/m^2 etc). The results were presented as ORs with 95% CI for each potential predictor and indicate the individual contribution of each variable after adjusting for all the others.

Ethical considerations

The Phys-Can project was approved by the Regional Ethical Review Board of Uppsala University (EPN D-number 2014/249).

In accordance with the ethical guidelines outlined in the Declaration of Helsinki [167], all participants received verbal and written information about the aims of the study in which they were taking part, and how the data would be collected and reported. They were also informed that participation was voluntary and that they could withdraw at any time. All gave informed written consent before participating and were guaranteed confidentiality. Collected data were stored securely at the Department of Public Health and Caring Sciences at Uppsala University, and de-identified through coding systems. Access to the data was restricted to authorised staff members only. Further, the Phys-Can project was designed to ensure that the benefits outweighed any potential risks of harms to participants. For this purpose, appropriate and safe measurement instruments and exercise programmes were carefully chosen after an intensive collaboration between researchers, exercise physiologists, oncologists and patient representatives. The study staff also attended mandatory courses where they were trained to test and supervise participants to ensure participants' safety and that the studies were conducted according to study protocols. Moreover, participants in the Phys-Can RCT may have experienced health benefits in exercising during cancer treatment as PA has proven safe and beneficial in this population. However, possible negative effects were considered. Answering questionnaires, performing physical tests and assessing PA several times could have been stressful for our participants, but their contribution to increased knowledge in the research area may have been experienced as useful and beneficial, aiming thereby at improving future interventions and clinical practice. In *Study II*, participants could have experienced distress during the interviews when exposing their own experiences. To minimise this risk, questions were carefully selected, and participants were informed that the interviews could be discontinued at any time. Further, to allow participants to talk freely about their experiences, an external interviewer conducted the interviews. Her expertise in conducting interviews also ensured their high quality. Hence, the interviews gave participants a unique opportunity to reflect and express their feelings and experiences in a safe setting.

Results

Agreement between a 7-day diary and the SWA

On average, the participants in the Phys-Can observational study (Study I) filled out the 7-day diary and wore the SWA for 6 valid days (SD 1). The mean SWA-wear time was 23.7 hours per day (SD 0.3). Daily time spent in MPA was on average 55 minutes (SD 54) according to the 7-day diary and 41 minutes (SD 38) according to the SWA. The mean difference between the two measurement instruments was 14 minutes (SD 52) per day (+34%, $p<0.01$), with limits of agreement of ±102 minutes (Figure 2). Differences between the 7-day diary and the SWA increased as the average minutes per day spent in MPA increased ($r=0.3$, $p< 0.01$).

Daily time spent in VPA was on average 3 minutes (SD 12) according to the 7-day diary and 2 minutes (SD 7) according to the SWA. The mean difference between the two measurement instruments was 1 minute (SD 10) per day (+50%, $p=0.014$), with limits of agreement of ±21 minutes (Figure 3). Differences between the 7-day diary and the SWA increased as the average minutes per day spent in VPA increased ($r=0.5$, $p<0.01$).

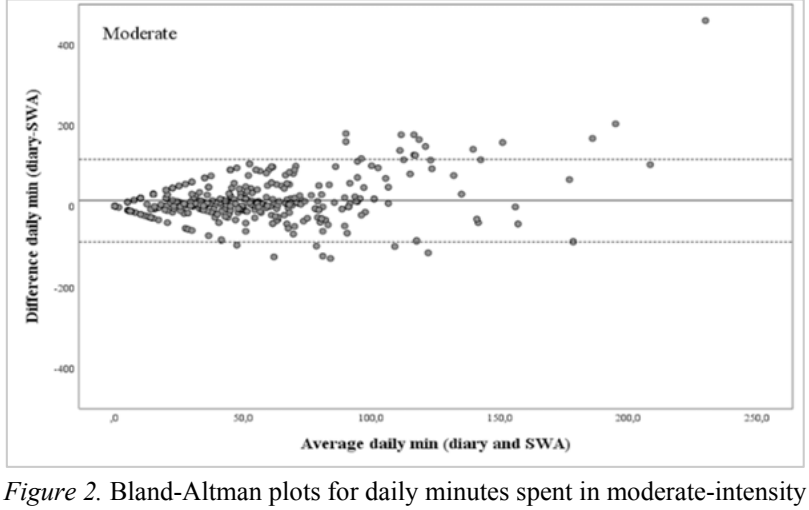

Figure 2. Bland-Altman plots for daily minutes spent in moderate-intensity physical activity from the 7-day diary and the SenseWear Armband mini (SWA). Each point represents a pair of measurements (diary and SWA) from the 65 participants with valid data (409 comparisons). The thick lines indicate the mean difference, and the broken lines indicate the limits of agreement

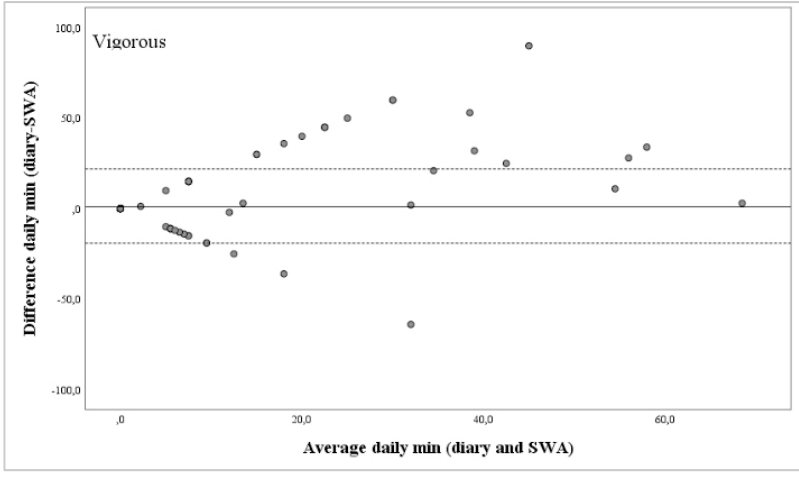

Figure 3. Bland-Altman plots for daily minutes spent in vigorous-intensity physical activity from the 7-day diary and the SenseWear Armband mini (SWA). Each point represents a pair of measurements (diary and SWA) from the 65 participants with valid data (409 comparisons). The thick lines indicate the mean difference, and the broken lines indicate the limits of agreement

Daily time spent sedentary was on average 517 minutes (SD 185) according to the 7-day diary and 713 minutes (SD 128) according to the SWA. The mean difference between the two measurement instruments was -196 minutes (SD 207) per day (-27%, $p<0.01$), with limits of agreement of ±408 minutes (Figure 4). Differences between the 7-day diary and the SWA increased as the average minutes per day spent sedentary increased ($r=0.4$, $p<0.01$).

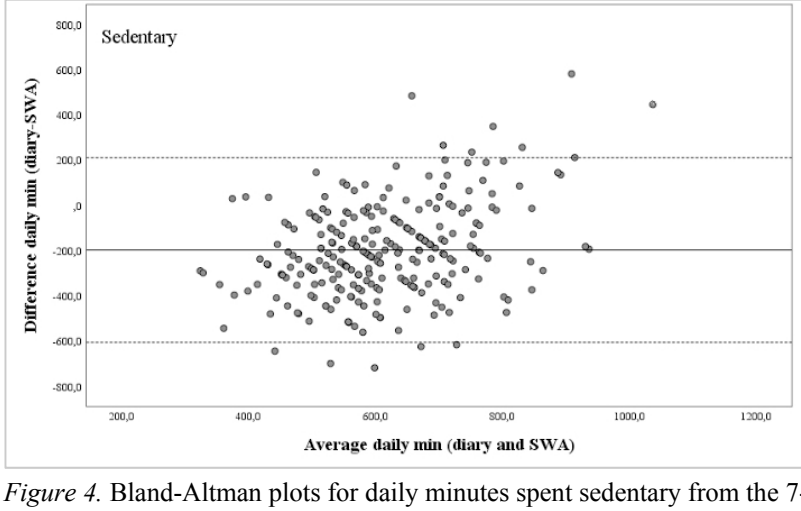

Figure 4. Bland-Altman plots for daily minutes spent sedentary from the 7-day diary and the SenseWear Armband mini (SWA). Each point represents a pair of measurements (diary and SWA) from the 42 participants with valid data (253 comparisons). The thick line indicates the mean difference, and the broken lines indicate the limits of agreement

A motivational process

An overarching theme "Finding my own motivation" with five themes and 10 subthemes were identified as participants' motivational experiences of exercise combined with behaviour change support during curative cancer treatment (Figure 5).

During the interviews (Study II), the participants described different incentives (themes) to exercise. They also described how experiencing these incentives created a favourable environment, fostering the satisfaction of the three psychological basic needs described in self-determination theory (autonomy, competence and relatedness) and increasing their motivation to exercise (Figure 5). More specifically, the participants described their incentives to exercise through experiencing health gains and mastery. They felt more alert and described a feeling of improved mood, well-being and vitality after exercising. These experienced health benefits were seen as rewards and led to the satisfaction of being able to promote their own health and fight the disease.

> *"I sort of wanted to… spit in the face of the cancer in some way, like "you're not going to get me" so to speak, so I was really motivated to exercise." #2*

Further, the participants described their incentives to exercise through gaining increased awareness and knowledge, and learning new skills. The use of BCTs such as self-registration of exercise and feedback on performance provided participants with ways to manage and encourage self-reflection, with a focus on personal achievement. The participants could see their progress and improvement, which increased their motivation and confidence in their ability to exercise. They felt thereby more competent and became more autonomous in performing exercise.

> "*The fitness tests were really fantastic. You saw that you had become stronger, so it was like a sort of positive motivation to continue*." #11

Feeling affinity with their peers and commitment to their coaches was another important incentive to exercise. The participants shared their experiences about how to deal with treatment side effects, their feelings and concerns about the disease. They felt connected to each other as a team, caring for each other and working towards the same goal. Peers and coaches also became an important source of inspiration.

> "*Sometimes when I was very down and I saw someone else from the group, more alert and can talk and laugh. It gave me hope and joy and strength*." *#5*

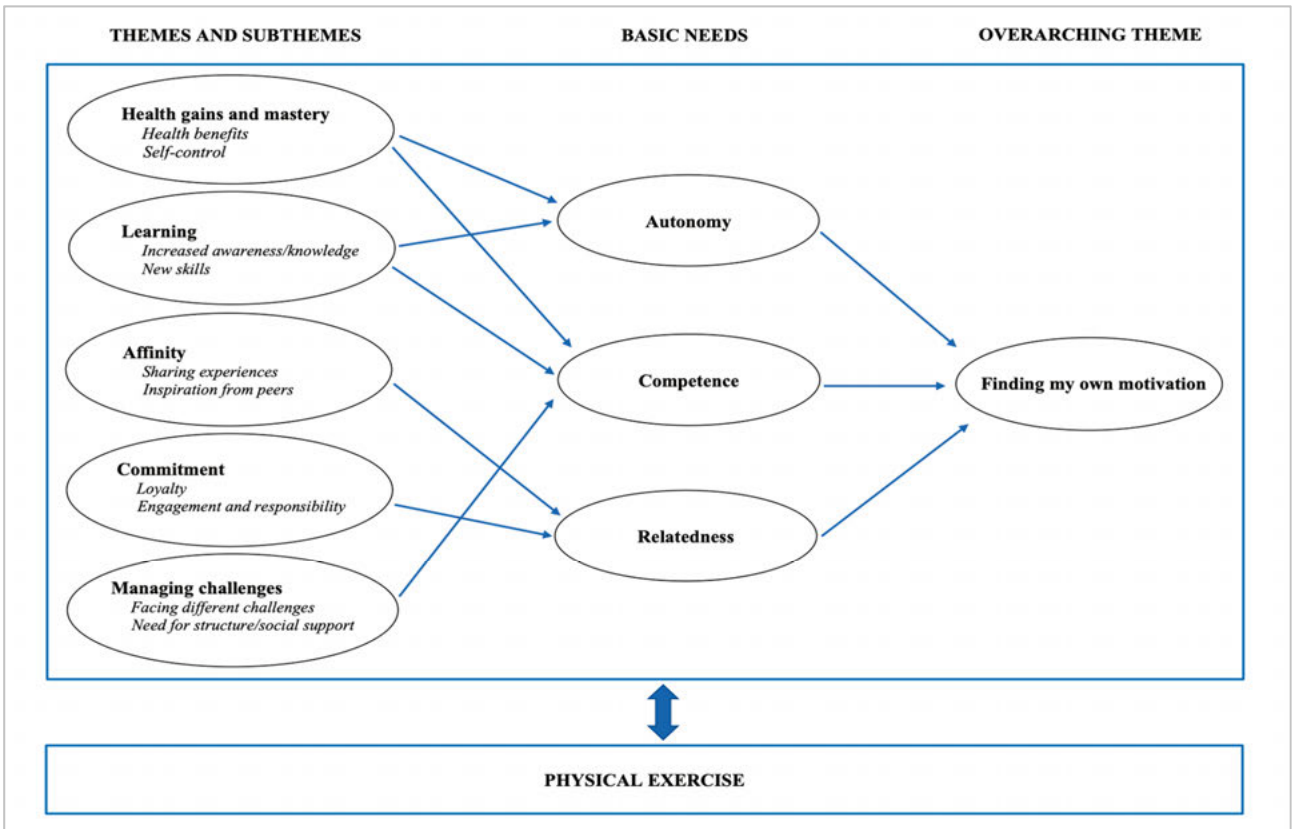

Figure 5. Motivational process described by the study participants in Study II

However, the participants had to face different challenges during their cancer treatment, which affected their ability to exercise. Treatment-related symptoms such as numbness and tingling, tiredness, pain and cognitive impairments made it difficult to exercise. Further, the participants who experienced a lack of enjoyment in exercising as prescribed in the research study found it hard to motivate themselves to complete the programme.

> *"I felt after a while that I hadn't been at training and felt like I'm not getting anything out of it and this really isn't my thing, to train in this way. [..] Then my motivation disappeared entirely." #5*

Yet, the structure and social support provided by coaches, peers, family and friends helped the participants to overcome and manage many of these challenges, and gave them a feeling of competence. Being supervised by experienced and knowledgeable coaches was also an important aspect, providing the participants with a feeling of safety, guidance and positive feedback on their exercise performance. Further, exercising in a public gym helped the participants to feel normal and healthy, while the scheduled training sessions helped them to bring structure into their everyday lives and was seen as a distraction from the disease.

> *"This endurance training, my husband has encouraged me. When he has seen that I was getting a bit tired or a bit so-so, he has asked me like "how much time (exercise) do we have left this week?", and then he has said "right well let's get cracking then". So, he has encouraged me and that feels good." #8*

> *"I think that this has been great and above all that you had something that you were supposed to do, that there were appointments because otherwise it could easily have been like this "no but today, I'm not feeling so great". But you knew that you had an appointment on Mondays at 9:30 am when you had to get up and eat reasonably [...] so, I think having those fixed times has been quite good" #6*

BCTs perceived as useful

Results from the questionnaire (Study II) indicated that the participants rated the BCTs, provided during the exercise intervention, with medians ranging from 3 to 5 on a scale from 1–5 (1= "Not at all valuable" and 5 = "Very valuable") (Table 8).

However, the highest valued BCTs were *social support* from coaches, f*eedback* with fitness tests and heart rate monitor, *self-registration of exercise* with training logs and *a structured environment* with scheduled sessions, which were all rated with a median of 5 (Table 8).

Table 8. *Values of behaviour change techniques in the Phys-Can RCT*

BCT (component)	n	Median	Q1-Q3
Supervised group-based resistance training[a]			
Action planning (initial interview on exercise habits)	221	4	4-5
Feedback (strength tests)	222	5	4-5
Problem solving (coping planning for maintenance)	210	4	4-5
Self-registration (resistance training log)	220	5	4-5
Social support (coaches)	226	5	5-5
Social support (peers)	222	4	3-5
Structured environment (scheduled sessions)	225	5	4-5
Home-based endurance training[a]			
Action planning (initial interview on exercise habits)	214	4	4-5
Action planning (regular exercise planning)	208	4	3-5
Feedback (fitness tests)	211	5	4-5
Feedback (use of heart rate monitor)	219	5	4-5
Feedback (reviews of heart rate monitor files)	203	4	4-5
Goal-setting (weekly and individual goals)	205	4	3-5
Problem solving (strategies to overcome obstacles)	208	4	4-5
Problem solving (coping planning for maintenance)	198	4	4-5
Self-monitoring (endurance training log)	214	4	3-5
Social support (coaches)	215	5	4-5
Social support (peers)	202	3	2-4
Intention to recommend the programme to others[b]	223	5	5-5

Note: [a] Response to the 1–5 rating scale: 1 = Not at all valuable and 5 = Very valuable, [b] Response to the 1–5 rating scale: 1 = No, definitely not and 5 = Yes, definitely. n's vary due to internal attrition. *Abbreviations:* Phys-Can= Physical Training and Cancer, RCT= randomised controlled trial, Q1-Q3= interquartile range.

Exercise adherence and physical activity maintenance

Adherence rates are reported for the entire study sample in the Phys-Can RCT. A detailed description by intervention group can be found in *Paper III*. For supervised group-based resistance training, participants performed on average 50% (SD 31) of the prescribed volume for the entire training period (overall adherence). More specifically, they attended 53% (SD 32) of prescribed sessions. When participants attended a session, they performed 77% (SD 38) of prescribed intensity (weight), and 78% (SD 38) of prescribed time (set and repetitions). Finally, they adhered to exercise type in 70% (SD 42) of attended sessions. For home-based endurance training, participants performed on average 47% (SD 37) of the prescribed volume for the entire training period (overall adherence). More specifically and only for the HI groups, participants performed on average 49% (SD 35) of prescribed sessions. They performed 60% (SD 35) of intervals at the prescribed intensity, and 72% (SD 36) of prescribed

time during the performed sessions. Finally, they adhered to exercise type in 78% (SD 37) of performed sessions. For dropout rates, 167 participants (29%) permanently discontinued exercising during the exercise intervention.

Regarding PA maintenance, 223 participants (74%) of the 301 participants included in the analyses maintained their level of PA at 12-month follow-up, either aerobic PA only (68%), resistance training only (2%) or both aerobic PA and resistance training (4%). A detailed description by intervention group can be found in *Paper VI.*

Effect of self-regulatory BCTs

The multiple linear (FITT-principles) and logistic (dropout) regression analyses revealed no statistically significant main effect of the self-regulatory BCTs on exercise adherence in the Phys-Can RCT, as presented in Table 9 (Study III).

Table 9. *Main effect of self-regulatory behaviour change techniques in the Phys-Can RCT*

Adherence	n	B (95% CI)	p-value
Supervised group-based resistance training			
Overall (total volume)	577	−0.6 (−5.6; 4.4)	0.81
Frequency (attendance)	577	−0.6 (−5.7; 4.6)	0.83
Intensity (weight)	577	2.8 (−3.3; 8.9)	0.37
Time (sets and repetitions)	577	3.1 (−3.1; 9.2)	0.33
Type (exercises)	577	2.9 (−3.9; 9.7)	0.40
Home-based endurance training			
Overall (total volume)	577	1.9 (−3.9; 7.6)	0.52
Frequency (performed sessions)	288	−3.4 (−11.0; 4.5)	0.40
Intensity (intervals at target heart rate)	288	−4.5 (−12.4; 3.4)	0.27
Time (interval duration)	288	−1.4 (−10.0; 7.1)	0.74
Type (interval training)	288	0.4 (−8.2; 9.0)	0.92
Dropout rates	577	0.08 (−0.3; 0.4)	0.66

Note: n's vary because some calculations were performed for two groups only (HI groups).
Abbreviations: Phys-Can= Physical Training and Cancer, RCT= randomised controlled trial, CI= confidence intervals.

However, the multiple logistic regression analysis revealed a statistically significant main effect of self-regulatory BCTs on PA maintenance at 12-month follow-up (B=0.59, OR=1.80, 95%CI [1.05; 3.08], p=0.03). A significant interaction was observed between exercise intensity and self-regulatory BCTs (B=0.57, OR=1.77, 95%CI [1.03;3.04], p=0.04), indicating that the effect of

self-regulatory BCTs was larger in participants in the HI group *with* self-regulatory BCTs compared to those in the LMI group *with* self-regulatory BCTs (Study IV).

Predictors of 12-month physical activity maintenance

Results from the multiple logistic regression analysis (Study IV) revealed that four baseline variables were statistically significant predictors of PA maintenance at 12-month follow-up (Table 10).

More specifically, participants reporting higher HRQoL (OR=1.03, 95%CI [1.00-1.06], p=0.02) or higher exercise motivation (OR=1.02, 95%CI [1.00-1.04], p=0.01) at baseline were more likely to maintain their PA levels at 12-month follow-up. Additionally, participants reporting higher expectations to reduce the risk of cancer recurrence with exercise (OR=0.88, 95%CI [0.78-0.99], p=0.04) or being former or current smokers/snus users (OR=0.43, 95%CI [0.21-0.86], p=0.02) at baseline were less likely to maintain their PA levels at 12-month follow-up (Table 10).

Table 10. *Multiple logistic regression model estimating potential predictors of physical activity maintenance[a] (n=238)*

Potential predictors		**OR (95% CI)**	**p-value**
Age	Per 1 year	1.00 (0.96-1.05)	0.85
Baseline living situation	Living with partner	Reference	
	Living alone	0.63 (0.30-1.30)	0.21
Baseline tobacco status	Never smoked or used snus	Reference	
	Former or current smoker/snus user	**0.43 (0.21-0.86)**	**0.02**
Baseline anxiety	Per 1 unit on a 0-21 scale	1.09 (0.99-1.20)	0.10
Baseline cancer-related fatigue	Per 1 unit on a 4-20 scale	1.04 (0.94-1.15)	0.50
Baseline HRQoL	Per 1 unit on a 0-100 scale	**1.03 (1.00-1.06)**	**0.02**
Baseline exercise self-efficacy	Per 1 unit on a 0-10 scale	1.17 (0.97-1.42)	0.10
Baseline outcome expectations	Per 1 unit on a 0-10 scale	**0.88 (0.78-0.99)**	**0.04**
Baseline exercise motivation	Per 1 unit on a 0-100 scale	**1.02 (1.00-1.04)**	**0.01**
Baseline $\dot{V}O_2$max	Per 1 mL/kg/min	0.95 (0.89-1.01)	0.07
Baseline BMI	Per 1 kg/m^2	1.02 (0.93-1.12)	0.71
Chemotherapy	No	Reference	
	Yes	0.83 (0.38-1.83)	0.65

Note: [a]Categorised as maintainers or non-maintainers at 12-month follow-up. The results indicate the individual contribution of each variable after adjusting for all the other variables and for intervention groups. Bold values indicate p-values below 0.05. *Abbreviations*: OR= odds ratio; CI= confidence intervals; HRQoL= Health-related quality of life; $\dot{V}O_2$max = maximal oxygen uptake; BMI= body mass index.

Discussion

Main findings

Different approaches were used in this thesis to increase knowledge about the promotion of PA in patients during and after curative cancer treatment. We first compared PA and ST assessment between two measurement instruments. The results revealed statistically significant mean differences and wide limits of agreement between the 7-day diary and the SWA when assessing daily time spent in MPA, VPA and ST in our study sample. We then explored participants' exercise experiences and perception of behaviour change support during curative cancer treatment. The results indicated that participants underwent a motivational process through the six-month exercise programme. They described different incentives to exercise, which in turn fostered feelings of autonomy, competence and relatedness and resulted in finding their own motivation to exercise during this difficult period of time. Four specific BCTs appeared particularly useful during this process, i.e. social support from coaches, feedback, self-registration of exercise and a structured environment. We also described exercise adherence during curative cancer treatment. The results showed that the study participants performed on average 50% of the prescribed sessions for both supervised group-based resistance training and home-based endurance training. When the participants performed the sessions, exercise adherence in terms of intensity, time and type was on average ≥60%. Approximately 30% of the participants dropped out during the exercise intervention. Further, we examined the effect of self-regulatory BCTs on PA and exercise, both in the short and long term. The results revealed that there was no effect of the self-regulatory BCTs on exercise adherence during the intervention. However, a positive effect was found on PA maintenance at 12-month follow-up, indicating that the self-regulatory BCTs improved PA maintenance in our study sample one year after the end of the exercise intervention. Finally, we examined predictors of long-term PA maintenance. The results revealed that participants with higher HRQoL or higher exercise motivation at baseline were more likely to be PA maintainers at 12-month follow-up. In contrast, those having higher expectations of exercise or being former or current smokers/snus users at baseline were less likely to be PA maintainers at 12-month follow-up.

Assessing physical activity and sedentary time

The results in *Study I* indicated that the participants tended to overestimate MPA and VPA, and underestimate ST when using the 7-day diary compared to SWA. This may be explained by the use of a self-report to assess PA and ST. Self-reports usually imply difficulties in assessing the duration and intensity of an activity [18] due to social desirability bias and the cognitive demands of recall [168]. The last-mentioned type of bias could be increased in cancer survivors because of the cognitive impairments that cancer and its treatment may induce, resulting in reduced memory [169-171] and decreased concentration [170]. Hence, the altered cognitive functions in cancer survivors may affect the quality of their report of PA and ST. The observed underestimation of ST by the participants could also be explained by the use of the SWA as a comparison measure. The SWA has been found to have difficulty in capturing light-intensity activities of daily living, and may thereby have misclassified light-intensity activities (e.g. standing stationary) as ST [142, 172].

Another interesting finding was the spearman's rank correlation coefficients, indicating that differences between the 7-day diary and the SWA increased as the average daily minutes spent in PA and ST increased. Thus, the level of agreement between the two instruments may vary from day to day, suggesting that the days the participants were the most physically active or the most sedentary were also the days with the poorest agreement, and vice versa. This is of particular interest because of the few VPA reported by the participants. Indeed, the results suggest the mean difference between the 7-day diary and the SWA in assessing VPA was small, which could be explained by the fact that few VPA were performed, limiting the risk for recall bias. However, it is important to bear in mind that the 7-day diary gave statistically higher estimates of VPA than the SWA (+50%), that the limits of agreement were large and that the difference increased as the amount of VPA increased. The variations in agreement level could also be explained by the timing of the assessment, i.e. when the assessment was performed during the week. Results from validation and observational studies indicated that PA varies in adults, with activity levels being higher during weekdays compared with weekend days [146, 173]. In *Study I*, the data were therefore collected during at least four consecutive days, including one weekend day in an attempt to capture those natural variations.

Few studies have compared diaries with accelerometers in cancer survivors, focusing exclusively on PA assessment and reporting mixed results [101, 102]. In line with the results in *Study I*, a validation study involving 22 men with prostate cancer compared a daily diary with an accelerometer (ActiGraph), and found poor agreement between the two instruments in assessing

MPA and VPA. Participants reported twice more minutes per day of PA compared to what the accelerometer registered [101]. In contrast, a validation study with 23 women with endometrial cancer found high agreement between a daily diary and an accelerometer (ActiGraph), with participants reporting similar PA duration and intensity, as indicated by the accelerometer. However, careful comparisons should be made due to several differences between studies, including different characteristics of the samples, different sample sizes and different methods used to assess agreement.

In the context of PA promotion, assessing PA through the whole intensity spectra, including ST, is often described as an important part, as it is the key for measuring the effectiveness of interventions aiming at increasing PA [97]. Assessments including contextual information about mode and domains of PA are also encouraged to provide a detailed description of PA patterns [174]. Results from several validation studies suggest that a combination of both objective and subjective monitoring is likely to yield the most reliable measurements and understanding of PA [150, 175]. Hence, when appropriate (i.e. mainly depending on the research question), the 7-day diary used in *Study I* could be a suitable instrument to complement data from the SWA due to its ability to provide detailed and contextual information about different aspects of PA (e.g. settings and type of performed activities).

Exercise adherence during curative cancer treatment

In *Study III*, exercise adherence, based on the FITT-principles and dropout rates, was calculated in participants taking part in the Phys-Can RCT during curative treatment for breast, prostate or colorectal cancer. The results illustrate the challenges faced by cancer survivors when exercising during treatment, even when participating in an exercise intervention.

Although adherence to resistance and endurance training in the Phys-Can RCT was within the range reported in other exercise interventions involving patients undergoing curative cancer treatment [176-178], the rates were not optimal compared with other studies [178-180]. Further, the dropout rates were higher than previously reported [181]. A possible explanation for these differences is the way adherence and dropout rates were calculated in *Study III*. Indeed, to give a more accurate picture of the feasibility of the exercise programme [129], we included in our calculations participants who dropped out of the Phys-Can RCT (i.e. participants who permanently discontinued exercise before the end of the exercise intervention). These participants were recorded as 0 adherence to any remaining training session until the end of the prescribed training period, which could have affected both the adherence and dropout rates. However, caution should be made when comparing the results in *Study*

III with other exercise interventions, as interventions are usually shorter, include only supervised exercise, involve less comprehensive exercise programmes and use different methods to calculate adherence.

The results in *Study III* indicated that adherence to frequency was lower than adherence in terms of intensity, time and type, especially when comparing adherence rates for supervised group-based resistance training. This demonstrates that attending the supervised training sessions twice a week during the intervention period was challenging for our participants. However, the results also indicated that when the participants did attend the training sessions, they adhered to the prescribed programme to a large extent, as indicated by the high adherence rates in terms of intensity, time and type. Two lessons can therefore be learned. First, it appears that supervised group-based training is a suitable form of exercise to help cancer survivors exercise at the prescribed intensity, time and type. This is of particular interest as several systematic reviews involving cancer survivors have found interventions offering group-based and/or supervised exercise to be more effective in reducing treatment-related side effects compared with home-based or unsupervised exercise interventions [182-185]. Second, encouraging patients to attend the gym may be the critical challenge for enhancing exercise adherence in future interventions. Previous research indicates that treatment-related side effects are among the major reasons why cancer survivors find it difficult to attend training sessions [92, 176], highlighting a need for an individually tailored exercise prescription based on each patient's experienced side effects. In an explanatory study, the researchers proposed a novel method of tailoring the exercise prescription in women undergoing chemotherapy for breast cancer, resulting in higher attendance rates compared with the group receiving a regular exercise prescription [177]. This novel method consisted of a periodized exercise prescription to adjust for chemotherapy-induced side effects (i.e. the prescription was periodized to chemotherapy treatment cycles). It included an intensity reduction of the prescribed exercise and prolonged recovery periods during the days when participants felt particularly fatigued or unwell. Although, the use of a periodized exercise prescription to improve exercise attendance is a promising strategy, more research is needed to examine how such adjustments could be applied in patients undergoing other cancer treatments. Such a strategy could also be tested to increase adherence to frequency for home-based exercise and minimise dropouts. Promoting exercise during treatment by preventing a gap in attendance/exercise frequency may increase overall programme adherence and thereby enhance the impact of exercise on health outcomes.

Behaviour change support

To facilitate exercise in the Phys-Can RCT, all participants were provided with behaviour change support in the form of specific BCTs, consisting of social support from coaches and peers, a structured environment with scheduled resistance training sessions, self-registration of exercise with training logs and feedback on performance. Additionally, participants randomised to receive self-regulatory BCTs used goal-setting, review of those goals, self-monitoring, action planning and problem solving, all provided during the exercise intervention. Further, follow-up prompts were performed at three and nine months after the end of the exercise intervention.

Patients' experiences

In *Study II*, specific BCTs such as *self-registration of exercise* with training logs and *feedback* with fitness tests and a heart rate monitor were described by the participants as useful tools in learning new skills and becoming aware of the importance of exercising to achieve health benefits during cancer treatment. This finding is also confirmed by the results from the questionnaire, where these two BCTs were highly valued. Self-registering one's performances of exercise and seeing progress or positive changes appear to enhance feelings of autonomy and competence and thereby increase exercise motivation. This finding is in line with a previous qualitative study that highlighted the importance of monitoring own behaviours and using feedback to motivate and facilitate exercise in cancer survivors [186].

Social support was also seen as an important BCT to increase exercise motivation. In the interviews, participants described different sources of social support (from peers, coaches, family and friends). Exercising with others who had similar experiences was seen as an important incentive to exercise and gave insights that the participants were not alone in facing the challenges of the disease and the treatment. They felt connected to each other, which encouraged them to continue to exercise. In addition to peer support, being supervised by skilled and knowledgeable coaches was crucial and helped the participants to feel safe to exercise during treatment. The relationship between the participants and the coaches was also important for staying motivated. Indeed, participants felt committed to their coaches, which was described as an important incentive to go to the gym and to exercise. The importance of social support from coaches is also reflected in the results from the questionnaire, as this BCT is one of the most valued. Similarly, authors from several qualitative reviews described both social support from peers and coaches as essential components in motivating cancer survivors to exercise [89, 90, 187]. These reviews support the implementation of supervised group-based exercise, highlighting the social benefits of supervision and group settings.

Finally, a *structured environment* with scheduled training sessions was seen as a useful BCT, as indicated both in the interviews and the questionnaire. The participants in the interviews described having scheduled training sessions as necessary to bring structure into their everyday lives and to distract them from the disease. In line with these findings, authors from a review of qualitative studies among cancer survivors described how scheduled exercise gave the participants "something to look forward to" and "resembled going to work", which provided them with a sense of control over their lives and the disease [187]. However, participants who did not enjoy the exercises prescribed in the Phys-Can RCT found it difficult to motivate themselves to continue in the programme despite the behaviour change support they received. This highlights the necessity of a tailored exercise programme based on each individual's needs and preferences to increase exercise motivation to all patients, which was indeed limited in the context of an RCT. Interestingly, this aspect was not reflected in the results from the questionnaire, where all BCTs were highly valued. One explanation could be that all participants who were eligible for *Study II* (i.e. who did not drop out from the exercise programme during the six-week familiarisation period) were those who had a more positive attitude and view on the exercise programme and the support provided in the RCT. It was deemed that a six-week familiarisation period was the time necessary to provide the participants with a gradual introduction to the exercise programme and the use of the different BCTs. This inclusion criterion was thus chosen because of the nature of the interviews and the questionnaire, to limit the difficulty of answering questions about an exercise programme and behaviour change support if participants did not get the opportunity to test and judge those components.

Results in *Study II* reflect the importance of creating a favourable environment for exercising during cancer treatment, fostering feelings of autonomy, competence and relatedness. The results also illustrate how "Finding my own motivation" (the overarching theme) can be increased through an exercise programme combining behaviour change support, supervised group-based training and home-based training in patients undergoing curative treatment. Self-determination theory appears to be a useful framework to understand how to enhance intrinsic motivation to exercise in cancer survivors, which is confirmed by other quantitative and qualitative studies [186, 188-190].

Self-regulatory BCTs and exercise adherence

The analyses in *Study III* revealed no effect of the self-regulatory BCTs on any aspect of exercise adherence (neither for the FITT-principles, nor for the dropout rates). Hence, the results indicated that the self-regulatory BCTs provided during the exercise intervention did not improve exercise adherence in the study sample. There are several plausible explanations for those results. A

first explanation is that all groups in the Phys-Can RCT were provided with some components of behaviour change support, as mentioned earlier. Those components (e.g. social support and feedback) were found to be associated with higher exercise adherence in cancer populations [120, 121]. Thus, the lack of effect of the self-regulatory BCTs could be due to the fact that all groups were provided with enough support to facilitate exercise, and that self-regulatory BCTs as additional support were not sufficient to make a difference. This is consistent with the findings from *Study II*, where the participants rated social support, feedback, self-registration of exercise and a structured environment as the most valued BCTs in the Phys-Can RCT, implying that the support provided to all was perceived as the most useful for performing exercise. The choice to provide behaviour change support to all the participants was made to optimise their participation and to be able to detect possible effects of different exercise intensities on the Phys-Can RCT's main outcome (cancer-related fatigue). Hence, it was a precarious balance between being able to evaluate the effects of exercise intensity on the main outcome and evaluating the effect of self-regulatory BCTs on exercise adherence. A second plausible explanation for the lack of effect of the self-regulatory BCTs is the characteristics of the study sample. The participants agreed to take part in a demanding exercise intervention for six months during cancer treatment and so were per definition motivated enough to participate. A majority was also physically active before entering the study. Previous research has demonstrated that baseline motivation and previous exercise habits are strong predictors for exercise adherence after a cancer diagnosis [138, 191]. This suggests that a more heterogeneous clinical population with lower baseline motivation levels and poorer exercise habits may benefit from the self-regulatory BCTs provided in the Phys-Can RCT. However, further investigations are needed to determine the effect of such support on a broader cancer population. Finally, the results from *Study III* could also be explained by the nature of the intervention. The participants were randomised to one condition and could therefore not choose to perform the exercise mode (resistance vs endurance) and intensity (HI vs LMI) they preferred. Thus, the exercise prescription may not have been totally in line with their own exercise preferences and needs. Nonetheless, it is well recognised that incorporating patients' preferences and needs is essential for behavioural strategies to be effective [160].

Self-regulatory BCTs for improved physical activity maintenance

Results from *Study IV* indicated that the self-regulatory BCTs provided in the Phys-Can RCT improved PA maintenance at 12-month follow-up in the study sample. The results are in line with findings from three previous systematic reviews of PA maintenance, albeit not only limited to cancer survivors [126,

127, 192]. Those reviews found that self-regulatory BCTs such as self-monitoring, goal-setting [126], action planning [127] and follow-up prompts [192] were often included in exercise interventions reporting higher rates of PA maintenance at follow-up.

The results from *Study III* and *Study IV* can be seen as somewhat contradictory (i.e. the self-regulatory BCTs having no effect on exercise adherence during the intervention but improving PA maintenance at follow-up). However, one possible explanation is that the self-regulatory BCTs used in the Phys-Can RCT may have been more effective in maintaining PA rather than adopting new PA behaviours, while the other BCTs provided to all the participants (e.g. social support and feedback) may have facilitated the adoption of new PA behaviours. Thus, the exercise intervention could have provided participants in the groups *with* self-regulatory BCTs the opportunity to develop self-regulatory skills (e.g. self-monitoring and action planning), which they used post-intervention to maintain their PA behaviours. This explanation is partly in line with a recent review with overweight and obese adults [126]. The authors of this review demonstrated that different BCTs were effective in promoting either the adoption of a new PA behaviour or the maintenance of this behaviour. This explanation is also in line with the results from a systematic review of behaviour theories [193], where self-regulation was described as a process occurring though the development or reinforcement of three components: 1) self-observation with self-monitoring to be aware of own behaviour, 2) self-evaluation with review of the behaviour to evaluate own performance and 3) self-reaction to the behaviour with problem solving, action/coping planning and goal-setting to rectify the behaviour if a discrepancy occurs between the current and intended behaviour. According to this model, individuals are more likely to maintain their PA behaviours if these three components are successfully integrated in the behaviour change process [193]. Another possible explanation for the different results obtained in *Study III* and *Study IV* is the large number of participants lost to follow-up in *Study IV*, introducing a selection bias that could have affected the results (e.g. participants at follow-up could be those who were most motivated and receptive to this behavioural support). Consequently, it remains unclear if similar results would be obtained in broader cancer populations.

Predictors of long-term physical activity maintenance

Potential predictors of long-term PA maintenance were examined in *Study IV*. Notably, higher HRQoL and higher exercise motivation were found to be positively associated with PA maintenance at 12-month follow-up in the study sample, although weak associations were observed compared to previous studies [137, 154]. These weak associations could be explained by the high

levels and small variation in baseline HRQoL and exercise motivation in our study sample, limiting the possibility to examine the predictive value of these variables on PA maintenance.

Tobacco use (previous or current) was one of the strongest baseline predictors, indicating that the participants who had a history of tobacco use were less likely to maintain the PA levels at follow-up. This is in contrast with findings from previous studies that have reported no association [154] or borderline associations between smoking status and PA maintenance in cancer survivors [194, 195]. Those divergent results could be explained by the way this variable is usually categorised. In *Study IV*, current and former smokers were included in the same category, while in other studies, the variable is often dichotomised as current smokers/non-smokers, which limits the exploration of history of tobacco use as a predictor. This classification may have clinical importance, as the results from *Study IV* indicate that history of tobacco use should be considered as a consistent predictor of long-term PA maintenance in cancer survivors. In previous studies involving non-cancer populations [196-198], smokers and former smokers were found to have poorer health habits than non-smokers, which partly is consistent with our results. It is also possible that study participants who reported themselves as former smokers/snus users at baseline quitted smoking/snusing at the time of their cancer diagnosis (i.e. some weeks before entering the Phys-Can RCT). A cancer diagnosis is often referred to as "a teachable moment", namely a period of time when patients are more motivated to healthy lifestyle changes [199]. However, the risk for relapse is highest the first year following smoking cessation [200], and it is possible that some of the participants relapsed during the follow-up period, which could explain the association found in *Study IV*. However, the association between history of tobacco use and long-term PA maintenance has not been sufficiently examined in cancer survivors, and needs to be further investigated to be able to draw any conclusions.

Two of the primary constructs in the social cognitive theory were also examined, namely self-efficacy and outcome expectations. According to the social cognitive theory, these two constructs are important predictors of PA [108]. Interestingly, exercise self-efficacy did not predict long-term PA maintenance in the study sample in *Study IV*, which is in contrast to previous studies that found a positive association between exercise self-efficacy and PA in cancer survivors [134, 201, 202]. However, a recurrent criticism against the social cognitive theory is its focus on factors that predict the *initiation* and *adoption* of behaviours rather than maintenance [203]. Several researchers argued that predictors of a behaviour may differ across the different phases of the behaviour change process (e.g. PA initiation, adoption, short/long-term maintenance) and that factors predicting the initiation of a behaviour such as self-efficacy may not necessarily predict long-term maintenance of this behaviour

[203-205]. This could explain the results in *Study IV* regarding exercise self-efficacy, as most of the above-mentioned studies have examined the association between exercise self-efficacy and PA adoption [202] or short-term maintenance (six months post-intervention) [134, 201] in contrast to *Study IV* that focused on long-term PA maintenance. Further, in *Study IV,* a negative association between baseline outcome expectations of exercise and long-term PA maintenance was found, indicating that participants who expected exercise to provide more health benefits at baseline (i.e. reducing risk for cancer recurrence) were those who were less physically active at follow-up. This phenomenon is usually referred to as *the false hope syndrome*, suggesting that high initial outcome expectations may undermine PA maintenance if the expected benefits are small or not attained [206, 207]. Indeed, it is possible that at baseline the study participants had unrealistic expectations to be cured from the disease soon or feel healthy soon by exercising regularly, but were still on treatment or suffering from treatment-related side effects at 12-month follow-up. The deception could have undermined their motivation to continue to be physically active at follow-up. Thus, this finding suggests that the association between outcome expectations and PA maintenance may depend on whether outcome expectations are achieved [203]. This is partly in line with the findings from an RCT involving 66 cancer survivors, where the authors found that outcome realisation (i.e. the discrepancy between outcome expectancies and experiences) was a strong predictor of PA maintenance at 10-week follow-up [208]. However, findings across the literature are mixed [209, 210], highlighting a need for further research to determine the association between outcome expectations and PA maintenance in cancer survivors.

Methodological considerations

Study I

In *Study I*, Bland-Altman analysis was used to assess agreement between the 7-day diary and SWA. The Bland-Altman analysis is a frequently applied technique in studies that investigate the mean difference (i.e. bias) between two methods using a graphical method, and is preferred to correlation analysis [211, 212]. The presentation of the 95% limits of agreement is for visual judgement of how well two methods of measurement agree, implying that the smaller the interval of those two limits is, the better the agreement is [162]. On the other hand, correlation analysis examines the degree to which two variables are related, i.e. the relationship between two variables; however, it does not say anything about the difference (or the level of agreement) between two methods [211, 212]. Indeed, it has been demonstrated that a high correlation between two methods does not automatically imply that there is good agreement [211]. However, using Bland-Altman analysis implies some challenges.

For example, it is sensitive to small samples and inadequate sample size may result in small differences, small limits of agreement and thereby may wrongly lead to the conclusion that there is good agreement between two methods. The relatively small sample size in *Study I* could therefore be considered as a limitation. However, recommendations about sample sizes for agreement studies are few [213] and vary widely, ranging from 32 [214] to over 100 participants [215], making it difficult to draw firm conclusions. Another challenge was to determine criteria for acceptable difference when comparing subjective and objective PA measurements as no guidelines exist. In *Study I*, study-specific criteria were applied. The two methods were considered as having a good level of agreement and interchangeable if the mean difference and the range between the limits of agreement did not exceed 10, 5 and 60 minutes per day regarding MPA, VPA and ST, respectively. These cut-off points were defined as a priori the limits of maximum acceptable differences, based on research findings indicating the importance of using measurement methods that are able to detect such clinical changes. Indeed, research suggests that an increase of 10 and 5 minutes of MPA and VPA per day, respectively, may lead to increased health benefits in the general population [163, 164], while an increase of 60 min per day in ST is associated with increased health risk [165].

Assessing PA and ST with an accelerometer includes some technical and practical considerations [22], which may have an impact on the results [149]. For example, there is no consensus regarding how to manage SWA data. In order to limit this issue, published guidelines [145, 147, 149, 216, 217] were followed to analyse SWA data in *Study I*. Those guidelines include recommendations regarding the required minimum number of valid days of monitoring, the required minimum wear time and criteria for valid PA bouts.

The generalisability of the results should also be reflected upon. The relatively small study sample and its homogeneity clearly limit how the results could be translated to broader cancer populations. Indeed, participants were women with breast cancer, highly educated and physically active at the start of their adjuvant cancer treatments, as indicated by the 7-day diary and SWA. They were also willing to take part in the Phys-Can observational study. All those aspects may affect the representativeness of the study sample. Thus, it is important to interpret the results with the characteristics of the participants in mind.

Study II

In *Study II,* qualitative (interviews) and quantitative (questionnaire) data were collected during the same timeframe at an initial stage and analysed separately and independently with equal priority in a second stage. Using a mixed methods design can be challenging, as such data increase the complexity of the

interpretations of the findings (e.g. how do we interpret qualitative and quantitative findings that are contradictory?) and requires increased resources in terms of careful planning, implementation and analyses of the great amount of data collected [218]. However, a mixed methods design has several advantages. First, this design gives a voice to study participants and ensure that study findings are grounded in participants' experiences [218]. Second, it enables to collect rich and comprehensive data, and provides a more complete story than either method would alone. Indeed, combining questionnaire and interview data provided detailed descriptions of participants' experiences of exercise combined with behaviour change support, both at an individual and group level, and enabled thereby a triangulation of the participants' experiences.

To ensure rigour and quality of qualitative research, the concept of *trustworthiness* is often mentioned as a key concept [219]. Trustworthiness is one way researchers can persuade themselves and readers that their research findings are worth paying attention to [220]. Lincoln and Guba suggested four criteria for developing the trustworthiness of a qualitative inquiry, corresponding to the conventional quantitative assessment criteria of validity and reliability. Those four criteria are *credibility* (i.e. confidence in the 'truth' of the findings), *dependability* (i.e. showing that the findings are consistent and could be repeated), *confirmability* (i.e. showing that the researcher's interpretations and findings are clearly derived from the data) and *transferability* (i.e. showing that the findings have applicability in other contexts) [219]. In *Study II*, several strategies were used to ensure the trustworthiness of the qualitative findings, addressing those four criteria. To address credibility, a maximum variation sampling strategy was used in the qualitative part of the study, resulting in a selection of participants with a wide range of variation in dimensions of interest. This sampling strategy was used to maximise the range of information uncovered by capturing many and various experiences and gave a rich, in-depth picture of participants' experiences. Further, to minimise the risk of recall bias, the majority of the data were collected within three months after participants completed or dropped out from the exercise programme. Frequent debriefings with all the study co-authors (MC, SB, KN and ID) were also performed to provide an external check on the research process. The co-authors had different professional backgrounds and expertise, which enabled reflections on alternative approaches and interpretations of the collected data. To address dependability, the research process of the study was reported in detail [221], using the checklist developed by Braun and Clarke [166] and the Consolidated criteria for reporting qualitative research (COREQ) [222] to enable readers to follow the research process and repeat the study. To address confirmability, the frequent debriefing with the study co-authors was used as a strategy to ensure that the interpretations and findings were clearly derived from the data and not from the authors' preferences and preunderstanding

[221]. The theoretical model based on self-determination theory [115] also served as a framework for the interpretation, enhancing objectivity and preventing the authors' preunderstanding from influencing the results. Finally, to address transferability, details of the setting and participants' characteristics were provided, allowing for a comparison of the study settings to other contexts [221]. Confidence in the transferability of the findings was also strengthened by the mixed methods design, with the maximum variation sampling used in the qualitative part and the large sample size included in the quantitative part [223]. However, it is important to bear in mind that the study participants agreed to take part in a demanding exercise intervention for six months and were per definition motivated enough to make this decision. Thus, this may limit the transferability of the findings to broader cancer populations.

Studies III and IV

A major strength of *Studies III-IV* is the use of data from a large multicentre RCT to examine the effect of self-regulatory BCTs on exercise adherence (Study III) and PA maintenance at 12-month follow-up (Study IV). Another strength is the careful monitoring of PA and exercise that was performed in the Phys-Can RCT. The careful monitoring of how participants exercised during the intervention, combining training logs and a heart rate monitor, allowed a detailed description of participants' exercise adherence based on the FITT-principles in *Study III*. Further, the assessment of PA using a 7-day diary and SWA allowed us to capture both aerobic PA and resistance training performed at follow-up and reported in *Study IV*. The intervention delivery was also closely monitored, and several actions were taken to ensure the intervention fidelity as presented in the Methods section. Before the exercise intervention started, all coaches attended a three-day mandatory course where they were trained to supervise participants randomised to one condition (i.e. either with or without self-regulatory BCTs). The coaches followed a detailed protocol during the exercise intervention and kept a week-by-week checklist for each participant, where notes were taken about any deviations from the protocol. Research staff made repeated visits to the gyms and arranged group meetings with the coaches during the exercise intervention to ensure that the intervention was delivered as planned. Finally, to ensure a clear delimitation between the conditions, the coaches who provided self-regulatory BCTs supervised only participants randomised to this condition, and the groups trained on different days.

However, some methodological aspects need to be considered. In *Study III*, the calculation of adherence to the FITT-principles was not possible for the LMI groups regarding *endurance training*, limiting the possibility to examine the effect of the self-regulatory BCTs in these groups. There were two main

reasons. First, the exercise prescription for endurance training regarding frequency, time and type of the sessions was not sufficiently specified in the protocol for the LMI groups. Second, the data collection for endurance training was not primarily intended to be used for a detailed description of exercise adherence (but for study coaches to check how participants exercised on their own). A recurrent inconsistency in the data collection therefore occurred. More specifically, participants in the LMI groups were asked to report and record a maximum of 150 minutes per week of LMI endurance training per week (and all HI exercise) to minimise the burden that such registration may imply. However, in practice, a large number of participants reported all PA they performed. This inconsistency in the data collection was unequally distributed between the intervention groups and made the data difficult to use, as it could have affected the results. We were therefore limited in the possibilities to explore this data in depth. However, the overall adherence could be calculated for all groups and provided valuable information for the LMI groups. In *Study IV*, the small number of participants who performed resistance training at 12-month follow-up did not allow us to analyse predictors of aerobic PA and resistance training separately. The outcome (PA maintenance) was therefore dichotomised (maintainers vs non-maintainers) regardless of the type of PA maintenance (aerobic or resistance). Making a valid dichotomisation was challenging. However, the choice to include maintainers of aerobic PA and resistance training in the same category was deemed adequate as current recommendations stipulate that cancer survivors should perform either aerobic PA or resistance training to achieve similar health benefits [6]. Another challenge was to determine what participants should be included in the analyses in *Study IV*. A first criterion was to include all participants with available PA data at the end of the exercise intervention and at follow-up. A second criterion was also applied and only participants meeting the PA recommendations at the end of the exercise intervention were included. This criterion was used to exclude participants who could otherwise have been categorised as maintainers at 12-month follow-up despite low PA levels at the end of the exercise intervention. Although applying such PA cut-off values may have limitations (e.g. the exclusion of participants who may have increased their PA levels after the exercise intervention), it is worth noting that only a small number of participants (5%) were excluded from the analyses. Further, the design of the Phys-Can RCT did not allow us to determine which self-regulatory BCTs were the most effective in improving long-term PA maintenance in the study sample, highlighting a need for more experimental studies to investigate the efficacy of individual or combinations of BCTs. Finally, the generalisability of the findings may be limited due to the homogeneous study samples in *Studies III-IV*. Indeed, participants were mainly women diagnosed with breast cancer and having previous exercise habits. The majority were highly educated, motivated to exercise and willing to take part in a comprehensive exercise

intervention. It is thus unclear how the results from *Studies III-IV* could translate to other cancer populations with different characteristics, highlighting a need for further investigations in broader cancer populations.

Conclusions

The aim of this thesis was to increase knowledge about physical activity promotion in patients during and after curative cancer treatment, by investigating physical activity assessment, patients' experiences and the effect of behaviour change support.

The results suggest that:

- Two methods to assess physical activity and sedentary time; a self-report 7-day diary and the Sensewear Armband mini have limited agreement and should not be used interchangeably in patients undergoing curative treatment for breast cancer. However, if appropriate to answer the research question, future studies should use a diary as a complement to the Sensewear due to its ability to provide detailed and contextual information about physical activity. (Study I)

- To increase exercise motivation during curative cancer treatment, individual incentives and a positive and supportive environment are crucial and can be promoted using specific BCTs such as social support, feedback, self-registration of exercise and structure with scheduled exercise sessions. (Study II)

- Within well-controlled exercise interventions, where both resistance and endurance training are prescribed twice a week, patients can manage to perform at least half of the exercise prescription during curative cancer treatment. Further, approximately one third of patients are at risk of dropping out of such exercise interventions during curative treatment. (Study III)

- Within well-controlled exercise interventions, where a highly structured exercise programme, social support, self-registration of exercise and supervision are provided, the addition of self-regulatory BCTs (e.g. goal-setting and action planning) is not likely to improve exercise adherence in motivated and relatively healthy patients undergoing curative treatment for breast, prostate or colorectal cancer. However, self-regulatory BCTs may improve long-term physical activity

maintenance. Patients with low health-related quality of life, low exercise motivation, high expectations of exercise or with a history of tobacco use at the start of their cancer treatment may be those most in need of such support to maintain physical activity. (Studies III-IV)

Clinical implications and future research

The results from the studies included in this thesis have several clinical implications. First, supervised group-based exercise combined with behaviour change support (e.g. feedback on exercise performance and self-registration of exercise) is recommended for patients undergoing curative cancer treatment to help them be physically active during treatment. Second, the use of self-regulatory BCTs (e.g. goal-setting, action planning and problem solving) as additional behaviour change support is recommended for promoting long-term PA maintenance in this population. Third, since treatment-related side effects are among the major reasons why cancer survivors find it difficult to attend training sessions, the exercise prescription should be individually tailored and based on each patient's experienced side effects. A tailored exercise programme based on patients' individual needs and preferences is also necessary to increase exercise motivation. Healthcare professionals are in a unique position to promote PA in patients undergoing cancer treatment and should therefore use the above-mentioned support as tools to encourage their patients to exercise. They should also pay particular attention to patients who may be more in need of such support, for example patients with lower HRQoL, lower exercise motivation, higher expectations of exercise or with a history of tobacco use at the start of their cancer treatment.

The results of this thesis also raise important questions that need to be addressed in future research. For example, additional investigations are needed to determine the effect of self-regulatory BCTs in broader cancer populations, such as patient groups with different cancer diagnosis, with lower motivation and/or without previous exercise habits. There is also a need for increased knowledge regarding which individual or combinations of self-regulatory BCTs are the most effective in promoting long-term PA maintenance in cancer survivors. More studies with experimental designs are therefore needed. Finally, because of the growing cancer population, it remains a challenge to reach all cancer survivors, including those who are not physically active and not willing to participate in exercise trials. Developing community-based physical activity rehabilitation is therefore warranted and a sustained collaboration between different sectors (e.g. healthcare and wellcare) is crucial to increase the opportunities for cancer survivors to receive exercise programming outside of a research setting. This may also require education and appropriate training of all staff involved, which could be achieved using cancer-specific

education and certification programmes. Such programmes have been developed in North America (e.g. ACSM/ACS Certified Cancer Exercise Trainer) and Europe (e.g. Aktiv mot kreft/AKTIVinstruktører in Norway) to provide education and training for exercise to healthcare and fitness professionals working in community-based settings, and could be used in adapted versions in Sweden.

Svensk sammanfattning

Bröst-, prostata- och kolorektalcancer är bland de vanligaste cancerformerna i Sverige. Allt fler patienter överlever sin cancer tack vare tidig upptäckt av sjukdomen, bättre diagnostik och effektivare behandlingar. Dock upplever många patienter biverkningar såsom cancer-relaterad fatigue, försämrad fysisk funktion och ångest/depression, vilka försämrar deras livskvalitet både på kort och lång sikt. Patienter med cancer fick tidigare råd från hälso-och sjukvården om att vila så mycket som möjligt samt begränsa sina fysiska aktiviteter för att orka med sjukdomen och behandlingen. Idag visar forskning att fysisk aktivitet, både under och efter cancerbehandling, är nödvändig för att minska de olika biverkningarna som orsakas av behandlingen. Flera internationella rekommendationer om fysisk aktivitet vid cancer har publicerats och det är nu vedertaget att fysisk aktivitet bör ingå som en del av cancervården. I Sverige finns fysisk aktivitet med i det nationella vårdprogrammet för cancerrehabilitering och varje patient bör erbjudas kontakt med en fysioterapeut och träning. Att vara fysiskt aktiv, både under och efter cancerbehandling, kan dock vara en utmaning. Flera studier visar att en stor andel patienter minskar sin fysiska aktivitet och har en mer stillasittande livsstil efter en cancerdiagnos. De är också mindre fysiskt aktiva än den allmänna befolkningen. Patienter som behandlats mot cancer har dessutom svårt att upprätthålla sin fysiska aktivitet även efter att ha deltagit i en träningsintervention. Detta tyder på att det finns ett behov av att öka kunskapen om hur fysisk aktivitet kan främjas hos patienter som har eller har haft cancer.

Denna avhandling syftade till att öka kunskapen om främjande av fysisk aktivitet hos patienter under och efter kurativ cancerbehandling. Avhandlingen innehåller fyra delstudier och använder data från forskningsprojektet Phys-Can (Fysisk träning och Cancer). Forskningsprojektet Phys-Can består av två huvudsakliga studier med separata datainsamlingar; en observationsstudie och en randomiserad kontrollerad studie (RCT). Patienter med nydiagnostiserad bröst-, prostata- eller kolorektalcancer rekryterades vid universitetssjukhusen i Uppsala, Linköping och Malmö/Lund. I Phys-Can observationsstudien, följdes deltagarna över tid utan intervention. I Phys-Can RCT, randomiserades deltagarna till sex månaders individbaserad högintensiv eller låg/måttligt intensiv träning, *med* eller *utan* extra beteendestöd. Träningsprogrammet innehöll instruktörsledd styrketräning i grupp två gånger i veckan och konditionsträning på egen hand. Alla deltagarna fick beteendestöd i form av socialt stöd,

feedback, självmonitorering och struktur med fasta träningstider. Utöver detta, fick deltagarna i interventionsgrupperna *med* extra beteendestöd hjälp med målsättning, planering och uppföljning av träningen.

Delstudie I

En tillförlitlig mätning av fysisk aktivitet och stillasittande hos patienter med cancer är viktig för att kunna utvärdera effekter av olika träningsinterventioner och därmed främja fysisk aktivitet i denna patientgrupp. Flera mätinstrument brukar användas för att mäta fysisk aktivitet och stillasittande, bland annat dagböcker och accelerometer. Dock har få studier jämfört dessa två mätinstrument hos patienter med cancer. Det finns därför ett behov av att utvärdera graden av överensstämmelse mellan dessa två mätinstrument för att optimera deras användning.

Syftet med delstudie I var att studera överensstämmelsen mellan en dagbok och en accelerometer för mätning av daglig fysisk aktivitet och stillasittande hos patienter med bröstcancer. Baslinjemätningen från Phys-Can observationsstudien användes. Sammanlagt inkluderades 65 deltagare med bröstcancer i denna delstudie. Tid i måttlig- och högintensiv fysisk aktivitet samt i stillasittande mättes med hjälp av en 7-dagars dagbok och SenseWear Armband mini (SWA). Grad av överensstämmelse mellan de två mätinstrumenten utvärderades med hjälp av Bland-Altman diagram. Resultatet visade att det fanns statistiskt signifikanta skillnader mellan båda mätinstrumenten vid mätning av fysisk aktivitet och stillasittande, och att dessa skillnader ökade ju fler aktiviteter som rapporterades i dagboken.

Delstudie II

Det finns begränsat med forskning kring motivation och erfarenheter av att träna under cancerbehandling och vad som kan underlätta träningen under denna period. Mer kunskap om detta behövs för att kunna förbättra cancervården i framtiden.

Syftet i delstudie II var att utforska patienters motivation och erfarenheter av att träna under cancerbehandling samt undersöka vilket beteendestöd (t.ex. socialt stöd och feedback) som kan underlätta träning under denna period. Patienter med bröst-, prostata- eller kolorektalcancer som deltog i denna delstudie, ingick i interventionsgrupperna *med* extra beteendestöd i Phys-Can RCT. I slutet av träningsperioden, skickades en enkät till 229 deltagare och individuella intervjuer genomfördes med 18 deltagare med varierande träningsvanor och följsamhet till träningsprogrammet. Intervjuerna analyserades med hjälp av tematisk analys och svaren från enkäten med hjälp av deskriptiv statistik.

Resultatet visade att deltagarna gick igenom en motivationsprocess under den sex månaders träningsperioden. De beskrev olika drivkrafter till att vara fysiskt aktiv och träna under cancerbehandling samt hur dessa drivkrafter gav en ökad känsla av autonomi, kompetens och samhörighet, som i sin tur ledde till en ökad motivation att träna. Med hjälp av regelbunden träning, upplevde deltagarna *fysiska och psykiska hälsoeffekter*. De kände sig starkare, piggare och gladare, och fick känslan av att kunna påverka sin egen hälsa och kämpa mot sjukdomen. Deltagarna fick också *ökad medvetenhet och kunskap* om hur träningen kunde påverka deras kropp under cancerbehandling, och lärde sig nya färdigheter (träna på ett säkert sätt, hantera sina biverkningar etc.). Dessutom upplevde deltagarna en stark *gemenskap* med träningsgruppen och coacherna. Deltagarna mötte dock *utmaningar och hinder* som de ofta kunde övervinna med hjälp av det stöd som de fick från sin träningsgrupp, coach, familj och sina vänner. Dessa positiva upplevelser var ett kvitto på att träningen lönade sig och upplevdes som en seger över sjukdomen. På så sätt hittade deltagarna sin egen motivation till att fortsätta träna under cancerbehandling trots utmaningar de mötte. Deltagarna skattade följande beteendestöd som mest värdefullt för att kunna genomföra träningen: *socialt stöd* från träningscoacherna, *feedback* som de fick när de gjorde återkommande fysiska tester och använde pulsklocka under träningen, *självmonitorering* med träningsböcker och *en strukturerad fysisk miljö* med fasta träningstider.

Delstudie III och IV

Det saknas kunskap om förmågan att vara fysiskt aktiv och träna under och efter cancerbehandling samt om effekten av extra beteendestöd (målsättning, planering och uppföljning av träningen) på träningsföljsamheten. Det finns dessutom begränsat med forskning kring vilka faktorer som predicerar fysisk aktivitet hos patienter som genomgått cancerbehandling och deltagit i en träningsintervention. Mer kunskap om dessa aspekter behövs för att kunna förbättra cancervården i framtiden.

Syftet i delstudie III var att 1) beskriva träningsföljsamheten i detalj med avseende på frekvens, intensitet, tid, typ av träning (FITT-principer) och andel avhopp, samt 2) studera effekten av extra beteendestöd på träningsföljsamheten hos patienter som deltar i en träningsintervention under sin cancerbehandling. De 577 deltagare med bröst-, prostata- eller kolorektalcancer som randomiserades i Phys-Can RCT inkluderades i denna delstudie. Träningsföljsamheten (andelen utförd träning i relation till planerad träning) beräknades med hjälp av närvarolistor, träningsböcker och pulsklockor. Regressionsanalyser genomfördes för att studera effekten av extra beteendestöd på träningsföljsamheten. Resultatet visade att deltagarna deltog i genomsnitt vid 53% av de planerade *styrketräningspassen*. Under dessa pass, utförde de 77% av den

avsedda belastningen och 78% av det avsedda repetitionsantalet. Deltagarna utförde de planerade övningarna i 70% av de utförda träningspassen. Gällande *konditionsträningen*, utförde deltagarna i genomsnitt 49% av de planerade träningspassen. Under dessa pass, utförde de 60% av den avsedda träningsintensiteten och 72% av den avsedda träningstiden. De utförde den planerade typen av konditionsträning i 78% av de utförda träningspassen. Andelen deltagare som avbröt träningsperioden var i genomsnitt 29%. Analyserna visade att det extra beteendestödet inte förbättrade träningsföljsamheten hos deltagarna.

Syftet i delstudie IV var att studera effekten av extra beteendestöd på fysisk aktivitet hos patienter ett år efter en träningsintervention under cancerbehandling samt studera vilka faktorer som kan predicera upprätthållande av fysisk aktivitet på lång sikt hos dessa patienter. Sammanlagt inkluderades i denna delstudie 301 deltagare med bröst-, prostata- eller kolorektalcancer som deltog Phys-Can RCT. Deltagarna lämnade data om sin fysiska aktivitet i slutet av träningsperioden och vid 1-årsuppföljningen. Datainsamlingen genomfördes med hjälp av en 7-dagars dagbok och SWA. Deltagarna kategoriserades som antingen ”har upprätthållit sin fysiska aktivitet” eller ”har inte upprätthållit sin fysiska aktivitet” vid 1-årsuppföljningen. Regressionsanalyser genomfördes för att studera effekten av det extra beteendestödet på upprätthållande av fysisk aktivitet samt studera möjliga prediktorer för upprätthållande av fysisk aktivitet. Resultatet visade att det extra beteendestödet förbättrade fysisk aktivitet vid 1-årsuppföljningen hos deltagarna. Fyra faktorer vid baslinjen var statistiskt signifikanta prediktorer, nämligen hälsorelaterad livskvalitet, motivation till att träna, förväntningar på träningen samt att vara tidigare eller nuvarande rökare/snusare.

Resultatet från delstudierna tyder på att:

- en 7-dagars dagbok och SWA har begränsad överensstämmelse och inte kan användas utbytbart hos patienter med bröstcancer. (Delstudie I)

- Individuella drivkrafter och en positiv och stödjande miljö är nödvändiga för att öka motivation till träningen, vilka kan främjas med hjälp av specifika beteendestöd (socialt stöd, feedback, självmonitorering och struktur med fasta träningstider) hos patienter som genomgår cancerbehandling. (Delstudie II)

- Inom ramen av väl-kontrollerade träningsinterventioner där både styrke- och konditionsträning bör utföras två gånger i veckan, kan patienter utföra minst hälften av den planerade träningen samtidigt som de får behandling mot bröst-, prostata- eller kolorektalcancer. Cirka

var tredje patient riskerar att avbryta träningen i sådana träningsinterventioner under pågående cancerbehandling. (Delstudie III)

- När instruktörsledd gruppträning, socialt stöd och självmonitorering med träningsböcker ges inom ramen av strukturerade träningsinterventioner, förbättrar tillägget av extra beteendestöd (målsättning, planering och uppföljning av träningen) sannolikt inte träningsföljsamheten hos patienter med bröst-, prostata- eller kolorektalcancer. Extra beteendestöd verkar däremot kunna främja patienternas fysiska aktivitet på längre sikt. Patienter som påbörjar sin cancerbehandling och har låg livskvalitet, låg motivation till att träning, höga förväntningar på träningen eller som är eller varit rökare/snusare kan vara de som behöver mest stöd för att upprätthålla sin fysiska aktivitet på lång sikt. (Delstudie III och IV)

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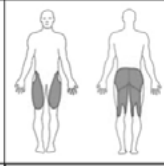
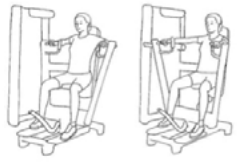
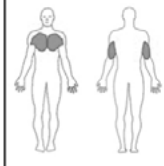
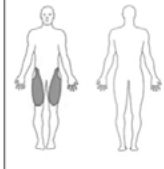
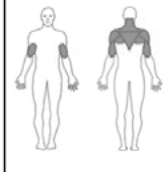
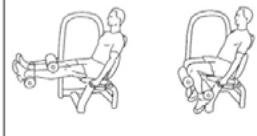
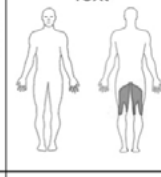
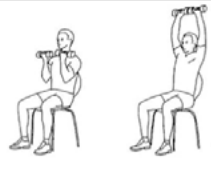
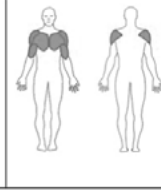
Appendix

Appendix 1. Resistance training programme in the Phys-Can RCT

Exercise	Illustration	Target muscles	Comment
1. Seated leg press			Place your feet on the footplate with shoulderwidth distance. Sit close to the footplate without losing contact with the backrest. Tighten your abdomen and press your lower back against the backrest. Press your feet to the footplate and stretch your knees until almost fully extended. Return to the starting position and repeat.
2. Chest press			Sit with relaxed shoulders and a firm grip on the handles. Let your elbows be in level with the handles. Press the handles forward until your arms are completely straight and then retract them back towards your chest.
3. Leg extension			Sit with your knees bent and with good support for your lower back. Extend your legs fully. Retract your legs controlled back to the starting position and repeat.
4. Seated row			Sit with your back straight and press your chest against the pillow. Hold the handles. Keep your arms straight and release your shoulders forward. Pull the handles back as far as you can. Squeeze the shoulder blades together in the end position. Keep contact with the chest pad throughout the movement.
5. Seated leg curl			Make sure you have good support for the lower back and fix the upper body with the help of the handles. Press the wrists against the cushion, bend your knees maximally and return slowly to the starting position.
6. Seated overhead press			Stand or sit (on a bench or a chair). Hold the dumbbells in front of you close to your shoulders. Press the dumbbells over your head until your arms are straight. Lower your arms and go back to the starting position.

Text

Appendix 2. Baseline characteristics, attendance and dropout rates of participants (Study II)

	Questionnaire participants (n=229)	**Interview participants (n=18)**
Age, mean years (SD)	59 (12)	63 (11)
Women, n (%)	178 (78)	9 (50)
Study site, n (%)		
Malmö/Lund	98 (43)	4 (22)
Linköping	31 (13)	3 (17)
Uppsala	100 (44)	11 (61)
Education, n (%)		
Elementary school	27 (12)	3 (17)
High school	63 (28)	4 (22)
University or equivalent	139 (61)	11 (61)
Occupation, n (%)		
Working [a]	131 (57)	5 (28)
On sick leave [a]	82 (36)	5 (28)
Retired	94 (41)	9 (50)
Previous exercise habits, median (IQR)		
Resistance training, times/week	0 (1)	0 (1)
Endurance training at moderate intensity, min/week	180 (205)	180 (203)
Endurance training at high intensity, min/week	0 (60)	0 (115)
Diagnosis, n (%)		
Breast cancer	175 (76)	8 (44)
Prostate cancer	45 (20)	7 (39)
Colorectal cancer	9 (4)	3 (17)
Primary (neo-)adjuvant treatment, n (%)		
Chemotherapy	122 (53)	8 (44)
Radiation therapy	83 (36)	9 (50)
Endocrine therapy	24 (11)	1 (6)
Intervention group, n (%)		
High intensity	114 (50)	9 (50)
Low-to-moderate intensity	115 (50)	9 (50)
Attendance at resistance training sessions (max n= 54), median (min-max)	39 (7-55)	41.5 (7-51)
Dropout, n (%)	9 (4)	2 (11)

Note: [a] Full-time and part-time. n's do not all sum to total due to missing data; % is of those with available data.
Abbreviations: SD= standard deviation, IQR= interquartile range.

Appendix 3. Baseline characteristics of participants by intervention group (Study III)

	Groups with BCTs		Groups without BCTs	
	HI (n=144)	**LMI** (n=145)	**HI** (n=144)	**LMI** (n=144)
Age, mean years (SD)	59 (13)	58 (12)	58 (11)	59 (12)
Women, n (%)	115 (80)	118 (81)	116 (81)	116 (81)
Study site, n (%)				
Malmö/Lund	65 (45)	68 (47)	66 (46)	64 (45)
Linköping	21 (15)	18 (12)	19 (13)	22 (15)
Uppsala	58 (40)	59 (41)	59 (41)	58 (40)
Education, n (%)				
Elementary school	19 (14)	16 (11)	20 (14)	25 (17)
High school	45 (31)	32 (22)	38 (26)	36 (25)
University or equivalent	80 (56)	97 (67)	86 (60)	83 (58)
Comorbidities, n (%)				
One or more	70 (56)	70 (55)	72 (58)	81 (65)
Self-reported exercise habits, n (%)				
Resistance training since ≥6 months	29 (25)	25 (22)	31 (26)	18 (15)
Endurance training since ≥6 months	44 (38)	55 (45)	50 (40)	38 (30)
MVPA, median min/day (IQR)	60 (57)	69 (59)	63 (67)	56 (56)
Diagnosis, n (%)				
Breast cancer	113 (78)	116 (80)	115 (80)	113 (79)
Colorectal cancer	5 (4)	6 (4)	6 (4)	6 (4)
Prostate cancer	26 (18)	23 (16)	23 (16)	25 (17)

Primary (neo-)adjuvant treatment, n (%)				
Chemotherapy	75 (53)	75 (53)	72 (52)	76 (55)
Radiation therapy	44 (31)	48 (34)	50 (36)	43 (31)
Endocrine therapy	22 (16)	17 (12)	16 (12)	20 (14)
Self-reported importance[a], median (IQR)				
Resistance training	73 (51)	83 (50)	82 (56)	79 (47)
HI endurance training	51 (52)	66 (52)	65 (64)	58 (64)
LMI endurance training	88 (38)	91 (38)	86 (42)	83 (38)
Exercise preferences, n (%)				
HI intensity	66 (49)	77 (57)	70 (51)	64 (46)
LMI intensity	70 (51)	58 (43)	67 (49)	75 (54)

Note: [a] Reported on a 100 mm visual analogue scale anchored at 'Not at all important' and 'Very important'. n's do not all sum to total due to missing data; % is of those with available data. *Abbreviations*: BCTs= self-regulatory behaviour change techniques, HI= high intensity exercise, LMI= low-to-moderate intensity exercise, SD= standard deviation, IQR= interquartile range, MVPA= moderate-to-vigorous physical activity.

Appendix 4. Baseline characteristics of follow-up participants and participants lost to follow-up (Study IV)

	Follow-up participants (n = 301)				**Participants lost to follow-up (n= 276)**	**p-value** [a]
	Groups with BCTs		Groups without BCTs		All groups	
	HI (n=77)	LMI (n=81)	HI (n=71)	LMI (n=72)		
Age, mean (SD)	60 (12)	58 (12)	57 (11)	60 (11)	59 (12)	0.907
Women, *n* (%)	61 (79)	64 (79)	56 (79)	57 (79)	227 (82)	0.341
Living situation, *n* (%)						
Living with partner	57 (75)	63 (82)	55 (78)	54 (75)	202 (79)	0.094
Education, *n* (%)						
University or equivalent	45 (59)	58 (73)	49 (69)	46 (64)	150 (57)	0.07
Tobacco status, *n* (%)						
Former or current smoker/snus user	24 (35)	23 (32)	26 (40)	30 (44)	121 (50)	**0.006**
Anxiety (0-21)[b], median (IQR)	4 (6)	5 (4)	6 (8)	5 (7)	6 (5)	0.451
Cancer-related fatigue (4-20) [c], mean (SD)	11 (4)	11 (4)	11 (5)	11 (5)	12 (4)	0.248
HRQoL (0-100)[d]**,** mean (SD)	70 (20)	66 (19)	70 (20)	68 (19)	63 (21)	**0.005**
Exercise self-efficacy (0-10)[e]**,** mean (SD)	6 (2)	6 (2)	6 (2)	5 (1)	5 (2)	0.055
Exercise motivation (0-100)[f], median (IQR)	91 (32)	88 (27)	92 (23)	85 (32)	88 (27)	0.674
Cancer outcome expectations (0-10)[g], mean (SD)	6 (3)	6 (3)	6 (3)	6 (3)	6 (3)	0.689
Comorbidities, *n* (%)						
One or more	37 (53)	35 (50)	37 (60)	38 (58)	146 (62)	0.087
$\dot{V}O_2$max, mean mL/kg/min (SD)	31 (8)	31 (7)	32 (6)	30 (7)	28 (7)	**<0.001**
BMI, mean kg/m^2 (SD)	26 (4)	25 (4)	25 (4)	25 (4)	27 (5)	**<0.001**
MVPA, median min/week (IQR)	424 (260)	429 (386)	522 (417)	437 (353)	321 (331)	**<0.001**

Diagnosis, *n* (%)						0.323
Breast cancer	60 (78)	63 (78)	56 (79)	56 (78)	222 (80)	
Prostate cancer	14 (18)	15 (18)	12 (17)	15 (21)	41 (15)	
Colorectal cancer	3 (4)	3 (4)	3 (4)	1 (1)	13 (5)	
Primary (neo-)adjuvant treatment, *n* (%)						0.284
Chemotherapy	42 (55)	43 (53)	37 (52)	35 (49)	141 (59)	
Radiation therapy	23 (30)	27 (33)	24 (34)	26 (36)	72 (30)	
Endocrine therapy	12 (16)	11 (14)	10 (14)	11 (15)	27 (11)	

Note: [a] p-value for differences between participants included in the analysis and those who were lost to follow-up (independent t-test or Mann-Whitney for continuous variables and Chi^2 test for nominal variables), Assessed by [b] Hospital Anxiety and Depression scale (Anxiety subscale), higher scores indicate worse outcome, [c] Multidimensional Fatigue Inventory (subscale general fatigue), higher scores indicate worse outcome, [d] European Organisation for Research and Treatment of Cancer (subscale global health status), higher scores indicate better outcome, [e] Exercise Barrier Self-Efficacy Scale, higher scores indicate better outcome, [f] Mean of 3-item study-specific questionnaire ("How important/confident/ready are you to perform ...? 0='Not at all' to 100='Very'), [g] Assessed by a study-specific numerical rating scale ("How confident are you that exercise can reduce the risk of cancer recurrence? 0='Not at all confident' to 10='Very confident'). n's do not all sum to total due to missing data; % is of those with available data. Baseline characteristics across intervention groups were compared with one-way ANOVA or Kruskal-Wallis (continuous variables) and Chi^2 test (nominal variables). *Abbreviations*: BCTs= self-regulatory behaviour change techniques; HI= high intensity exercise; LMI= low-to-moderate intensity exercise; SD= standard deviation, HRQoL= health-related quality of life; $\dot{V}O_2max$ = maximal oxygen uptake; BMI= body mass index; MVPA= moderate-to-vigorous physical activity, IQR= interquartile range.

Appendix 5. Study-specific questionnaire to evaluate the BCTs provided in the Phys-Can RCT (Study II) (Swedish)

Phys Can

Studiekod: ☐☐☐☐☐

Datum:

Frågor kring ditt deltagande i PhysCan

Detta formulär innehåller några tilläggsfrågor om hur du upplevt att delta i studien. Vi är intresserade av din *personliga* åsikt. Det finns alltså inga "rätt" eller "fel" svar.

1. Hur värdefulla bedömer du att nedanstående delar av projektet har varit för din STYRKETRÄNING?

Sätt kryss för den siffra som stämmer bäst: 1=”inte alls värdefull” och 5=”mycket värdefull”. Välj alternativet ”Vet inte” om du inte deltagit eller inte använt dig av en viss metod.

	Inte alls värdefull				Mycket värdefull	Vet inte
	1	2	3	4	5	
Stöd från instruktör	☐	☐	☐	☐	☐	☐
Stöd från andra Studiedeltagare	☐	☐	☐	☐	☐	☐
Fasta tider för styrketräning	☐	☐	☐	☐	☐	☐
Introduktionssamtal kring träningsvanor och förväntningar på att träna i PhysCan	☐	☐	☐	☐	☐	☐
Träningsdagbok för styrketräning	☐	☐	☐	☐	☐	☐
Plan för vidmakthållande efter träningsperiodens slut	☐	☐	☐	☐	☐	☐
Styrketesten på gymet	☐	☐	☐	☐	☐	☐
Annat, vad?	☐	☐	☐	☐	☐	☐

2. Hur värdefulla bedömer du att nedanstående delar har varit för din KONDITIONSTRÄNING?

Sätt kryss för den siffra som stämmer bäst: 1=”inte alls värdefull” och 5=”mycket värdefull”

Välj alternativet ”Vet inte” om du inte deltagit eller inte använt dig av en viss metod.

	Inte alls värdefull				Mycket värdefull	Vet inte
	1	2	3	4	5	
Stöd från instruktör	☐	☐	☐	☐	☐	☐
Stöd från andra studiedeltagare	☐	☐	☐	☐	☐	☐
Introduktionssamtal kring träningsvanor och förväntningar på att träna i PhysCan	☐	☐	☐	☐	☐	☐
Konditionstest	☐	☐	☐	☐	☐	☐
Pulsklocka	☐	☐	☐	☐	☐	☐
Titta på pulsfiler med instruktören	☐	☐	☐	☐	☐	☐
Träningsdagbok för konditionsträning (häfte eller web)	☐	☐	☐	☐	☐	☐
Sätta veckomål för konditionsträning	☐	☐	☐	☐	☐	☐
Planering av konditionsträning	☐	☐	☐	☐	☐	☐
Uppföljande samtal med instruktören kring vad som styr din konditionsträning	☐	☐	☐	☐	☐	☐
Plan för vidmakthållande efter träningsperiodens slut	☐	☐	☐	☐	☐	☐
Annat, vad?	☐	☐	☐	☐	☐	☐

3. Skulle du rekommendera en släkting eller vän med liknande situation och behandling som din att delta i ett program med samma upplägg som PhysCan?

Nej, definitivt inte	Nej, troligen inte	Vet ej/ingen åsikt	Ja, troligen	Ja, definitivt
☐	☐	☐	☐	☐

Kommentera gärna _____

_____

_____

_____

Appendix 6. Calculation of exercise adherence (Study III)

Adherence	Groups	Calculation
Supervised resistance training		
Overall	HI and LMI	Total performed reps x sets x weight/ Total prescribed reps x sets x weight
Frequency	HI and LMI	Attended sessions/ Prescribed sessions
Intensity	HI and LMI	Performed weight/ Prescribed weight during performed sessions
Time	HI and LMI	Performed sets x repetitions/ Prescribed sets x repetitions during performed sessions
Type	HI and LMI	Sessions where all prescribed exercises were performed/ Performed sessions
Home-based endurance training		
Overall	HI and LMI	Total performed min at prescribed intensity/ Total prescribed min
Frequency	HI*	Performed sessions/ Prescribed sessions
Intensity	HI*	Performed intervals where the target heart rate zone was met/ Prescribed intervals during performed sessions
Time	HI*	Duration of performed intervals / Prescribed duration of intervals during performed sessions
Type	HI*	Performed interval training sessions / Performed sessions
Dropout rates		
	HI and LMI	Participants who left the study or did not exercise during the last month (or more) of the intervention/ Participants

Note: * Not applicable for the LMI groups. *Abbreviations*: HI= High intensity, LMI= Low-to-moderate intensity, Min= minutes.

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