Exercise-Based Cardiac Rehabilitation in Patients with Coronary Artery Disease

Attendance, Adherence and the Added Value of a Behavioural Medicine Intervention

Sabina Borg

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Linköping University, Sweden

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With all my love to my family
Marcus, Ellen and Victor

“Knowledge is of no value unless you put it into practice”

Anton Chekhov

CONTENTS

ABSTRACT	1
SVENSK SAMMANFATTNING	3
LIST OF PAPERS	5
DESCRIPTION OF CONTRIBUTIONS	7
ABBREVIATIONS	9
BACKGROUND	11
Coronary artery disease	11
<i>Cardiovascular risk factors</i>	11
Cardiac rehabilitation	12
Exercise-based cardiac rehabilitation	12
<i>Definitions of exercise, physical activity, and physical fitness</i>	13
<i>Pre-exercise screening</i>	13
<i>Recommendations for exCR</i>	13
<i>ExCR setting</i>	15
Effects of exercise-based cardiac rehabilitation	15
Exercise maintenance	16
Attendance at and adherence to exCR	16
<i>Factors associated with non-attendance at exCR</i>	16
<i>Adherence</i>	17
<i>Strategies to increase uptake of and adherence to exCR</i>	18
Behavioural medicine	18
<i>Health behaviour change theories</i>	19
<i>Social cognitive theory</i>	19
<i>Control theory</i>	20
<i>Behaviour change techniques</i>	20
Rationale of the thesis	22
AIMS OF THE THESIS	23
Overall aim	23
Specific aims	23
METHODS	25

Overview of the studies	25
Designs and settings.....	26
Participants and data collection	26
<i>Study A – Paper I</i>	26
<i>Study B – Papers II and III</i>	28
Measurements	30
<i>Study A – Paper I</i>	30
<i>Study B – Papers II and III</i>	31
Intervention.....	34
<i>Routine exCR care</i>	34
<i>Behavioural medicine intervention</i>	35
Data analysis.....	38
<i>Study A – Paper I</i>	38
<i>Study B – Papers II and III</i>	38
Ethical considerations	40
RESULTS	41
Factors associated with non-attendance at exCR (Study A, Paper I) .	41
<i>Logistic regression model</i>	43
The added value of a BMIP in exCR (Study B, Papers II and III)	44
<i>Adherence</i>	47
<i>Physical fitness</i>	48
<i>Psychological outcomes and HRQoL</i>	48
<i>Per-protocol analysis within and between groups</i>	53
DISCUSSION	55
Main findings.....	55
Factors associated with non-attendance at exCR	55
<i>Structural factors</i>	55
<i>Individual factors</i>	56
<i>Early commencement of CR</i>	57
The added value of a BMIP in exCR	58
<i>Exercise adherence</i>	58
<i>ExCR setting</i>	60
<i>Physical fitness, psychological outcomes and HRQoL</i>	61

<i>Design of the BMIP</i>	63
<i>Exercise maintenance</i>	64
Methodological considerations	65
CONCLUSIONS	69
Clinical implications	70
Implications for future research	70
ACKNOWLEDGEMENTS	71
REFERENCES	73

ABSTRACT

Background: Coronary artery disease (CAD) is the leading global cause of death. After an index event related to CAD, exercise-based cardiac rehabilitation (exCR) is strongly recommended as part of the secondary prevention. Despite the well-established beneficial effects of exCR in patients with CAD, attendance at and adherence to the programme are low, and remain a matter of major concern. One strategy that may increase adherence and rehabilitation outcomes in patients with CAD is to add a behavioural medicine intervention to routine exCR care. The added value of such interventions needs to be further explored. Although several factors associated with non-attendance at exCR appear to be similar between different countries, patterns of attendance may differ due to differences in contextual aspects. The factors that affect attendance at exCR in a Swedish context remain to be explored.

Overall aim: To investigate barriers for exCR attendance and to evaluate the added value of a behavioural medicine intervention in physiotherapy on exercise adherence and rehabilitation outcomes in patients with CAD.

Methods: The three papers in this thesis are based on two studies of patients with CAD, one registry-based cohort study of 31,297 patients included from the SWEDEHEART registry (Paper I), and one randomised controlled trial of 170 patients included at a Swedish university hospital (Papers II and III). In the first paper, several individual and structural variables were compared for attenders and non-attenders, using multivariable analysis in a logistic regression model. In Papers II and III, patients were randomised 1:1 either to a behavioural medicine intervention in physiotherapy in addition to routine exCR care or to routine exCR care alone for four months. The behaviour change techniques used in the behavioural medicine intervention – specific goal-setting, re-evaluation of the goals, and self-monitoring and feedback – were based on control theory. Outcome assessment took place at baseline, four and 12 months, and included physical fitness, psychological outcomes and health-related quality of life. Exercise adherence was evaluated at the end of the four-month intervention. An intention-to-treat and a per-protocol analysis were performed.

Results: Individual and structural factors associated with non-attendance at exCR in a Swedish context were identified as having a distance greater than 16 km to the hospital, belonging to a county hospital, having a higher burden of comorbidities, being male, and being retired. Exercise adherence was higher for patients who received the behavioural medicine intervention in physiotherapy together with routine exCR (31%) than it was for those who received routine exCR care alone (19%). Rehabilitation outcomes did

not differ significantly between the two groups, either between baseline and four months or between four and 12 months. Both groups improved significantly in all measures of physical fitness, and in several measures of health-related quality of life and anxiety at the four-month follow-up. Sufficient enablement remained for patients in both groups at the 12-months follow-up.

Conclusions: Distance to the hospital was the strongest predictor for non-attendance at exCR in a Swedish context. The individual factors associated with non-attendance at exCR identified in this thesis confirm previous results, with the exception that female gender was associated with a higher attendance at exCR. The results of this thesis confirm what others have pointed out: it is challenging to achieve behavioural change in patients with the aim to improve rehabilitation outcomes. Even though adherence was higher when a behavioural medicine intervention was added, it was low in both groups. The current behavioural medicine intervention in physiotherapy did not give any improvements over routine exCR care alone in physical fitness, psychological outcomes or health-related quality of life. As such, there is still room for further development and evaluation of behavioural medicine interventions within the context of exCR. A greater tailoring of these interventions to individual needs in a broader population of patients with CAD is suggested.

SVENSK SAMMANFATTNING

Bakgrund: Kranskärslssjukdom är den ledande dödsorsaken i världen. Efter en hjärthändelse till följd av kranskärslssjukdom är träningsbaserad hjärtrehabilitering högt rekommenderad som en del av sekundärpreventionen. Trots att träningsbaserad hjärtrehabilitering har väletablerade positiva effekter hos patienter med kranskärslssjukdom är deltagande och följsamhet till behandlingen låg och ett fortsatt stort bekymmer. En beteendemedicinsk intervention i tillägg till sedvanlig träningsbaserad hjärtrehabilitering kan vara en strategi för att öka följsamheten och förbättra rehabiliteringsutfallet hos patienter med kranskärslssjukdom. Betydelsen av sådana interventioner behöver dock undersökas ytterligare. Även om det finns faktorer associerade med icke-deltagande i träningsbaserad hjärtrehabilitering som är likartade mellan olika länder, kan mönster för deltagande också skilja sig åt på grund av skillnader i kontextuella aspekter. Faktorer som påverkar deltagande i träningsbaserad hjärtrehabilitering i en svensk kontext är understuderat.

Övergripande syfte: Att undersöka barriärer för deltagande i träningsbaserad hjärtrehabilitering samt utvärdera mervärdet av en beteendemedicinsk intervention inom träningsbaserad hjärtrehabilitering avseende följsamhet samt rehabiliteringsutfall hos patienter med kranskärslssjukdom.

Metod: De tre delarbeten som ingår i den här avhandlingen baseras på två studier innefattande patienter med kranskärslssjukdom, en registerbaserad kohortstudie med 31 297 patienter inkluderade från SWEDEHEART-registret (delarbete I) och en randomiserad kontrollerad studie med 170 patienter inkluderade på ett svenskt universitetssjukhus (delarbete II och III). I det första delarbetet jämfördes deltagare och icke-deltagare i träningsbaserad hjärtrehabilitering avseende samtliga inkluderade individuella och strukturella variabler och en multivariabel analys med logistisk regressionsmodell utfördes. I delarbete II och III randomiserades patienterna 1:1 till en beteendemedicinsk intervention i tillägg till sedvanlig träningsbaserad hjärtrehabilitering eller till enbart sedvanlig träningsbaserad hjärtrehabilitering under fyra månader. De beteendeförändringstekniker som användes i den beteendemedicinska interventionen innefattade specifik målsättning, omvärdering av målen, självmonitorering och feedback och baserades på kontrollteorin. Test av utfallsmått ägde rum vid baslinjen och efter fyra och 12 månader och inkluderade fysisk kapacitet, psykologiska utfallsmått samt hälsorelaterad livskvalitet.

Följsamhet till det träningsbaserade hjärtrehabiliteringsprogrammet utvärderades efter avslutad intervention vid fyra månader. En intention-to-treat och en per-protokoll analys utfördes.

Resultat: Individuella och strukturella faktorer associerade med icke-deltagande i träningsbaserad hjärtrehabilitering i en svensk kontext var ett avstånd längre än 16 km till sjukhuset, att tillhöra ett länssjukhus, ha en högre grad av komorbiditet, vara av manligt kön samt att vara pensionär. Följsamheten till träningsprogrammet var bättre för de patienter som erhöll en beteendemedicinsk intervention i tillägg till sedvanlig träningsbaserad hjärtrehabilitering (31%) jämfört med de som enbart erhöll sedvanlig träningsbaserad hjärtrehabilitering (19%). Utfallsmåtten skilde sig inte signifikant mellan de två grupperna, varken mellan baslinjen och fyra månader eller mellan fyra och 12 månader. Båda grupperna förbättrades dock signifikant i samtliga utfallsmått för fysisk kapacitet, ångest samt i flera mått av hälsorelaterad livskvalitet mellan baslinjen och fyra månader. Patienterna i båda grupperna uppvisade en kvarstående förmåga att förstå och hantera sin sjukdom (enablement) vid 12 månaders-uppföljningen.

Konklusion: Avstånd till sjukhuset var den starkaste prediktorn för icke-deltagande i träningsbaserad hjärtrehabilitering. Individuella faktorer som associerades med icke-deltagande i en svensk kontext var i linje med resultat från tidigare studier, med undantaget att kvinnligt kön var associerat med högre deltagande i träningsbaserad hjärtrehabilitering. Resultaten av denna avhandling bekräftar tidigare rapporterade utmaningar med att lyckas uppnå beteendeförändringar hos patienter i syfte att förbättra rehabiliteringsutfall. Trots att följsamheten var bättre med ett tillägg av en beteendemedicinsk intervention, så var den låg i båda grupperna. Den aktuella beteendemedicinska interventionen gav inget mervärde avseende effekter av fysisk kapacitet, psykologiska utfallsmått och hälsorelaterad livskvalitet jämfört med enbart sedvanlig träningsbaserad hjärtrehabilitering. Således finns det fortfarande utrymme för vidareutveckling och utvärdering av beteendemedicinska interventioner inom ramen för träningsbaserad hjärtrehabilitering. En större anpassning av dessa interventioner utifrån individuella behov i en bredare population av patienter med kranskärslsjukdom föreslås.

LIST OF PAPERS

- I. **Sabina Borg**, Birgitta Öberg, Margret Leosdottir, Daniel Lindholm, Lennart Nilsson, Maria Bäck. Factors associated with non-attendance at exercise-based cardiac rehabilitation. *BMC Sports Sci Med Rehabil* 2019; 11: 13.
- II. **Sabina Borg**, Birgitta Öberg, Lennart Nilsson, Anne Söderlund, Maria Bäck. The added value of a behavioural medicine intervention in physiotherapy on adherence and physical fitness in exercise-based cardiac rehabilitation (ECRA): A randomised controlled trial. *Patient Prefer Adherence* 2020; 14: 2517-2529.
- III. **Sabina Borg**, Birgitta Öberg, Lennart Nilsson, Joakim Alfredsson, Anne Söderlund, Maria Bäck. The added value of a behavioural medicine intervention in physiotherapy on secondary psychological outcomes and health-related quality of life in exercise-based cardiac rehabilitation (ECRA): A randomised controlled trial. In manuscript.

DESCRIPTION OF CONTRIBUTIONS

Paper I

Study design:	Sabina Borg , Birgitta Öberg, Lennart Nilsson, Maria Bäck
Data collection:	Registry data
Data analysis and interpretation:	Sabina Borg , Birgitta Öberg, Margret Leosdottir, Daniel Lindholm, Lennart Nilsson, Maria Bäck
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ABBREVIATIONS

ACE	Angiotensin-converting enzyme
ACS	Acute coronary syndrome
ARB	Angiotensin receptor blocker
ASA	Acetylsalicylic acid
BCT	Behaviour change technique
BHW PA	Board of Health and Welfare physical activity
BMI	Body mass index
BMIP	Behavioural medicine intervention in physiotherapy
CABG	Coronary artery bypass graft
CAD	Coronary artery disease
CI	Confidence interval
CR	Cardiac rehabilitation
CR-10	Category ratio scale
CT	Control theory
EF	Ejection fraction
EQ-5D	EuroQol 5 dimensions
ExCR	Exercise-based cardiac rehabilitation
FITT	Frequency, Intensity, Time and Type of exercise
HADS	Hospital Anxiety and Depression Scale
HADS-A	Anxiety subscale of HADS
HADS-D	Depression subscale of HADS
HRQoL	Health-related quality of life
IQR	Interquartile range
MI	Myocardial infarction
NSTEMI	Non-ST-elevation myocardial infarction
OR	Odds ratio
PCI	Percutaneous coronary intervention
PEI	Patient Enablement Instrument
RC	Routine care

RCT	Randomised controlled trial
RIKS-HIA	Register of Information and Knowledge about Swedish Heart Intensive Care Admissions
RPE	Rating of Perceived Exertion
SCT	Social cognitive theory
SD	Standard deviation
SEE	Self-Efficacy for Exercise Scale
SEPHIA	Secondary Prevention After Intensive Heart Care Unit
SF-36	Short-Form 36
SF-36; BP	Bodily pain
SF-36; GH	General health
SF-36; MCS	Mental component score
SF-36; MH	Mental health
SF-36; PCS	Physical component score
SF-36; PF	Physical functioning
SF-36; RE	Role limitations due to emotional problems
SF-36; RP	Role limitations due to physical problems
SF-36; SF	Social functioning
SF-36; VT	Vitality
STEMI	ST-elevation myocardial infarction
SWEDEHEART	Swedish Web-system for Enhancement and Development of Evidence-based care in Heart disease Evaluated According to Recommended Therapies
VAS	Visual analogue scale
VO _{2max}	Maximal oxygen uptake
VO _{2peak}	Peak oxygen uptake

BACKGROUND

Coronary artery disease

Coronary artery disease (CAD), including myocardial infarction (MI), is the leading cause of death globally and accounts for 16% of the world's total deaths¹. In 2017, approximately 35 million individuals across Europe were living with CAD and 3.6 million new cases of CAD were reported². In Sweden, around 24,300 individuals suffered an MI in 2019. The incidence of MI increases considerably with age, and is more common in men than in women, with men accounting for about 63% of all incidental cases of MI in Sweden. Men also tend to suffer an MI earlier in life than women³. In recent decades, mortality rates of CAD have steadily decreased, mainly attributed to improved acute cardiac care and reductions in cardiovascular risk factors^{4, 5}. This means that the number of individuals in need of secondary prevention is gradually increasing.

CAD is usually caused by atherosclerosis, characterised by remodelling and atherosclerotic plaque accumulation in the coronary arteries, which supply blood to the myocardium⁶. Symptoms of myocardial ischemia classically appear, or become more severe, with increased levels of physical exertion, and disappear within a few minutes as these causal factors diminish (stable angina pectoris)⁷. Acute coronary syndrome (ACS) is defined as follows: atherosclerosis and thrombosis with disruption of flow in the coronary artery, and ischemia in the myocardium. A ruptured atherosclerotic plaque, in which thrombosis does not produce complete occlusion of the artery, may result in unstable angina pectoris or a non-ST-elevation myocardial infarction (NSTEMI). An acute complete occlusion of the artery leads to an ST-elevation myocardial infarction (STEMI). The term "ACS" encompasses the diagnosis of unstable angina, NSTEMI and STEMI⁶. In addition to these categories, MI can be classified into various types, in which atherosclerotic plaque disruption with thrombosis is designated as a type 1 MI⁸. Percutaneous coronary intervention (PCI) and coronary artery bypass grafts (CABG) are reperfusion strategies used in patients with CAD, of which PCI is the most frequently used⁹.

Cardiovascular risk factors

The development and progression of atherosclerosis are related to genetic and environmental factors⁶. Cardiovascular risk factors can be classified into modifiable and non-modifiable risk factors. Non-modifiable risk factors include age, gender, ethnicity, and a family history of CAD. The risk of CAD increases with age, and is higher in men than in women¹⁰. The following nine potentially modifiable risk factors explain more than 90% of

the risk of experiencing an MI: abnormal lipids, smoking, hypertension, diabetes, abdominal obesity, psychosocial factors, regular alcohol use, low daily consumption of fruits and vegetables, and low physical activity. The effect of these risk factors is similar in men and women, at all ages and across different regions of the world¹¹.

Cardiac rehabilitation

The secondary prevention of CAD is administered through cardiac rehabilitation¹². Cardiac rehabilitation (CR) is a comprehensive intervention whose core components are defined as a *“specific area of intervention in the context of multifaceted and multidisciplinary structured cardiac rehabilitation activities, aimed (per se or in association to other areas) at obtaining clinical stabilization, cardiovascular risk reduction, disability reduction, psychosocial and vocational support, and lifestyle behaviour change including patients’ adherence and self-management”*¹². Core components of CR include baseline patient assessment, risk factor management, physical activity counselling, prescription of exercise, nutritional counselling, and psychosocial management/interventions^{12, 13}. The evaluation of outcome parameters and the establishment of structured follow-up at the end of the programme should also be considered as core components of a modern CR intervention¹². CR typically consists of three phases, and should ideally begin during in-hospital stay (phase 1), proceed after discharge to the early ambulatory (out-patient) phase (phase 2), and be maintained for life (phase 3) in a continuum process¹⁴. The core components of CR are routinely delivered during phase 2 of CR¹².

The delivery of a comprehensive CR programme is essential to ensure favourable outcomes and expected cost-effectiveness¹², but such programmes are currently widely underused¹⁵. In Sweden, the overall quality of CR programme characteristics and their performance against standards recommended by European Guidelines on Cardiovascular Disease Prevention is high¹⁶. However, secondary prevention measures are still an area with scope for improvement^{17, 18}, especially in variables associated with lifestyle changes^{18, 19}.

Exercise-based cardiac rehabilitation

Exercise-based cardiac rehabilitation (exCR) as part of the secondary prevention of CAD is highly recommended (class I level of evidence A) in the international guidelines published by the European Society of Cardiology²⁰ and the American Heart Association¹³, and in Swedish guidelines from the National Board of Health and Welfare (priority 2)²¹. ExCR is therefore often identified as a central component in CR²².

Definitions of exercise, physical activity, and physical fitness

Exercise, physical activity, and physical fitness are closely related constructs, but it is important to note that they are distinct²³.

- Physical activity is defined as *“any bodily movement produced by skeletal muscles that results in energy expenditure”*²⁴.
- Exercise is defined as *“a subset of physical activity that is planned, structured, and repetitive and has a final or an intermediate objective, the improvement or maintenance of physical fitness”*²⁴.
- Physical fitness is defined as *“a set of attributes that are either health- or skill-related”*²⁴, that relates to the ability to perform physical activity. The health-related components of physical fitness comprise cardiorespiratory endurance, muscle endurance, muscular strength, body composition and flexibility. Skill-related components of physical fitness are agility, balance, coordination, power, reaction time and speed. The degree to which individuals have or achieve these attributes can be measured with specific tests²⁴.

Pre-exercise screening

The exCR programme should be individually prescribed after a careful clinical evaluation that includes risk stratification, behavioural characteristics, personal goals and exercise preferences^{12, 13}. A pre-exercise screening that includes such components as clinical history, investigation of symptoms, cardiovascular risk factor profile, level of previous physical activity, current fitness level and monitoring of electrocardiogram, heart rate and blood pressure at rest and during tests of physical fitness, is, therefore, required before the start of an exCR programme^{12, 20}. ExCR should be delivered as part of a multifaceted and multidisciplinary structured CR programme, led by a cardiologist¹². The physiotherapist plays an important role in the CR team when it comes to performing tests of physical fitness and prescribing individually tailored exercise programmes.

Recommendations for exCR

International guidelines have established recommendations for exCR in patients with CAD (Table 1)^{12, 13}. Exercise should be prescribed according to the FITT (frequency, intensity, time (duration) and type of exercise) principle^{12, 13, 20}, and should include progressive updates to the exercise prescription¹³. In routine exCR care in Sweden, patients do not perform maximal cardiopulmonary exercise testing, but a submaximal aerobic exercise test on a bicycle ergometer, before starting an exCR programme²⁵⁻²⁷. Intensity cannot, therefore, be specified based on a percentage of $\text{VO}_{2\text{max/peak}}$ or maximum/peak heart rate. Instead, Borg's rating of

perceived exertion scale (RPE)²⁸, is used to prescribe exercise intensity, showing established relationships between a percentage of $\text{VO}_{2\text{max/peak}}$, or maximum/peak heart rate and Borg RPE²⁹. A load-repetition relationship, such as a 10-RM (repetition maximum) test, complemented with Borg RPE, can be used to determine exercise intensity during resistance exercise³⁰.

Table 1. Exercise-based cardiac rehabilitation recommendations in CAD^{12, 13}

	Aerobic exercise	Resistance exercise
Frequency	3-5 days/week	2-3 days/week
Intensity	(40%) 50-85% of $\text{VO}_{2\text{max}}$ (12) 13-17 on Borg RPE	10-15 repetitions per set 40-80% of 1 RM
Time	20-60 minutes	1-3 sets of 8-10 different upper and lower body exercises
Type	Interval or continuous walking, running, cycling, swimming, etc.	Body weight, elastic bands, free weights, weight machines, etc.
Each session should include warm-up and cool-down		
Aerobic and resistance exercise can be combined at the same exercise session		

RPE, rating of perceived exertion; RM, repetition maximum; $\text{VO}_{2\text{max}}$, maximum oxygen uptake.

Four general exercise principles should be considered when conducting an exCR programme, to optimise its effects. The principle of *individuality* means that not all individuals respond similarly to a given exercise stimulus. For this reason, exercise programmes must be designed to meet individual needs. The principle of *specificity* states that exercise adaptations are specific to the type, intensity, and duration of the exercise. The performed exercise should therefore be relevant and appropriate for the type of activity the individual wants to improve. The principle of *overload* means to systematically increase the demands on the body to obtain continued improvement. The principle of *reversibility* states that reversibility of exercise effects will occur if exercise is decreased or discontinued²⁹.

Exercise recommendations for patients with CAD should be supplemented with recommendations for physical activity in daily life and a reduction in time spent being sedentary, as specified by public health recommendations for adults^{12, 13, 20, 31}. For individuals over the age of 65 years, balance exercise is also recommended. Older adults or individuals with chronic illness, unable to reach the public health recommendations for adults, should be as active as the condition allows³¹.

ExCR should be started as soon as possible after an index event of MI or PCI, and should include at least 24 sessions¹⁴, and cover an exercise period of at least 3 months. ExCR has beneficial effects on the left ventricular remodelling in patients post-MI, with greatest benefits occurring when the programme starts early (from one week) after the MI and lasts longer than 3 months³².

ExCR setting

The exCR programme is traditionally performed in a supervised, hospital-based setting¹⁴ supported by international guidelines^{12, 13}. During supervised exCR, individual responses, tolerability and clinical stability are verified, and signs and symptoms that suggest that the programme should be modified or terminated can be promptly identified¹². In routine exCR care in Sweden, hospital-based exCR is usually offered 2 days/week for 3 months, under the guidance of a physiotherapist. Each session includes a combination of aerobic and resistance exercises. To fulfil the recommendation of at least three aerobic exercise sessions/week, patients are instructed to perform one additional home-based aerobic exercise session/week. Home-based exCR programmes³³ lack supervision during exercise and the safety aspects that a hospital-based setting entails, but may be considered as an alternative model for low-risk patients who are not able or not willing to participate in a hospital-based setting.

Effects of exercise-based cardiac rehabilitation

Meta-analyses clearly confirm the positive health benefits of exCR in terms of reduced cardiovascular mortality (26%) and a reduced risk of hospital re-admission (18%) in patients with CAD³⁴. In addition, exCR has beneficial effects on modifiable cardiovascular risk factors such as smoking, body weight, blood pressure, and lipid profile³⁵, as well as on aerobic exercise capacity³⁶. Improving aerobic exercise capacity is an important outcome in exCR as it is a strong predictor of reduced mortality in patients with CAD. A small exercise-induced gain can have positive impacts on both functional capacity and survival prospects^{37, 38}, and aerobic and resistance exercise should be combined in order to achieve the best effects on overall risk reduction and cardiovascular fitness^{39, 40}.

ExCR may also have favourable effects on psychological well-being including the health-related quality of life (HRQoL)^{41, 42}, and anxiety and depression⁴³. These effects have been measured by patient-reported outcome measures, which serve as a valuable tool for collecting patient-centred data⁴⁴. This is important, since depression and anxiety are common in patients post-MI^{45, 46}, and are associated with an increased risk of mortality^{45, 47} and a reduced HRQoL⁴⁸. However, there is a heterogeneity among studies that have evaluated the effects on psychological well-being, and patient-reported outcome measures have been less studied in exCR than clinical outcomes, such as survival, disease, and physiological markers.

Exercise maintenance

Phase 2 CR plays an important role in ensuring that patients achieve risk factor targets and adopt a healthy lifestyle, but this must be maintained for patient outcomes to be optimised⁴⁹. Given that aerobic exercise capacity is a strong predictor of mortality in patients with CAD^{37, 38}, it is of great importance that patients preserve the effects of phase 2 exCR on physical fitness and maintain a regular exercise programme as time passes. Phase 3 CR includes the maintenance of the healthy lifestyle behaviours achieved in the previous phases, particularly exercise⁵⁰. Few trials have evaluated the effects of maintenance CR on secondary preventive outcomes in patients with CAD⁴⁹, and there is a heterogeneity among different interventions in terms of setting, exercise prescription and comprehensiveness^{49, 50}.

Attendance at and adherence to exCR

Despite well-established positive effects and the highest possible recommendation in international guidelines, attendance at and adherence to exCR in patients with CAD remains a matter of concern. The proportion of patients who attend CR programmes has been relatively constant over the past decades⁵¹. In Sweden in 2019, the proportion of referred patients who successfully completed a hospital-based exCR programme during the first year after an MI was only 19%. This number was unchanged from previous years¹⁹. Furthermore, fewer than 50% maintain a long-term exercise regimen after completion of the exCR programme^{52, 53}, and only 16% of European patients with CAD performed vigorous exercise for longer than 20 minutes, at least three times/week, one year after the CAD event¹⁸.

Factors associated with non-attendance at exCR

Attendance can relate to the act of being present (in this case attend exCR) or it can be related to the frequency with which a person is present (i.e. the number or the percentage of sessions attended)⁵⁴. The proportion of patients being referred to CR programmes, and thus being offered the opportunity to attend, differs between countries. Only half of European patients with CAD are referred, and a minority attend a CR-programme¹⁵. In Sweden, the CR uptake is high, with about 80% of patients with MI younger than 80 years being referred to CR^{19, 55}.

Systematic reviews confirm that several factors affect attendance at CR programmes, including exCR^{56, 57}. These factors can be classified as inherent to the patient or related to the accessibility of CR⁵⁶. Associated factors such as CR programme factors have also recently been reported⁵⁷. Many of these factors appear to be similar between different countries, although patterns of attendance may also differ due to differences in contextual aspects⁵⁶. Factors associated with non-attendance at exCR can

be divided into six main categories: intrapersonal factors, clinical factors, interpersonal factors, logistical factors, CR programme factors and health system factors⁵⁷. Examples of factors under each category are presented in Table 2.

Table 2. Factors associated with non-attendance at CR programmes⁵⁷

Intrapersonal factors	Older age, female gender, low socioeconomic status, comorbid conditions, ethnicity, anxiety/depressive symptoms.
Clinical factors	Smoking, higher body mass index, poor functional capacity, physical inactivity, risk factor profile.
Interpersonal factors	Single/no partner, unemployed or retired, low practical and social support.
Logistical factors	Transportation issues, long distance and travel time to the CR centre.
CR programme factors	Not having participated previously in a CR programme when referred.
Health system factors	Lack of referral and low strength of endorsement from physicians.

CR, cardiac rehabilitation.

Adherence

Definition

The World Health Organization introduced the term “adherence” and defined it as *“the extent to which a person’s behaviour – taking medication, following a diet and/or executing lifestyle changes, corresponds with agreed recommendations from a health care provider”*⁵⁸. The term “adherence” reflects a partnership between the healthcare provider and the patient⁵⁹, and is based on the patient agreeing with the prescribed recommendations, rather than passively obeying⁵⁸. By building up this partnership over time, the provider learns the patient’s unique characteristics and needs, allowing better tailoring of the treatment⁵⁹. Within physiotherapy, the construct of adherence can relate to attendance at appointments, following advice, or undertaking prescribed exercises⁶⁰. The definition of adherence used in this thesis includes consideration of exercise dose, and reads *“the extent to which a patient acts in accordance with the agreed (original stated as ‘advised’) interval, exercise dose and exercise dosing regimen”*⁶¹.

Adherence must be distinguished from the related constructs “compliance” and “concordance”, both of which have their own definitions. Compliance is defined as *“the extent to which the patient’s behaviour matches the prescriber’s recommendations”*⁶². This term has been criticised for its paternalistic attitude towards the patient, implying that the caregiver decides on the treatment and issues an order that is followed by the patient.

Adherence develops the definition of compliance by emphasising the need for patient agreement. The less widely used construct concordance is a complex and less clearly defined term, relating to the process (e.g. partnership) and outcomes (agreement or shared decision-making)⁶². The term adherence was chosen for this thesis as it corresponds to the term that is preferred from a behavioural perspective.

Strategies to increase uptake of and adherence to exCR

A recent Cochrane Review by Santiago et al.⁶³ reported low-quality evidence of the effects of interventions that aim to increase uptake of and adherence to exCR. The ability to determine the consistency of findings was limited due to the heterogeneity of the interventions used. Subgroup analysis revealed better effects on adherence when offered remotely, but the reliability of these findings is limited by few studies and small study samples. Interventions to increase enrolment were most effective if delivered face-to-face by healthcare providers⁶³.

Given the low rates of adherence to exCR, it is clear that routine exCR programmes are not sufficiently effective in promoting adherence on their own⁶⁴. It has been suggested that the evaluation of adherence levels, screening for non-adherence, and promoting adherence to secondary prevention therapies should be included in the core components of a modern CR programme¹². Tailoring the exCR programme to the patients' preferences and the integration of the patients' perspectives may help to increase uptake and adherence¹². The use of behaviour change techniques has shown promising results in increasing physical activity in healthy adults⁶⁵. The addition of behaviour change techniques to routine exCR care may be a strategy to positively increase adherence⁶⁶ and improve exercise behaviour in patients with CAD^{64, 67}.

Behavioural medicine

The biopsychosocial model includes biological, psychological and social dimensions of illness⁶⁸. Behavioural medicine is based on the biopsychosocial model and can be defined as *“the interdisciplinary field concerned with the development and integration of psychosocial, behavioural and biomedical knowledge relevant to health and illness and the application of this knowledge to prevention, etiology, diagnosis, treatment and rehabilitation”*⁶⁹.

When a physiotherapist applies a behavioural medicine perspective, he or she works systematically with the patient to support a behavioural change by integrating both biomedical factors, cognitive factors and the social and/or physical environment⁷⁰. Tailored behavioural medicine interventions within the context of physiotherapy are effective in, for

example, adults with musculoskeletal pain^{71, 72}, and may improve levels of physical activity and self-efficacy for exercise in older women⁷³.

Health behaviour change theories

A multitude of theoretical frameworks and models for understanding and changing health behaviour are available. The social cognitive theory (SCT), the transtheoretical model, and the health belief model are common theories of health behaviour and health behaviour change. Different theoretical models of health behaviour may reflect the same general ideas, but each theory employs a unique vocabulary to describe the specific factors considered important. The choice of a suitable theory should include identification of the problem, goal, and units of practice⁷⁴.

In this thesis, the control theory (CT), which is part of the SCT, was used as a theoretical framework to support the use of methods to increase self-efficacy for adherence to exCR. These theories are described below.

Social cognitive theory

The SCT is based on a model, known as reciprocal determinism, in which behaviour, personal and socioenvironmental factors all interact⁷⁴. The core constructs include *knowledge* of health risks and the benefits of different health practices, *perceived self-efficacy*, i.e. the confidence to engage in a behaviour, *outcome expectations* for the expected positive or negative consequences of various health habits, *goals* that individuals set for themselves, including concrete plans and strategies for realising them, and the *perceived facilitators/barriers* to the behavioural changes they try to achieve⁷⁵.

Self-efficacy plays a central role in behaviour change and affects health behaviour both directly and indirectly, by influencing other constructs⁷⁵. Self-efficacy is defined as “*the perceived capability to perform a target behaviour*”, and is affected by four major sources of information: mastery experience, vicarious experience, verbal persuasion, and physiological and emotional states⁷⁶. Mastery experience relate to performance outcomes: they are improved by repeated success and undermined by repeated failures. Vicarious experience can be described as observational learning, while verbal persuasion is the process in which people are led, through communicative influence, into believing they can perform a task successfully. Physiological and emotional states can affect one’s perceived self-efficacy for coping with various situations⁷⁶.

According to the SCT, human behaviour is extensively motivated and regulated by the ongoing exercise of self-influence. Self-regulation operates through three subfunctions: self-monitoring of one’s behaviour, its determinants, and its effects; judgement of one’s behaviour in relation to personal standards and environmental circumstances; and self-reaction,

which provides the mechanism by which standards regulate courses of action. Self-efficacy belief is an important construct for self-regulation and can partly determine how the various subfunctions operate⁷⁷.

Control theory

The control theory is part of the SCT and states that the process of self-regulation involves the self-imposition of behavioural standards, observation of one's own actions, and evaluation of these actions by comparing them with the standards⁷⁸. According to the CT, the perception of the sensing of a present condition (input function) is compared against a standard or goal (reference value) via a comparator. If a discrepancy is perceived between the input function and the reference value, a behaviour (output function), intended to reduce the discrepancy, is performed. The discrepancy is not reduced by the behaviour directly, but by having an impact on the environment. Such an impact leads to a change in the present condition and a different perception, which in turn is compared again against the reference value. Thus, a negative feedback loop is formed that minimises the deviation from the reference value. The present state can be influenced also by factors from outside the system (disturbances)⁷⁸. Figure 1 illustrates the negative feedback loop.

Figure 1. The negative feedback loop in CT*

* Carver, C. S. and Scheier, M. F. (1982). Control theory: A useful conceptual framework for personality-social, clinical, and health psychology. *Psychological Bulletin*, 92(1), 111–135. <https://doi.org/10.1037/0033-2909.92.1.111> Copyright © 1982. Reproduced with permission.

Behaviour change techniques

Interventions to change behaviour are typically complex and contain many interacting components, including behaviour change techniques (BCTs)⁷⁹. BCTs are defined as “*observable, replicable, and irreducible components of an intervention designed to change behaviour*” (i.e., a technique is

proposed to be a potentially “active ingredient”)⁷⁹. A taxonomy of 93 clearly defined BCTs has been developed by Michie et al.⁷⁹, to provide a standardised method of classifying the detailed content of a wide range of behaviour change interventions⁷⁹. CT includes the following BCTs: prompt specific goal-setting, prompt review of behaviour goals, prompt self-monitoring of behaviour, and the provision of feedback on performance⁸⁰. Interventions using combinations of self-monitoring and other self-regulation BCTs derived from the CT are more effective in increasing physical activity in healthy adults than interventions that do not include these techniques⁶⁵. Furthermore, interventions that emphasise the BCTs self-monitoring, specific goal-setting and feedback, delivered either during or after completion of exCR, are most frequently associated with positive physical activity outcomes^{64, 67}. Goal-setting and providing information are among the most commonly used BCTs in CR⁸¹, while social support and goal setting are frequently used BCTs in home-based CR programmes⁸².

Several behaviour change components intended to increase adherence to exCR programmes and improve their physical and psychological outcomes have been used in a limited number of studies^{63, 64, 83-85}. Lynggaard et al.⁸³, for example, found that adding learning and coping strategies to a short eight-week CR-programme improved adherence to exercise and education from that seen with routine CR alone⁸³. An intervention based on action planning and coping planning enhanced self-reported exercise and adherence in patients with CAD in a study by Sniehotta et al.⁸⁴. Focht et al.⁸⁵ reported favourable improvements in HRQoL in a group-mediated cognitive behavioural physical activity intervention group in men and in women, and in men in a routine exCR group, compared with women in the routine exCR group⁸⁵.

Self-regulatory BCTs, such as those included in the CT, have been positively associated with levels of physical activity in both healthy adults⁶⁵ and patients with CAD^{64, 67}. However, previously reported studies have referred to levels of physical activity, and it is unclear whether different BCTs have measurable effects also on objective outcome measures of physical fitness in patients with CAD. Furthermore, previous studies suffer from limitations, such as small study samples^{64, 67}, a lack of long-term follow-up^{83, 84}, the use of self-reported outcomes of physical activity/exercise⁸⁴, and a lack of a clear description of the components included in the behavioural medicine interventions⁶⁴. Consequently, further high-quality research in this field is needed.

Rationale of the thesis

Despite the undisputable positive effects of exCR, attendance and adherence remain suboptimal. Previous research in healthy adults and in patients with CAD has shown that behavioural change components appear to enhance exercise adherence and have a positive impact on physical and psychological outcomes. Knowledge about the added value of behavioural medicine interventions in physiotherapy within the context of exCR is, however, limited. The use of such an intervention will add valuable information about its effect on exercise adherence, physical fitness, psychological outcomes and HRQoL. This information will be important in determining how to support and improve the secondary prevention of patients with CAD.

Further, there is a need to increase the understanding of individual and structural factors associated with non-attendance at exCR in a Swedish context. Previous research has identified a large number of factors associated with non-attendance at exCR in other countries. Patterns of attendance may, however, differ between countries due to different attitudes and perceptions regarding exCR programmes, and possible differences in accessibility, the distribution of comorbidities, and patient-referral routines. Such knowledge will be important when developing and designing future interventions that promote increased attendance at exCR programmes.

AIMS OF THE THESIS

Overall aim

The overall aim of this thesis was to investigate barriers for exCR attendance and to evaluate the added value of a behavioural medicine intervention in physiotherapy on exercise adherence and rehabilitation outcomes in patients with CAD.

Specific aims

- To identify factors associated with non-attendance at exCR in a large Swedish cohort.
- To investigate the added value of a behavioural medicine intervention in exCR on exercise adherence compared with routine exCR care only.
- To investigate the effects of a behavioural medicine intervention added to routine exCR care on physical fitness, psychological outcomes and HRQoL, compared with routine exCR care only.

METHODS

Overview of the studies

The three papers in this thesis are based on two studies. Table 3 presents an overview of the two studies (A and B) and the three papers (I-III).

Table 3. Overview of the two studies (A and B) and the three papers (I-III)

	Study A	Study B	
	Paper I	Paper II	Paper III
Design	Retrospective, registry-based cohort study	Randomised controlled trial	
Aim	Identify factors associated with non-attendance at exercise-based cardiac rehabilitation (exCR) in patients post-myocardial infarction (MI) in a large Swedish cohort.	Investigate the added value of a behavioural medicine intervention in routine exCR care on adherence and the primary outcome (physical fitness) compared with routine exCR care only.	Investigate the added value of a behavioural medicine intervention in routine exCR care on secondary psychological outcomes and health-related quality of life compared with routine exCR care only.
Participants	31,297 patients post-MI included from the SWEDEHEART registry from the years 2010-2016.	170 patients post-MI and/or percutaneous coronary intervention consecutively included at a Swedish university hospital between January 2016 and October 2018.	
Methods	Examining differences in individual variables and structural variables between attenders and non-attenders to exCR.	Examining the effect of a 4-month behavioural medicine intervention in exCR, in addition to routine exCR care alone. Outcome assessment at baseline, 4 months and 12 months	
Variables	Individual variables: demographics, body mass index, occupational status, smoking, previous diseases, index event and intervention, left ventricular function, medication. Structural variables: type of hospital, distance to hospital.	Submaximal aerobic exercise capacity, exercise adherence, muscle endurance and self-reported physical activity and physical capacity.	Health-related quality of life, anxiety and depression, patient enablement and self-efficacy.
Data analysis	Descriptive statistics, independent samples t-test, Wilcoxon test, chi-squared test, multivariable analysis in a logistic regression model.	Descriptive statistics. Intention-to-treat and per-protocol analysis. Independent samples t-test, paired t-test.	
Ethical approval	Ethical approval granted; 2015/209-31.	Ethical approval granted; 2015/209-31 with amendment: 2018/383-32. Trial registration number: NCT02895451	

Designs and settings

Study A was a retrospective, registry-based cohort study based on national data from the Swedish Web-system for Enhancement and Development of Evidence-based care in Heart disease Evaluated According to Recommended Therapies (SWEDEHEART).

Study B was an open-label randomised controlled trial, entitled “Exercise-based Cardiac Rehabilitation Adherence, ECRA”, carried out at the coronary care unit at Linköping University Hospital in Sweden.

Participants and data collection

Study A – Paper I

Study A used data from the sections Register of Information and Knowledge about Swedish Heart Intensive Care Admissions (RIKS-HIA), and Secondary Prevention After Intensive Heart Care Unit (SEPHIA), within the SWEDEHEART registry⁵⁵. The inclusion criteria were: individuals registered in RIKS-HIA and included in SEPHIA, with an index diagnosis of type 1 MI, aged between 18 and 74 years, and alive 2 months post-MI. SEPHIA includes post-MI patients younger than 80 years (since 1 January 2018). At the time for data collection in Study A, SEPHIA comprised patients younger than 75 years. Data were collected from two follow-up visits during the first year after the MI, at 6-10 weeks post-MI (Visit 1) and 12-14 months post-MI (Visit 2)^{19, 55}. For patients included in Study A, follow-up Visits 1 and 2 had occurred between 1 January 2010 and 31 December 2016. Out of 43,689 eligible patients, 31,297, were included. Figure 2 shows further details.

The SWEDEHEART registry

The SWEDEHEART registry contains data from a unique CR cohort of patients who have suffered an MI: it is the largest such registry and has extensive national representability¹⁹. The purpose of SWEDEHEART is to support evidence-based developments of therapy in cardiac care, and to register changes in the quality and content of patient care over time. The coverage of the registry is high: SEPHIA and RIKS-HIA collect information from all Swedish hospitals. The SWEDEHEART registry consists of several sections, one of which is the RIKS-HIA, which focuses on the acute care of patients who have undergone an MI. Data registered in RIKS-HIA are collected by healthcare providers during hospitalisation. Another section of SWEDEHEART is SEPHIA, in which more than 8,600 new patients with MI are registered every year. SEPHIA describes the quality of secondary preventive care and CR during the first year after an MI, including such

information as participation in exercise programmes, treatment goal fulfilment, and cardiovascular and psychological status^{19, 55, 86}.

Figure 2. Flowchart of study participants in Study A

Study B – Papers II and III

Physiotherapists at the coronary care unit received daily information about patients eligible for inclusion in the study through medical records and asked potential patients about participation.

The inclusion criteria were:

- An index event due to type 1 MI and/or PCI
- Age ≥ 18 years and < 75 years

The exclusion criteria were:

- Serious physical or mental health issues that would interfere with participation in exCR
- An inability to understand the Swedish language

Four hundred and fifty-three patients were consecutively screened for study inclusion between January 2016 and October 2018, and 170 patients were included. Figure 3 presents the study flowchart.

Baseline testing, performed by the physiotherapist responsible for the testing procedure, took place two to three weeks after discharge. After completed baseline tests, the patients were randomised 1:1 to one of the two groups, using sealed envelopes. Randomisation was stratified by submaximal aerobic work capacity with a cut-off at 100 watts, based on previous clinical data from a similar exCR setting and clinical experience from the present exCR setting. Patients were not informed of the group to which they had been allocated, but organisational reasons meant that the physiotherapists were not blinded to the intervention given. Three physiotherapists were involved in the testing procedure, and one physiotherapist, not involved in the testing procedure, was responsible for the behavioural medicine intervention.

Figure 3. Flowchart of study participants in Study B

Measurements

Study A – Paper I

In Study A, attendance at exCR was defined by the variable “participation in an exercise training programme”, registered in SEPHIA through patient interview or review of medical records by a nurse at Visit 2. The design of the variable was based on evidence of exercise recommendations for patients with CAD, and includes hospital-based exCR under the guidance of a physiotherapist, 2 times/week for at least 3 months. The variable contains three different categories: “no”, “yes <3 months” and “yes ≥3 months”. To register “yes ≥3 months”, the patient must have completed at least 75% of the recommended 24 exercise sessions over a period of 4 months⁸⁷. This definition was established in 2018 and was a clarification from earlier description of this variable. In Study A, the variable was dichotomised into “attenders” (yes <3 months and yes ≥3 months), and “non-attenders” (no).

Table 4 presents an overview of the variables included in Study A, Paper I. The following individual variables, self-reported or retrieved from medical records, were obtained from the RIKS-HIA registry at hospital admission or discharge.

Demographic variables

Age (years), sex (male/female).

Body mass index

Body mass index (BMI), calculated as the weight in kilograms divided by the height in metres squared (kg/m²).

Occupational status

The variable contained four different categories: employed, retired, on sick leave, and unemployed/student/other.

Smoking

The variable was classified as: never smoked, former smoker (duration longer than 1 month), and current smoker.

Previous diseases

Previous diseases were defined as having a history of CAD (MI, PCI or CABG), diabetes, hypertension, chronic heart failure or stroke.

Index event and intervention

The definition of the index event was based on the type of myocardial infarction: ST-elevation myocardial infarction (STEMI) or non-ST-elevation myocardial infarction (NSTEMI). Type of intervention was defined as PCI or CABG.

Left ventricular function

Left ventricular function was classified as: normal (ejection fraction (EF) >50%), slightly reduced (EF 40-49%) and moderate/severely reduced (EF <40%).

Medication

Prescribed MI medication included: angiotensin-converting enzyme (ACE), angiotensin receptor blocker (ARB), acetylsalicylic acid (ASA), antiplatelets and anticoagulants, beta-blockers and statins.

Study A also included two structural variables:

Type of hospital

The structural variable “type of hospital” was formed by categorising data of all registered hospitals at Visit 2 into three groups: university hospital, county hospital or district hospital.

Distance to hospital

Driving distance to the hospital was estimated for the patients using a custom interface to the OpenStreetMap Routing Machine. The centroid of each individual patient’s postal code area served as a proxy for their address, from which the route to the nearest hospital was calculated⁸⁸.

Table 4. Overview of variables in Study A

Individual variables	Structural variables
Demographic variables	Type of hospital
Body mass index	Distance to hospital
Occupational status	
Smoking	
Previous diseases	
Index event and intervention	
Left ventricular function	

Study B – Papers II and III

Demographic and clinical patient characteristics in Study B were collected from medical records and patient interviews. Table 5 presents an overview of the variables and the measurements used in Study B, Paper II and III. Paper II focused on variables of physical fitness and exercise adherence, and Paper III focused on psychological variables and HRQoL.

Exercise adherence

Exercise adherence was defined in Study B as achieving at least 75% of the recommended exercise dose according to exCR guidelines^{12, 13}. This definition is in line with those used in both European position statement recommendations¹⁴ and the SWEDEHEART registry^{19, 55}. In the present study, exercise adherence was a composite variable based on calculations

from medical records (hospital-based setting) and exercise diaries (home-based setting) at the end of the four-month intervention.

Outcome assessment

Outcome assessment included the variables listed below and took place at baseline, four and 12 months, apart from the self-rated physical capacity described in Paper II and patient enablement described in Paper III, which were only measured at four and 12 months.

Submaximal aerobic exercise capacity

The primary outcome in Study B was change in watts (W) achieved on the submaximal exercise test on a bicycle ergometer from baseline to the first follow-up visit (4 months). Blood pressure and heart rate were registered before the start of the test. The test was performed on a bicycle ergometer according to the modified WHO protocol, with an increase in workload of 25 W every 4.5 min²⁵⁻²⁷. The initial starting load, 25 W or 50 W, was decided from the patient's exertion history. A pedalling rate of 50 revolutions per minute was used. After 2 and 4 min at each workload level, heart rate, rating of perceived exertion according to Borg RPE, and subjective symptoms, including chest pain and dyspnoea according to Borg's Category Ratio Scale, CR-10, were recorded. After 3 min, the systolic blood pressure was registered. The exercise test was discontinued at Borg RPE 17 and/or dyspnoea 7 on Borg's CR-10 scale. The submaximal exercise test on a bicycle ergometer is a well-established procedure that is part of routine exCR care in Sweden and included in the SWEDEHEART registry⁵⁵. The test gives reliable results for patients with CAD⁸⁹.

Muscle endurance

Muscle endurance was evaluated by two clinical endurance tests that are part of routine exCR in Sweden and included in SWEDEHEART. Both give reliable results for patients with CAD⁸⁹. The first test was unilateral isotonic shoulder flexion, for which the patient sits comfortably on a chair, with his/her back touching a wall, holding a dumbbell (2 kg for women and 3 kg for men) in an optional hand. The patient is asked to lift his/her shoulder from 0° to 90° flexion as many times as possible, using a pace of 20 lifts per minute, kept by a metronome. The number of elevations was registered. The second test was unilateral isotonic heel lift, for which the patient performs a maximum heel lift on a wedge tilted at 10°, one lift every other second, with the pace kept by a metronome. The patient chooses which leg to perform the test, and the contralateral foot is held slightly above the floor and, for balance, a wall is touched with the fingertips. The number of heel lifts was counted.

Self-reported physical activity and self-rated physical capacity

The level of physical activity was measured using two indicator questions about physical activity, taken from the Swedish National Board of Health

and Welfare (the BHW PA questions)⁹⁰. These questions concern the total time of exercise (high intensity) and of everyday physical activity (moderate intensity) during a regular week, specified in fixed response alternatives. The results for the two questions are merged into a new parameter entitled “activity minutes”. The BHW PA questions give valid results for adults in Sweden⁹⁰. Physical capacity was self-rated on a visual analogue scale according to the SWEDEHEART registry, with a range from 0-100, where 0 is the worst possible state of physical capacity and 100 the best possible state of physical capacity⁹¹.

Health-related quality of life

HRQoL was evaluated by the Short Form-36 (SF-36)⁹² and the EuroQoL 5 dimensions (EQ-5D)⁹³. The SF-36 comprises 36 items across eight dimensions (physical functioning (PF), role limitations due to physical problems (RP), bodily pain (BP), general health (GH), vitality (VT), social functioning (SF), role limitations due to emotional problems (RE), and mental health (MH)), and two summary components (physical component score (PCS) and mental component score (MCS)). Within each dimension, the responses to each question are combined to generate a score from 0-100. A higher score indicates better health⁹². The EQ-5D consists of a descriptive part with five questions/dimensions compiled into an index score, and a visual analogue scale on which the patient rates state of health on a scale ranging from 0 (worst possible state of health) to 100 (best possible state of health)⁹³. Both the SF-36 and the EQ-5D are reliable and valid for patients with CAD^{94, 95}.

Anxiety and depression

Anxiety and depression were measured using the Hospital Anxiety and Depression Scale (HADS)⁹⁶. This scale consists of 14 items, seven anxiety items and seven depression items. The items are scored on a four-point Likert scale, ranging from 0 to 3 points, from which separate anxiety (HADS-A) and depression (HADS-D) scores are calculated. Recommended cut-off scores are 8-10 for doubtful cases and ≥ 11 for definite cases of both HADS-A and HADS-D⁹⁶. HADS gives reliable results and is valid for patients with CAD^{97, 98}, while better sensitivity for patients with CAD can be obtained by lowering the cut-off score for definite cases of HADS-D from 11 to 8⁹⁸.

Self-efficacy

Self-efficacy was evaluated through the Self-Efficacy for Exercise Scale (SEE)⁹⁹. This instrument describes nine situations that may affect participation in exercise. Confidence in performing exercise is rated by the patient on a scale from 0 (not confident) to 10 (very confident). The total score ranges between 0-90 and is calculated by summing the responses to each question. A higher score indicates higher self-efficacy for exercise. The

SEE is reliable and valid for older adults⁹⁹, and for patients with CAD (Cavrak et al., unpublished data).

Patient enablement

Patient enablement was measured by the Swedish validated version of the Patient Enablement Instrument (PEI)¹⁰⁰. This consists of six questions that focus on the ability to understand and cope with health issues and illness, for which the answers are graded on a three-point scale ranging from 0-2 points. Thus, the total PEI score ranges between 0 and 12, with a higher score indicating better patient enablement. The PEI is reliable and valid for patients in a primary care setting¹⁰⁰.

Table 5. Overview of variables and measurements in Study B

Variables	Measurement	Paper II	Paper III
Exercise adherence	Exercise diary	•	
Submaximal aerobic exercise capacity	Submaximal exercise test	•	
Muscle endurance	Unilateral isotonic heel lift, unilateral isotonic shoulder flexion	•	
Self-reported physical activity and physical capacity	The BHW PA questions, VAS physical capacity	•	
Health-related quality of life	SF-36, EQ-5D		•
Anxiety and depression	Hospital Anxiety and Depression Scale		•
Self-efficacy	Self-Efficacy for Exercise Scale		•
Patient enablement	Patient Enablement Instrument		•

BHW PA, The Swedish National Board of Health and Welfare physical activity; EQ-5D, EuroQoL 5 dimensions; SF-36, Short Form-36; VAS, visual analogue scale.

Intervention

A pilot study comprising five patients with CAD was completed prior to the main study to ensure the quality of the test procedure and to test the different components of the BMIP. The results of the pilot study led us to make small modifications to the behavioural medicine intervention protocol, and to clarify some wording in the study protocols.

Routine exCR care

Patients randomised to RC followed routine exCR care. The exercise programme was individually prescribed, based on tests of physical fitness, and consisted of hospital-based continuous aerobic exercise two days/week for 20-60 minutes/session at an intensity of 40-85% of VO_{2max} , corresponding to 12-17 according to Borg RPE, in combination with resistance exercise containing 8-10 different exercises, 10-15 repetitions in 1-3 sets^{12, 13}. In order to achieve the recommendation of at least three aerobic exercise sessions/week, patients were instructed to perform one

additional home-based aerobic exercise session/week. Following routine exCR care, patients who were unable or unwilling to attend hospital-based exCR could choose to perform their entire exCR in a home-based setting. Routine exCR care included three face-to-face meetings with a physiotherapist for outcome assessment at baseline, 4 and 12 months. In addition, patients who performed the exCR programme in a hospital-based setting interacted with the physiotherapists in connection with those exercise sessions. No structured interventions to control or increase exercise adherence were included in routine care. However, certain elements of BCTs, such as social support from physiotherapists and verbal persuasion, are included in routine exCR care, and were thus given equally to all participants in Study B. Furthermore, routine exCR care includes general goal-setting for the exercise programme, and patients registered their home-based exercise sessions in an exercise diary. The diary was, however, not followed up by a physiotherapist during the exCR period.

Behavioural medicine intervention

Patients in the intervention group underwent a BMIP in addition to routine exCR care, intended to increase adherence to the prescribed exercise programme. In this way, the BMIP also had the potential to affect physical fitness, psychological outcomes and HRQoL. The self-regulatory BCTs used in Study B, i.e. specific goal-setting, re-evaluation of the goals, self-monitoring and feedback, are based on CT⁷⁸. Table 6 describes BCTs included in Study B, and illustrates the differences in these BCTs between BMIP and RC. Figure 4 is an overview of the timeline of the behavioural medicine intervention.

Specific goal-setting and re-evaluation of goals

The patients met a physiotherapist for detailed planning and specific goal-setting for the exCR programme before it started. Since the intervention in this study had a patient-centred approach, it was important that the detailed planning for the exCR programme (what to do, the exercise dose and the context for exercise) was agreed between the patient and the physiotherapist. Possible facilitators and barriers to achieving the exercise goals were identified, and an action plan with strategies to promote facilitators and overcome barriers was developed together with the patient. The patient's motivation and self-efficacy for the exCR programme were also discussed in relation to the goals set. The exercise goals were re-evaluated during and at the end of the intervention period.

Self-monitoring and feedback

Patients self-monitored their exercise goals, including specification of the exercise dose they had performed, in an exercise diary. The exercise diary was followed up by a physiotherapist every three weeks in a consultation that included structured, comprehensive feedback on achieved goals, analysis of perceived barriers, and a discussion about strategies to increase

adherence. At nine weeks, visual feedback on physical activity levels was given, using accelerometer cut-points to classify the measured physical activity into different intensity levels. At the end of the intervention (four months), a follow-up meeting with the physiotherapist took place to discuss perceptions of the intervention and goal achievement, and to set a long-term exercise goal.

To summarise, the behavioural medicine intervention contained one face-to-face meeting (baseline), three structured telephone/face-to-face follow-up meetings (3, 6 and 12 weeks), one face-to-face follow-up meeting for visual feedback (9 weeks), and one face-to-face meeting at the end of the intervention (16 weeks).

Figure 4. The timeline of the behavioural medicine intervention

Table 6. Description of behaviour change techniques used in study B

BCTs according to CT	Behavioural medicine intervention	Routine exCR care only
Specific goal-setting; i.e. detailed planning that specifies what to do, the exercise dose and the context in which the exercise is performed.	Detailed planning that specified what to do, the exercise dose and the context in which the exercise is to be performed.	General planning regarding what to do, the exercise dose and the context in which the exercise is to be performed.
	Action plan with strategies to promote possible facilitators and overcome barriers.	No action plan was developed.
	The patient's motivation and self-efficacy for initiating and maintaining the exCR programme were self-rated using a visual analogue scale, and discussed in relation to the goals set.	No self-rating or discussion about motivation and self-efficacy for initiating and maintaining the exCR in relation to the goals set.
Review of behaviour goals; i.e. review and/or reconsideration of previously set goals or intentions.	The previously set exercise goals were comprehensively and structurally reviewed and/or reconsidered every third week during the intervention and at the end of the intervention.	No structured review of exercise goals during the intervention. A less comprehensive and structural review at the end of the intervention.
Self-monitoring of behaviour; i.e. keeping a record of exercise in a diary.	Patients kept a record of exercise in a diary, which was regularly followed up every three weeks during the exCR period.	Patients kept a record of exercise in a diary, which was not followed up during the exCR period.
Providing feedback on performance; i.e. providing data about recorded behaviour, or evaluating performance in relation to a set standard or the performance of other people, i.e. the person received feedback on their behaviour	Structured, comprehensive feedback every three weeks, including positive feedback on achieved goals, supporting feedback in relation to barriers, and the opportunity to discuss strategies to increase adherence.	General feedback on performance during exercise sessions for patients participating in hospital-based exCR, and no feedback during the intervention for patients participating in a home-based setting.
	Additional visual feedback on physical activity levels, using accelerometer data at one time during the intervention.	No visual feedback on physical activity levels.
	Structured follow-up meeting at the end of the intervention to discuss how the intervention had been perceived, goal achievement, long-term exercise goal-setting, and potential future barriers, facilitators and strategies.	Less extensive structured and comprehensive follow-up meeting at the end of the intervention.

BCT, behaviour change technique; CT, control theory; exCR, exercise-based cardiac rehabilitation.

Data analysis

Study A – Paper I

Data analyses were conducted using SPSS Version 24 for Windows (IBM Corp. Armonk, NY, USA) and R Version 3.4.4 (R Foundation for Statistical Computing, Vienna, Austria, 2018). Continuous variables are presented as means and standard deviations (SD) for normally distributed variables, and medians and interquartile ranges for non-normally distributed variables. Categorical variables are reported by numbers and proportions (%). Comparisons between attenders and non-attenders to exCR were carried out at baseline for each individual variable, using an independent samples t-test or the Wilcoxon test for continuous variables, and the chi-squared test for categorical variables, as appropriate.

Missing values in at least one variable were present for about 15% of observations, although infrequent when looking per variable. Imputation by chained tree-ensembles was therefore performed (as implemented in the missRanger R package), setting the maximum number of chaining iterations to 10 (the default value).

The distribution of driving distance was right-skewed, and it was therefore log-transformed before analysis. The unadjusted association between driving distance and non-attendance at exCR was assessed by a spline plot, entering driving distance as a restricted cubic spline in an unadjusted logistic regression model.

The first stage of the multivariable analyses was to fit a logistic regression model that included age, sex, BMI, occupational status, smoking status, previous diseases, type of index cardiac event, type of intervention, and type of hospital at follow-up Visit 2 as independent variables. Non-attendance at exCR at follow-up Visit 2 was used as dependent variable in this fitting procedure. The second stage of the analysis was to fit an additional model that also included distance to the hospital. All continuous variables were entered as restricted cubic splines, to account for possible non-linear associations with outcome. The results are presented as odds ratios (OR) and 95% confidence intervals (CI). The Wald statistic (the number of degrees of freedom [df] for each variable subtracted from its chi-squared value) was used as a variable-importance metric.

Study B – Papers II and III

The calculation of required sample size was based on previous clinical data from a similar exCR setting (n=50) for differences in the primary outcome, aerobic exercise capacity measured by a submaximal exercise test (watts), before and after a completed exCR programme. The required sample size was calculated to be 160 patients, using a two-sided test, 80% power, a

significance level of $p < 0.05$, a minimum mean difference at 10 W (SD 20 W) and an expected loss to follow-up of 20%. To compensate for a possible larger loss to follow-up, an additional 10 patients were recruited.

Descriptive statistics were used for demographic data and are presented as means and standard deviations, or numbers and proportions (%), as appropriate. Missing values for submaximal aerobic exercise capacity, muscle endurance, self-reported physical activity and self-rated physical capacity in Paper II were handled with multiple imputation. The same procedure was used for EQ-VAS, SF-36, HADS, SEE, and PEI in Paper III. In both Paper II and Paper III, demographic data, medical records and outcome measurements at baseline were included as independent variables, while outcome measurements at four months and 12 months were entered as both independent and dependent variables in the multiple imputation model. The model used a chained equations procedure (the fully conditional specification method provided in SPSS) to complete 10 data sets¹⁰¹. In Paper II, constraints were applied to each variable according to the minimum and maximum value from observed data, except for self-rated physical capacity, for which the range of the scale was used. In Paper III, constraints were applied according to the minimum and maximum value of each variable. The EQ-5D index proved to be difficult to enter as a variable in the imputation model in Paper III, and was not included in the analyses.

For both Paper II and Paper III, within-group changes, from baseline to four months and from four months to 12 months, in each outcome measurement were analysed with paired sample t-tests. Between-group differences at each time point, and the change between time points, were analysed with an independent samples t-test. Means with 95% confidence intervals and p-values, based on the pooled results of each analysis, are presented. An intention-to-treat analysis and a per-protocol analysis were performed.

A response analysis based on demographic data and outcome measurements at baseline was conducted and presented in both Paper II and Paper III. In Paper II, patients with complete data at four months follow-up are compared with patients without complete data at four months follow-up. In Paper III, responders and non-responders (participants with complete missing data) are compared at four months follow-up. Both response analyses revealed no substantial differences, which means that missing at random can be assumed. Statistical analysis was performed using SPSS statistical software for Windows (SPSS Version 25, IBM Corp. Armonk, New York, USA). A significance level of 0.05 was used in all analyses.

Ethical considerations

The studies described in this thesis were performed according to the ethical principles for medical research stated in the Declaration of Helsinki. In accordance with ethical regulations for Swedish registries, patients are informed about the registration in SWEDEHEART, have the right to deny registration, and to be removed from the registry on request at any time. In Study A, the study design did not involve any interaction with the participants included. In Study B, informed written consent was obtained from all patients before they entered the study. Participants could withdraw from the study at any time without giving a reason. The physiotherapists involved in Study B all had experience of exCR, which was performed in accordance with routine care. The testing procedure took place at the coronary care unit at Linköping University Hospital, with emergency equipment and medical expertise readily available if needed. Ethical approval for Study A and Study B was received from the Regional Ethical Board in Linköping, Sweden (reference numbers are presented in Table 3).

RESULTS

Factors associated with non-attendance at exCR (Study A, Paper I)

Out of a total of 31,297 included post-MI patients, 16,214 (52%) did not attend exCR. Non-attenders differed significantly from attenders and were older, more often retired, had more previous diseases (diabetes, MI, PCI, CABG, chronic heart failure and stroke), had higher BMI and lower left ventricular function, and were more often smokers (all p-values <0.009). Table 7 shows baseline demographics for attenders and non-attenders.

Figure 5 presents the unadjusted association between driving distance from the hospital and non-attendance at exCR. Distance was modelled using a restricted cubic spline to account for non-linearities, and Figure 5 shows that the relationship was non-linear. A distance greater than 16 km was associated with an increased probability of non-attendance at exCR.

Figure 5. Association between distance to hospital and non-attendance at exCR

Table 7. Baseline demographics for attenders and non-attenders at exCR, n = 31,297

Attending exercise-based CR		No (n = 16,214)	Yes (n = 15,083)	p-value	missing, %
Age (years), mean $\pm$ SD		62.9 $\pm$ 8.3	62.0 $\pm$ 8.4	<0.001A	0.0
BMI (kg/m ²), mean $\pm$ SD		27.8 $\pm$ 4.5	27.7 $\pm$ 4.3	0.009A	3.6
Sex, n (%)	Male	12,212 (75.3)	11,219 (74.4)	0.058B	0.0
	Female	4002 (24.7)	3864 (25.6)		
Occupational status, n (%)	Employed	6152 (40.1)	6711 (47.2)	<0.001B	5.5
	Retired	8321 (54.2)	6810 (47.9)		
	Sick leave	431 (2.8)	344 (2.4)		
	Unemployed, student, other	435 (2.8)	365 (2.6)		
Smoking status, n (%)	Never smoked	5002 (31.5)	5563 (37.8)	<0.001B	2.2
	Ex- smoker > 1 month	5615 (35.4)	5455 (37.0)		
	Smoker	5252 (33.1)	3718 (25.2)		
Previous diseases, n (%)	MI	2853 (17.7)	1718 (11.4)	<0.001B	0.4
	PCI	2339 (14.5)	1407 (9.4)	<0.001B	0.4
	CABG	1100 (6.8)	576 (3.8)	<0.001B	0.2
	Diabetes	3150 (19.5)	2326 (15.5)	<0.001B	0.2
	Hypertension	7049 (43.8)	6406 (42.7)	0.057B	0.6
	Chronic heart failure	625 (4.0)	386 (2.6)	<0.001B	3.3
	Stroke	736 (4.6)	431 (2.9)	<0.001B	0.3
Type of index cardiac event, n (%)	STEMI	5986 (36.9)	6279 (41.6)	<0.001B	0.0
	NSTEMI	10,228 (63.1)	8804 (58.4)		
Type of index cardiac intervention, n (%)	PCI	13,204 (81.4)	12,588 (83.5)	<0.001B	0.0
	CABG	644 (4.0)	878 (5.8)	<0.001B	0.0
Left ventricular function, n (%)	Normal (EF >50%)	9288 (66.5)	9091 (68.5)	<0.001B	13.0
	Lightly reduced (EF 40-49%)	2767 (19.8)	2648 (19.9)		
	Moderate/severely reduced (EF <40%)	1903 (13.6)	1535 (11.6)		
Medication, n (%)	ACE	10,979 (67.7)	10,313 (68.4)	0.025B	0.1
	ARB	2697 (16.6)	2613 (17.3)	0.108B	0.1
	Anticoagulants	1014 (6.3)	805 (5.4)	0.001B	0.1
	Other platelet inhibitors	14,951 (92.2)	13,857 (91.9)	<0.010B	0.1
	ASA	15,623 (96.4)	14,655 (97.2)	<0.001B	<0.1
	Beta-blockers	14,744 (91.0)	13,889 (92.1)	<0.001B	<0.1
	Statins	15,691 (96.8)	14,809 (98.2)	<0.001B	<0.1
Distance to hospital (km), median (IQR)		11.3 (4.4-25.3)	18.3 (5.8-34.3)	<0.001C	1.6
Type of hospital, n (%)	University hospital	3462 (21.4)	3982 (26.4)	<0.001B	0.0
	County hospital	7079 (43.7)	5698 (37.8)		
	District hospital	5673 (35.0)	5403 (35.8)		

^A Student's t-test, ^B Chi² test, ^C Wilcoxon test

ACE, angiotensin-converting enzyme; ARB, angiotensin receptor blocker; ASA, acetylsalicylic acid; BMI, body mass index; CABG, coronary artery bypass graft, CR, cardiac rehabilitation; EF, ejection fraction; IQR, interquartile range; km, kilometre; MI, myocardial infarction; NSTEMI, non-ST-elevation myocardial infarction; PCI, percutaneous coronary intervention; STEMI, ST-elevation myocardial infarction.

Logistic regression model

Figure 6 shows the importance of the variables in the regression model, with and without driving distance as an independent variable, for non-attendance at exCR. The model as a whole explained 5.1% of the variance, without driving distance included as an independent variable. When distance to the hospital was included as an independent variable, the amount of variation in non-attendance at exCR explained by the model was markedly higher, 7.6%.

Figure 6. The importance of variables in a model with and without distance to hospital as an independent variable

Table 8 presents the logistic regression model with driving distance included as an independent variable. The strongest predictor for non-attendance at exCR was distance to the hospital (OR 1.75 (CI: 1.64-1.86) comparing upper and lower quartiles). Other predictors that increased the odds for non-attendance included current smoking, and a previous history of diseases (MI, PCI, CABG, stroke or diabetes). Being followed-up at a county hospital was also a predictor for non-attendance. Female gender was associated with higher attendance at exCR as was being employed vs. being retired. Patients with STEMI as the index cardiac event, and those intervened with PCI or CABG, were more likely to attend.

Table 8. Logistic regression model with distance to hospital included as an independent variable.

Independent variables	OR	95% CI
Age (years)	1.00	(0.90 - 1.10)
BMI (kg/m ²)	1.05	(0.99 - 1.11)
Sex (female vs. male)	0.85	(0.80 - 0.90)
Occupational status (employed vs. retired)	0.86	(0.80 - 0.93)
Occupational status (sick leave vs. retired)	1.05	(0.89 - 1.23)
Occupational status (unemployed/student/other vs. retired)	1.02	(0.87 - 1.20)
Smoking status (smoker vs. ex-smoker)	1.63	(1.54 - 1.74)
Smoking status (never smoked vs. ex-smoker)	0.91	(0.86 - 0.96)
<i>Previous diseases</i>		
Diabetes (yes vs. no)	1.20	(1.13 - 1.28)
Hypertension (yes vs. no)	0.94	(0.89 - 0.98)
Chronic heart failure (yes vs. no)	1.01	(0.88 - 1.16)
Stroke (yes vs. no)	1.37	(1.21 - 1.55)
Myocardial infarction (yes vs. no)	1.19	(1.08 - 1.31)
PCI (yes vs. no)	1.28	(1.16 - 1.42)
CABG (yes vs. no)	1.31	(1.16 - 1.48)
<i>Type of index cardiac event and intervention</i>		
STEMI vs. NSTEMI	0.84	(0.80 - 0.88)
PCI (yes vs. no)	0.81	(0.76 - 0.87)
CABG (yes vs. no)	0.55	(0.49 - 0.62)
Distance to hospital (km)	1.75	(1.64 - 1.86)
Type of hospital (university hospital vs. county hospital)	0.79	(0.75 - 0.84)
Type of hospital (district hospital vs. county hospital)	0.78	(0.74 - 0.82)

BMI, body mass index; CABG, coronary artery bypass graft; CI, confidence interval; NSTEMI, non-ST-elevation myocardial infarction; PCI, percutaneous coronary intervention; STEMI, ST-elevation myocardial infarction; OR, odds ratio.

The added value of a BMIP in exCR (Study B, Papers II and III)

Table 9 presents baseline demographics for the patients in Study B. The only significant difference in baseline characteristics between the groups was a higher proportion of patients with unstable angina ($p=0.011$) and a lower proportion of patients with NSTEMI ($p=0.037$), as the index cardiac event, in the intervention group than in the routine care group.

There were no statistical differences between the groups in outcome measurements of physical fitness at baseline, except for a significantly higher number of activity minutes in the BHW PA questions (302.1 vs.

243.8 activity minutes, $p=0.004$), in the BMIP group than in the RC group. For psychological outcomes and HRQoL, SF-36; GH ($p=0.035$) were significantly higher in the BMIP group than in the RC group, and HADS-A ($p=0.043$) was significantly lower. The EQ-5D index showed a ceiling effect at baseline in both groups (BMIP: 0.895 (SD 0.12) and RC: 0.857 (SD 0.18)).

Twenty patients in each group participated in hospital-based exCR, whereas most patients ($n=55$ in BMIP and $n=58$ in RC) chose to perform the exCR in a home-based setting. Ten (BMIP) and five (RC) patients, respectively, participated in hospital-based exCR once a week in combination with home-based exercise. Due to early exclusion after baseline testing (as a result of critical ischaemia or other disease), information about the choice of exCR setting was missing for one patient in each group. No serious adverse events related to the exCR programme or the BMIP occurred.

Table 9. Baseline demographics for participants in Study B

		Whole group (n=170)	Behavioural medicine (n=86)	Routine care (n=84)
Age, years, mean $\pm$ SD		62.3 $\pm$ 7.9	62.7 $\pm$ 7.8	61.8 $\pm$ 8.0
BMI, kg/m ² , mean $\pm$ SD		27.2 $\pm$ 4.1	27.2 $\pm$ 4.3	27.1 $\pm$ 4.0
Sex, n (%)	Male	136 (80)	72 (84)	64 (76)
	Female	34 (20)	14 (16)	20 (24)
Country of birth, n (%)	Sweden	165 (99)	86 (100)	79 (99)
	Other	1 (1)	0 (0)	1 (1)
Relationship status, n (%)	Married/partner	135 (79)	69 (80)	66 (79)
	Living alone	35 (21)	17 (20)	18 (21)
Educational level, n (%)	Elementary school	11 (7)	8 (9)	3 (4)
	High school	32 (19)	13 (15)	19 (23)
	Vocational school	44 (26)	20 (23)	24 (29)
	University	82 (49)	45 (52)	37 (45)
Occupational status, n (%)	Employed	89 (55)	43 (51)	46 (58)
	Retired	71 (44)	40 (48)	31 (39)
	Sick leave	2 (1)	0 (0)	2 (3)
	Unemployed, student, other	1 (1)	1 (1)	0 (0)
On sick leave at time for baseline, n (%)		41 (45)	16 (36)	25 (52)
Smoking status, n (%)	Never smoked	73 (43)	36 (42)	37 (44)
	Ex- smoker > 1month	83 (49)	45 (52)	38 (45)
	Smoker	14 (8)	5 (6)	9 (11)
Previous diseases, n (%)	MI	13 (8)	5 (6)	8 (10)
	PCI	18 (11)	8 (9)	10 (12)
	CABG	6 (4)	3 (4)	3 (4)
	Diabetes	17 (10)	11 (13)	6 (7)
	Hypertension	80 (47)	45 (52)	35 (42)
	Chronic heart failure	1 (1)	0 (0)	1 (1)
	Stroke	5 (3)	2 (2)	3 (4)
Type of index cardiac event, n (%)	STEMI	47 (28)	25 (29)	22 (26)
	NSTEMI	53 (31)	20 (23)	33 (39)
	Unstable angina	30 (18)	22 (26)	8 (10)
	Stable angina	40 (24)	19 (22)	21 (25)
Type of index cardiac intervention, n (%)	PCI	163 (96)	83 (97)	80 (95)
Left ventricular function, n (%)	Normal (EF >50%)	93 (69)	53 (74)	40 (64)
	Lightly reduced (EF 40-49%)	28 (21)	13 (18)	15 (24)
	Moderate/severely reduced (EF <40%)	14 (10)	6 (8)	8 (13)
Experience of exCR, n (%)		14 (8)	6 (7)	8 (10)

BMI, body mass index; CABG, coronary artery bypass graft; EF, ejection fraction; exCR, exercise-based cardiac rehabilitation; MI, myocardial infarction; NSTEMI, non-ST-elevation myocardial infarction; STEMI, ST-elevation-myocardial infarction; PCI, percutaneous coronary intervention.

Adherence

Data from exercise diaries were missing for 25 patients out of 170, due to exclusion during the four-month intervention period ($n=7$), loss to follow-up at 4 months ($n=11$, of which 3 were drop-outs), or the patient forgetting to report or losing the exercise diary ($n=7$). Data from medical records and/or exercise diaries were available for 145 patients (BMIP: $n=75$ and RC: $n=70$) and these patients were included in the evaluation of exercise adherence.

Twenty-three (31%) patients in the BMIP group and 13 (19%) patients in the RC group met the adherence definition of having performed at least 75% of the recommended exercise dose, and were thus defined as fully adherent to the exCR programme. Table 10 gives the proportions of adherent patients in the different exCR settings.

Table 10. Numbers of adherent patients in the different exCR settings

ExCR setting	BMIP ($n = 23$)	RC ($n = 13$)
Hospital-based	5	5
Combined	5	2
Home-based	13	6

BMIP, behavioural medicine intervention in physiotherapy;
ExCR, exercise-based cardiac rehabilitation; RC, routine care.

Patients in both groups were more adherent to aerobic exercise than to resistance exercise. Forty-three (57%) patients in the BMIP group and 31 (44%) patients in the RC group met the adherence definition for the recommended aerobic exercise dose only. Almost all (95%) of the patients in Study B were at least partially (greater than 20%) adherent to the aerobic exercise regimen. Table 11 shows the levels of exercise adherence for aerobic exercise and for resistance exercise for the whole Study B group.

Table 11. Levels of exercise adherence to aerobic and resistance exercise, $n=145$

Adherence level	Aerobic exercise		Resistance exercise	
	n	%	n	%
<20%	7	4.8	31	21.4
20-50%	31	21.4	40	27.6
50-75%	33	22.8	21	14.5
>75%	74	51.0	53	36.6

If the definition of exercise adherence was extended in Study B to include patients who met the definition of at least 75% of the recommended dose for either aerobic or resistance exercise and at least 50% of the recommended dose of the corresponding training modality, 38 (51%) in the BMIP group and 23 (33%) in the RC group were adherent to the exCR programme.

Physical fitness

There were no significant differences in the primary outcome measure (change in submaximal aerobic exercise capacity) between BMIP and RC, either between baseline and four months or between four and 12 months. Nor were there any significant differences between the groups in the other evaluated measures of physical fitness (unilateral isotonic heel lift, unilateral isotonic shoulder flexion, the BHW PA questions and the VAS physical capacity) between baseline and four months or between the four- and the 12-months follow-up (Table 12). Between the end of the intervention (four months) and the long-term follow-up at 12 months, a non-significant tendency towards the maintenance of submaximal aerobic exercise capacity in the BMIP group (118.3 vs. 120.0 W, $p=0.333$) and a deterioration in the RC group (115.3 vs. 111.6 W, $p=0.095$) was found.

All outcomes had improved significantly in both groups at the four-month follow up, but there was no significant difference in the change within groups between four and 12 months (Table 12).

Psychological outcomes and HRQoL

Psychological outcomes and HRQoL did not differ between the two groups, either between baseline and four months or between four and 12 months (Table 13).

At the four-month follow-up, both groups had improved significantly in the EQ-VAS and in all SF-36 domains, except for BP, MH and GH, and HADS-A was significantly lower in both groups. The BMIP group significantly improved in the SF-36; MH at four months and significantly declined in SEE between the four- and the 12-month follow-up. In the RC group, SF-36; GH improved between baseline and four months, while there was no significant difference in the change within groups between the four- and 12-month follow-ups (Table 13).

Table 12. Intention-to-treat analysis of change in physical fitness within and between groups

Variable	1. Routine care (n = 84)		2. Behavioural medicine (n = 86)		Between-group effects (1-2) Mean (95% CI), p-value
	Mean (95% CI), p-value		Mean (95% CI), p-value		
Symptom-limited bicycle ergometer test (watt)	Baseline	104.9		107.5	
	4 months	115.3		118.3	
Within-group change	Baseline to 4 months	10.4 (6.3 to 14.5), p < 0.001	10.8 (6.8 to 14.8), p < 0.001		-0.4 (-6.1 to 5.4), p = 0.902
	4 months to 1 year	-3.7 (-8.0 to 0.6), p = 0.095	1.7 (-1.8 to 5.2), p = 0.333		5.4 (-11.0 to 0.2), p = 0.060
Change in unilateral isotonic heel lift (repetitions)	Baseline	12.5		13.1	
	4 months	15.7		15.3	
Within-group change	Baseline to 4 months	3.2 (1.0 to 5.5), p = 0.004	2.2 (0.6 to 3.9), p = 0.008		1.0 (-1.6 to 3.7), p = 0.455
	4 months to 1 year	-0.5 (-2.8 to 1.8), p = 0.666	1.6 (-0.4 to 3.6), p = 0.113		-2.1 (-5.0 to 0.8), p = 0.157
Unilateral isotonic shoulder flexion (repetitions)	Baseline	24.6		29.0	
	4 months	33.6		37.3	
Within-group change	Baseline to 4 months	9.0 (5.2 to 12.8), p = 0.001	8.3 (5.0 to 11.6), p < 0.001		0.7 (-4.3 to 5.7), p = 0.785
	4 months to 1 year	0.9 (-2.9 to 4.7), p = 0.642	1.7 (-1.9 to 5.3), p = 0.361		-0.8 (-5.8 to 4.2), p = 0.758
BHW PA questions (activity minutes)	Baseline	243.8		302.1	
	4 months	345.5		367.3	
Within-group change	Baseline to 4 months	101.7 (72.4 to 131.0), p < 0.001	65.2 (35.0 to 95.5), p < 0.001		36.5 (-6.1 to 79.1), p = 0.093
	4 months to 1 year	-29.1 (-62.5 to 4.4), p = 0.093	-28.5 (-58.8 to 1.9), p = 0.068		-0.6 (-44.6 to 43.4), p = 0.978
VAS physical capacity (millimetre)	4 months	70.0		72.2	
	Within-group change	4 months to 1 year	0.3 (-3.4 to 4.1), p = 0.858	-2.3 (1.0 to -5.6), p = 0.165	2.7 (-2.3 to 7.7), p = 0.297

CI, confidence interval; BHW PA, The Swedish National Board of Health and Welfare physical activity; VAS, visual analogue scale.

Table 13. Intention-to-treat analysis of change in health-related quality of life and psychological outcomes within and between groups

Variable	1. Routine care (n = 84)		2. Behavioural medicine (n = 86)		Between-group effects (1-2)	
		Mean (95% CI), p-value		Mean (95% CI), p-value	Mean (95% CI), p-value	
SF-36 PF	Baseline	86.2 (83.4 to 89.1)		87.0 (84.2 to 89.8)	-0.7 (-4.7 to 3.2), p = 0.711	
	4 months	89.5 (86.8 to 92.2)		89.7 (87.4 to 92.0)	-0.3 (-3.9 to 3.4), p = 0.888	
	Within-group change	3.3 (0.7 to 5.8), p = 0.011		2.8 (0.2 to 5.3), p = 0.035	0.5 (-3.1 to 4.1), p = 0.793	
SF-36 RP	Baseline	-0.2 (-2.6 to 2.1), p = 0.835		0.8 (-1.3 to 2.9), p = 0.476	-1.0 (-4.0 to 1.9), p = 0.504	
	4 months	49.4 (40.3 to 58.5)		54.2 (45.3 to 63.1)	-4.8 (-17.3 to 7.1), p = 0.457	
	Within-group change	78.5 (71.4 to 85.6)		81.4 (74.5 to 88.3)	-2.9 (-12.9 to 7.1), p = 0.573	
SF-36 BP	Baseline	29.1 (19.4 to 38.8), p < 0.001		27.2 (17.3 to 37.1), p < 0.001	1.9 (-11.8 to 15.6), p = 0.787	
	4 months	1.9 (-6.5 to 10.3), p = 0.662		-3.8 (-13 to 5.4), p = 0.415	5.7 (-6.5 to 17.9), p = 0.360	
	Within-group change	75.2 (70.1 to 80.3)		75.8 (71.1 to 80.6)	-0.6 (-7.5 to 6.2), p = 0.854	
SF-36 GH	Baseline	79.4 (74.5 to 84.3)		79.0 (73.9 to 84.2)	0.4 (-7.4 to 8.1), p = 0.928	
	4 months	4.2 (-1.7 to 10.2), p = 0.165		3.2 (-3.0 to 9.4), p = 0.310	1.0 (-7.8 to 9.8), p = 0.822	
	Within-group change	-5.5 (-11.8 to 0.8), p = 0.091		-1.5 (-8.1 to 5.1), p = 0.661	-4.0 (-12.9 to 4.9), p = 0.377	
SF-36 VT	Baseline	66.8 (62.2 to 71.5)		73.1 (69.6 to 76.7)	-6.3 (-12.1 to -0.5), p = 0.035	
	4 months	71.9 (67.7 to 76.0)		76.5 (72.2 to 80.7)	-4.6 (-10.6 to 1.4), p = 0.130	
	Within-group change	5.0 (1.4 to 8.6), p = 0.007		3.3 (-0.3 to 7.0), p = 0.072	1.7 (-3.3 to 6.7), p = 0.511	
SF-36 SF	Baseline	-0.1 (-4.3 to 4.1), p = 0.955		-2.4 (-6.2 to 1.3), p = 0.206	2.3 (-3.2 to 7.8), p = 0.407	
	4 months	64.3 (59.5 to 69.2)		63.4 (58.9 to 68.0)	0.9 (-5.7 to 7.5), p = 0.789	
	Within-group change	69.6 (64.9 to 74.4)		71.8 (67.6 to 76.0)	-2.1 (-8.6 to 4.4), p = 0.526	
SF-36 SF	Baseline	5.3 (0.8 to 9.8), p = 0.021		8.3 (3.9 to 12.8), p < 0.001	-3.0 (-9.2 to 3.2), p = 0.341	
	4 months	-0.8 (-4.7 to 3.1), p = 0.690		-1.3 (-5.5 to 2.9), p = 0.539	0.5 (-4.8 to 5.9), p = 0.847	
	Within-group change	83.8 (79.2 to 88.4)		85.0 (81.2 to 88.9)	-1.2 (-7.2 to 4.7), p = 0.680	
SF-36 SF	Baseline	88.7 (84.7 to 92.8)		90.7 (86.9 to 94.5)	-2.0 (-7.7 to 3.8), p = 0.502	
	4 months	5.0 (0.2 to 9.7), p = 0.040		5.7 (1.6 to 9.8), p = 0.007	-0.7 (-6.9 to 5.5), p = 0.822	
	Within-group change	0.3 (-4.5 to 5.1), p = 0.912		2.3 (-1.7 to 6.3), p = 0.255	-2.1 (-7.8 to 3.7), p = 0.482	

Table 13 continued.

Variable	1. Routine care (n = 84)		2. Behavioural medicine (n = 86)		Between-group effects (1-2)	
		Mean (95% CI), p-value		Mean (95% CI), p-value	Mean (95% CI), p-value	
SF-36 RE	Baseline	65.8 (56.7 to 74.9)		74.4 (66.2 to 82.7)	-8.6 (-20.7 to 3.5), p = 0.166	
	4 months	83.4 (76.9 to 89.9)		86.2 (80.0 to 92.4)	-2.8 (-12.1 to 6.6), p = 0.566	
	Within-group change	17.6 (8.4 to 26.8), p < 0.001		11.7 (2.9 to 20.6), p = 0.010	5.8 (-6.8 to 18.5), p = 0.365	
SF-36 MH	Baseline	1.3 (-7.8 to 10.4), p = 0.783		-0.4 (-8 to 7.2), p = 0.920	1.7 (-9.3 to 12.7), p = 0.767	
	4 months	76.8 (72.6 to 80.9)		79.6 (76 to 83.3)	-2.9 (-8.3 to 2.6), p = 0.301	
	Within-group change	80.9 (77.5 to 84.2)		85.8 (82.7 to 89)	-4.9 (-10.3 to 0.4), p = 0.071	
SF-36 PCS	Baseline	4.1 (-0.4 to 8.6), p = 0.074		6.2 (2.9 to 9.5), p < 0.001	-2.1 (-7.8 to 3.6), p = 0.472	
	4 months	1.1 (-2.5 to 4.7), p = 0.545		0.3 (-3.1 to 3.7), p = 0.842	0.8 (-4.4 to 5.9), p = 0.770	
	Within-group change	46.3 (44.7 to 47.9)		46.9 (45.3 to 48.5)	-0.6 (-2.8 to 1.7), p = 0.615	
SF-36 MCS	Baseline	49.8 (48.1 to 51.4)		49.9 (48.2 to 51.6)	-0.1 (-2.6 to 2.3), p = 0.927	
	4 months	3.5 (1.8 to 5.2), p < 0.001		3.0 (0.8 to 5.3), p = 0.008	0.5 (-2.2 to 3.2), p = 0.738	
	Within-group change	-0.8 (-2.7 to 1.2), p = 0.437		-0.8 (-2.8 to 1.3), p = 0.460	0.0 (-2.6 to 2.6), p = 0.993	
SF-36 MCS	Baseline	46.3 (43.6 to 48.9)		48.0 (45.8 to 50.3)	-1.8 (-5.2 to 1.7), p = 0.317	
	4 months	49.5 (47.4 to 51.6)		51.5 (49.6 to 53.4)	-2.0 (-5.0 to 1.0), p = 0.187	
	Within-group change	3.2 (0.7 to 5.7), p = 0.013		3.5 (1.2 to 5.7), p = 0.003	-0.3 (-3.6 to 3.0), p = 0.873	
	4 months	0.6 (-1.6 to 2.8), p = 0.590		0.3 (-1.6 to 2.3), p = 0.735	0.3 (-2.5 to 3.1), p = 0.855	

Table 13 continued.

Variable	1. Routine care (n = 84)		2. Behavioural medicine (n = 86)		Between-group effects (1-2)	
	Mean (95% CI), p-value		Mean (95% CI), p-value		Mean (95% CI), p-value	
EQ-VAS	Baseline	75.9 (72.3 to 79.4)	77.9 (75.0 to 80.7)		-2.0 (-6.5 to 2.5), p = 0.388	
	4 months	80.2 (77.4 to 82.9)	81.7 (79.0 to 84.4)		-1.5 (-5.6 to 2.6), p = 0.465	
Within-group change	Baseline to 4 months	4.3 (0.5 to 8.1), p = 0.028	3.8 (0.6 to 7.0), p = 0.019		0.5 (-4.4 to 5.3), p = 0.853	
	4 months to 1 year	0.0 (-2.9 to 3.0), p = 0.981	-0.7 (-3.7 to 2.4), p = 0.666		0.7 (-3.5 to 4.9), p = 0.742	
HADS Anxiety	Baseline	4.4 (3.6 to 5.1)	3.3 (2.7 to 4)		1.0 (0.0 to 2.0), p = 0.043	
	4 months	3 (2.4 to 3.6)	2.7 (2 to 3.4)		0.3 (-0.6 to 1.3), p = 0.532	
Within-group change	Baseline to 4 months	-1.4 (-2.0 to -0.8), p < 0.001	-0.7 (-1.1 to -0.2), p = 0.011		-0.7 (-1.5 to 0.1), p = 0.077	
	4 months to 1 year	0.3 (-0.3 to 0.9), p = 0.334	0.2 (-0.3 to 0.6), p = 0.505		0.1 (-0.7 to 0.9), p = 0.756	
HADS Depression	Baseline	2.2 (1.7 to 2.7)	2.0 (1.5 to 2.5)		0.2 (-0.5 to 0.9), p = 0.605	
	4 months	2.2 (1.7 to 2.8)	1.7 (1.2 to 2.2)		0.5 (-0.2 to 1.3), p = 0.173	
Within-group change	Baseline to 4 months	0.1 (-0.4 to 0.6), p = 0.827	-0.3 (-0.7 to 0.1), p = 0.193		0.3 (-0.3 to 1.0), p = 0.326	
	4 months to 1 year	-0.2 (-0.7 to 0.4), p = 0.547	0.2 (-0.2 to 0.5), p = 0.354		-0.3 (-0.9 to 0.3), p = 0.319	
Self-Efficacy for Exercise Scale	Baseline	51.2 (46 to 56.5)	57.7 (52.6 to 62.8)		-6.5 (-13.7 to 0.8), p = 0.080	
	4 months	49.7 (44.5 to 54.8)	56.5 (51.6 to 61.4)		-6.8 (-14 to 0.3), p = 0.062	
Within-group change	Baseline to 4 months	-1.6 (-7.6 to 4.5), p = 0.615	-1.2 (-6.4 to 4), p = 0.650		-0.3 (-8.2 to 7.6), p = 0.932	
	4 months to 1 year	-3.1 (-7.9 to 1.8), p = 0.219	-5.9 (-10.8 to -1), p = 0.020		2.8 (-3.9 to 9.5), p = 0.409	
Patient enablement instrument	4 months	6.0 (5.2 to 6.7)	6.8 (6.1 to 7.6)		-0.9 (-2.1 to 0.3), p = 0.148	
	1 year	5.9 (5.2 to 6.7)	6.2 (5.4 to 6.9)		-0.3 (-1.4 to 0.9), p = 0.658	

BP, bodily pain; CI, confidence interval; EQ-VAS, EuroQoL visual analogue scale; GH, general health; HADS, Hospital Anxiety and Depression Scale; MCS, mental component score; MH, mental health; PCS, physical component score; PF, physical functioning; RE, role limitations due to emotional problems; RP, role limitations due to physical problems; SF, social functioning; SF-36, Short Form-36; VT, vitality.

Per-protocol analysis within and between groups

The change between groups was not significantly different for any of the evaluated outcomes, as shown by the per-protocol analysis of the patients who were defined as fully adherent to the exCR programme. Both groups, however, improved significantly in all outcomes of physical fitness and in the SF-36; RP, GH, PCS, and EQ-VAS between baseline and four months. Generally, patients defined as fully adherent in both groups presented better physical fitness, HRQoL and psychological outcome values than those of the whole Study B group.

DISCUSSION

Main findings

Factors associated with non-attendance at exCR in a Swedish context are similar to those reported from several other countries. Further, the structural factors add to the existing literature concerning the importance of distance to the hospital and type of hospital. The results from the intervention study illustrate the challenge to achieve a behavioural change in patients as part of work to enhance rehabilitation outcomes. Even though exercise adherence was higher when a behavioural medicine intervention was added, it was low in both groups. Furthermore, physical fitness, psychological outcomes and HRQoL after completion of the exCR programme were equally improved irrespective of whether a BMIP was added to exCR. This may appear initially to throw doubt onto the value of adding a BMIP, including structured specific goal-setting, re-evaluation of the goals, self-monitoring and feedback, to routine exCR care. However, the results indicate that there is room for improvement in how to use behavioural medicine interventions in exCR to improve outcomes.

Factors associated with non-attendance at exCR

Structural factors

The results presented in Study A, Paper I, show that distance to hospital is the strongest factor associated with non-attendance at exCR: the unadjusted association has a non-linear relationship in which a distance greater than 16 km increases the probability of non-attendance at exCR. Long distance and travel time to the CR centre are well-known barriers for exCR^{56, 57, 102, 103}, but the distances that are associated with increased probability of non-attendance at exCR in different contexts have less often been measured using objective geographic parameters¹⁰⁴⁻¹⁰⁷. Enrolment in CR programmes was lower for patients living further than 50 km from the CR centre in a region in Spain, with a service population of more than 640,000 people¹⁰⁵. Furthermore, patients with travel time of 60 minutes or more to the nearest hospital in a relatively densely populated region of Canada were less likely to be referred and enrol in CR¹⁰⁴. Other logistical factors that play a role include a lack of transportation and being a non-driver, and living in a rural or a geographically inaccessible area⁵⁷. Distance to the hospital as a barrier for exCR attendance should also be considered in relation to the availability of public transport and traffic density, which may differ between different contexts¹⁰⁶.

The type of hospital was the other structural factor examined in Study A. Patients being followed up either at a university hospital or at a district hospital attended exCR more than those being followed up at a county hospital. This suggests that both large, highly specialised hospitals and small hospitals achieve better uptake. The finding that patients from small hospitals were more likely to attend CR confirms results from previous research¹⁰⁷. Also, according to the SWEDEHEART registry, four out of five hospitals with the highest proportion of patients who had started an exCR programme in 2019 were district hospitals¹⁹. Future studies should examine which aspects related to the type of hospital (such as the model of care, and the expertise of the healthcare providers) are important for ensuring high attendance at exCR.

Individual factors

Individual factors associated with non-attendance at exCR in a Swedish context are similar to those reported from other countries^{56, 57, 102, 103, 108, 109}. Having a higher burden of comorbidities was associated with an increased risk of non-attendance at exCR, which is consistent with previous research^{56, 57, 102, 110}. A higher burden of comorbidities is associated with up to nearly twice the odds of non-attendance at CR programmes⁵⁷. Smoking was also associated with an increased risk of non-attendance at exCR, which is in line with previous studies^{56, 57}. Smokers are more likely to be referred to CR, but less likely to attend and complete CR programmes¹¹¹. Also, continued smoking following a cardiac event is associated with lower rates of adherence to changes in other lifestyle behaviours, such as diet and exercise¹¹². Employment was associated with a lower risk of non-attendance at exCR. This is consistent with previous studies^{56, 57}, and may be due to interaction between employment status and other factors that affect attendance at exCR, such as socioeconomic status^{56, 57, 102, 110}. Competing work commitments are, however, also associated with a higher risk of non-attendance at CR programmes¹¹⁰. What distinguishes the results from the Swedish context from those of most previous studies^{56, 57, 102, 110} is that female gender is associated with higher attendance at exCR. One possible explanation is an increased awareness of the importance of CR in women, while women and men are referred to CR to the same extent in Sweden¹⁹. CR referral is significantly lower for women than for men in many countries¹¹³. However, a recently published European study reported no significant gender differences in referral or attendance at CR¹¹⁴. Differences between countries regarding other factors that explain the lower CR uptake in women, such as family obligations, caretaking responsibilities and multiple role conflicts¹¹⁵, may also play a role in explaining the findings of Study A.

In Study A, only the variables recorded in the SWEDEHEART registry could be investigated. Previous studies have shown that such factors as culture/ethnic aspects^{57, 102, 103, 110}, socioeconomic status^{56, 57, 102, 110}, civil

status^{56, 57}, self-efficacy⁵⁷, and anxiety and depressive symptoms⁵⁷ are important in uptake of exCR, but these were not able to be examined in Study A. Patients with depression are four times as likely not to participate and seven times as likely to dropout from exCR⁵⁷, which shows that psychological screening before starting an exCR programme is necessary, as is also a striving to reach these patients in both clinical and research settings.

Early commencement of CR

The first days of hospitalisation after a cardiac event (phase 1 CR) are important for patient assessment, education and support, and to motivate patients to attend the CR programme¹². Knowledge of the factors associated with non-attendance at exCR, identified in Study A, can be useful at this early stage to identify an individual's needs and conditions, and useful in adapting information, education and support. This can be important to promote attendance at exCR and later also adherence to the programme. Exploration before participation of the participants' characteristics, barriers and facilitators is a key factor in high exercise adherence, as shown by a recent meta-analysis by Collado-Mateo et al.¹¹⁶ that included patients with chronic diseases and older adults¹¹⁶.

Referral routines and the strength of endorsement from physicians are also of high importance for attendance at exCR^{56, 57}. CR should be delivered by a trained multidisciplinary team led by a cardiologist¹². A recently published study¹⁶ suggests that Swedish CR practice can be improved by providing visible leadership through a medical director, and having more regular multidisciplinary team meetings¹⁶. This might facilitate a more coordinated and consistent approach, and in this way provide optimal treatment and referral to exCR. The consistency of information about exCR from all healthcare professionals within the multidisciplinary CR team increases the rate of patients' decisions to attend exCR, while contradictory information negatively affects it¹¹⁷.

Another factor associated with non-attendance at exCR is the feeling that CR is not necessary⁵⁷. CR should be initiated during CR Phase 1¹⁴: at most Swedish CR centres, patients meet a physiotherapist prior to hospital discharge to receive physical activity advice and information about exCR¹⁶. Perk et al.¹¹⁸ reported that a majority of post-PCI patients perceive, from the information provided by physicians and nurses at discharge from the hospital, that they have been cured through the PCI procedure, and only 20% of the patients perceive that they still have CAD and need to change their life habits¹¹⁸. This highlights the difficulty of providing the right information at the right time during a short hospital stay after an acute index event. The timing of the meeting with the physiotherapist and the establishment of a good interaction in this meeting are important for a patient's decision to attend exCR¹¹⁷. It is essential that patients with CAD understand that the disease persists after the reperfusion treatment, and

that it is possible to obtain large positive health benefits by working with modifiable risk factors. Patients who are aware of the health benefits of exercise in relation to their condition are more likely to adhere to exercise programmes¹¹⁶. Uptake and attendance at exCR may benefit from further exploration of how information is being given and received.

The added value of a BMIP in exCR

Exercise adherence

In Study B, the level of exercise adherence (19%) in patients who received routine phase 2 exCR only was the same as the proportion of patients who completed a hospital-based exCR programme in Sweden in 2019¹⁹. Although exercise adherence in the BMIP group was higher (31%), it was lower than expected, and lower than the target value, 60%^{19, 55}. These results illustrate how difficult it is for patients with CAD to adhere to an exCR programme, even when receiving a behavioural medicine intervention. The results of study B are consistent with previous research showing that poor adherence to treatment recommendations, including prescribed exercise, is a worldwide problem among persons with chronic diseases^{58, 119}. Up to 40% of patients with various disease conditions have been reported to fail to adhere adequately to treatment recommendations, with the figure rising to 70% when significant lifestyle modification or complex behavioural changes are required¹²⁰.

The level of exercise adherence in Study B was, however, lower than those of previous studies that also used behavioural change components to enhance adherence to exCR in patients with CAD^{83, 84}. Lynggaard et al.⁸³ found that 80% of the patients who received patient education, including learning and coping strategies, adhered to at least 75% of the hospital-based exercise sessions of an 8-week exCR programme, to be compared with 73% of patients who received routine exCR care only⁸³. In a study by Sniehotta et al.⁸⁴, the adherence level was 71% for a combination of action planning and coping planning with non-supervised aerobic home-based exercise for 2 months following a short residentially based exCR programme. The level was 42% for controls⁸⁴.

One possible explanation of the large variation in adherence between studies may be that “exercise adherence” is defined differently between studies, as there is no clear consensus⁵⁴. It is, thus, difficult to compare studies that evaluate exercise adherence, and difficult to interpret the results. A large spread, from levels of 30% to 110%, has been reported¹²¹. Exercise adherence can be reported in relation to the specific components of the exercise dose or in terms of exercise programme attendance¹²¹. Since the positive treatment effects of exCR depend on adherence in relation to the prescribed exercise dose, it is reasonable to include all components of

the FITT principle when assessing exercise adherence. This was the case in Study B, but has been less common in previous studies^{54, 83, 84}. Even when studies have used the same conceptual measure, different approaches and/or different cut-off points have been used to define exercise adherence⁵⁴. The chosen definition and exact cut-off point that will lead to the expected treatment effect are uncertain. Conraads et al.⁶¹ have presented one definition that allows patients to be divided into three categories: adherent patients (who carry out more than 80% of the prescribed exercise dose), non-adherent patients (who carry out less than 20%, of the prescribed exercise dose), and partially adherent patients who carry out some of the prescribed exercises⁶¹. The definition of exercise adherence used in Study B (i.e. meeting at least 75% of the recommended dose of aerobic and resistance exercise according to exCR guidelines) was in line with the definition used in the SWEDEHEART registry, and with the European cardiac rehabilitation standards^{14, 19}.

The exercise period in Study B was four months, in line with Swedish and European guidelines, which recommend an exercise period of at least three months^{12, 19}. A longer intervention period is a factor that can be related to lower adherence to an exercise programme¹¹⁶. This is alarming, not least for long-term adherence, but also since some physical properties may need a certain amount of time before they are improved by exercise²⁹. Reducing the duration of the interventions, as has been done in some studies of exCR^{63, 83, 84}, may, therefore, not be a satisfactory alternative. Instead, the need for individualisation of the exercise programme in terms of the FITT principle, but also taking into consideration the needs and interests of the patient, is important in promoting adherence¹¹⁶. Burnet et al.¹²² have described the importance of addressing also positive affective responses, known as enjoyment, when prescribing exercise in order to enhance exercise adherence¹²². In Study B, patients were not randomised to a certain exCR setting, and were thus able to take part in a setting in line with their preferences.

In Study B, only patients who fulfilled the definition of adherence for both aerobic and resistance exercise were considered fully adherent. Patients who fulfilled the adherence definition for one type of exercise only were thus classified as non-adherent. The exercise adherence was higher for aerobic exercise than it was for resistance exercise for both groups. Adherence to resistance exercise was also lower in a recently published study that examined the effect of self-regulatory BCTs on exercise adherence in patients during curative cancer treatment¹²³. In exCR, the efficacy of aerobic exercise is well-established, based on the association between cardiorespiratory fitness and mortality^{37, 38}. Thus, aerobic exercise forms the basis of the exCR programme. Personnel in the clinical setting may, thus, give it higher focus, despite greater improvements in cardiovascular fitness and overall risk reduction when aerobic and resistance exercise are combined^{39, 40}. Xia et al.¹²⁴ reported that resistance exercise was more rarely included in home-based exCR programmes than

in hospital-based exCR programmes, in which aerobic and resistance exercise are combined during each session¹²⁴. The combination of aerobic and resistance exercise during each session may increase adherence to resistance exercise. Also, clinical experience has shown that some patients find it easier to appreciate the need for aerobic exercise in their daily life. However, adherence to both aerobic and resistance exercise, and the lower level of adherence to resistance exercise, need to be further investigated.

ExCR setting

Hospital-based exCR was offered as first-hand option in Study B as specified by usual care routines, while patients were also given the option to perform the exCR in a home-based or a combined setting. The proportions of patients in the different settings were similar to those of routine clinical care, and were equal in the two groups. For patients who were defined as fully adherent to the exCR programme, the proportion of patients in the home-based setting did not differ from those of the other two settings. As the intervention in Study B had a patient-centred approach, it was important that the exCR setting and the exercise dose were agreed between the patient and the physiotherapist. ExCR emphasises that a patient-centred approach, which integrates lifestyle changes with exercise, is important¹²⁵. It is also important to incorporate the preferences and needs of the patient if behavioural change components are to be effective¹²⁶.

Different settings offer different possibilities to provide behavioural change components. Supervised exercise is one important factor that positively may increase adherence to exercise programmes. Advantages of supervision include access to the professional's knowledge, feedback, and support during the exercise sessions, which may increase self-efficacy for the exercise programme¹¹⁶. In routine exCR care, resources that can provide feedback relating to the prescribed home-based exercise programme during the exercise period are rare. The support and guidance provided by the physiotherapist at the CR centre and the social support received by peers¹¹⁷, together with vicarious experiences from the group-based exCR, are aspects that cannot be directly transferred into other contexts. Unsupervised exercise programmes can, however, provide increased flexibility, as they can be performed whenever the patient wishes without having to adapt to a schedule¹¹⁶.

Furthermore, the different settings provide different ways to assess exercise adherence. Home-based exercise is often self-reported (so also in Study B), whereas supervised hospital-based exercise offers ways to validate adherence through medical records (so also in Study B)^{116, 121}. These aspects show that measured adherence may not be comparable between supervised and unsupervised settings¹⁵. Hughes et al.¹²⁷ have shown in a meta-analysis that self-reported adherence to exercise for fall prevention in older adults is higher in unsupervised home-based

programmes, while the benefits were lower than those observed in supervised exercise settings¹²⁷.

Alternative models to traditional hospital-based exCR, including home-based settings³³ and E-health solutions¹²⁸⁻¹³⁰, have been developed as part of initiatives to widen access to exCR. Distance to the CR center, which Study A showed to be a strong predictor for non-attendance at exCR, and driving time to hospital are important factors that influence patients' decisions to choose an alternative model of unsupervised home-based exCR over traditional hospital-based exCR¹³¹. Unsupervised home-based programmes can overcome common barriers for attendance at exCR, such as distance to the hospital, but it is difficult in this setting to optimally prescribe and determine the quality of the exercise performed¹²⁴. The use of technological innovations provides opportunities to deliver more supervision to remotely offered exCR programmes¹²⁹, and are being increasingly used^{124, 129}. The use of remote solutions has been given impetus by the Covid-19 pandemic¹³². E-health solutions have, however, been investigated mainly in small heterogeneous studies^{128, 129}, and their efficacy must be further investigated¹²⁴. A multicentre SWEDEHEART registry-based cross-over RCT that evaluate real-time video-based exCR, offered as an alternative to centre-based exCR for patients post-MI, is being conducted, and may provide additional knowledge¹³³. The hospital-based exCR setting differs from remotely offered alternatives also in terms of safety aspects and proximity to the multidisciplinary team, both of which are factors that needs to be considered. Consequently, more research is needed to determine the appropriate setting of an exCR programme⁵. Prerequisites for being able to widen access to exCR programmes are also important. Many programmes that offer alternative models report that resources are insufficient to meet demand¹³⁴. Sufficient physiotherapy resources will be needed to meet the possible increase in the number of patients who take exCR, which is the goal of promoting attendance and adherence to the programme.

Physical fitness, psychological outcomes and HRQoL

It is important to increase adherence to exCR, since this will improve the effects of the treatment. Low levels of exercise adherence may cause some randomised controlled trials intended to assess the benefits of exercise on one or more health outcomes to fail to give significant results¹¹⁶. The current BMIP, which includes self-regulatory BCTs, was intended to increase adherence to the exCR programme. The measurements of physical fitness, psychological outcomes and HRQoL, however, were not significantly different from those of routine exCR care alone. All outcomes of physical fitness, most SF-36 domains, EQ-VAS and HADS-A improved significantly for both groups between baseline and the four-month follow-up.

The results of Study B that showed improved aerobic exercise capacity in both groups at the four-month follow-up are in line with a newly published European position statement, which states that aerobic exercise capacity will increase by at least 5-10% after attendance in an exCR programme¹⁴. The mean change in submaximal aerobic exercise capacity during the exCR programme in the current study was also in line with SWEDEHEART registry data, which reported a mean change of 12.1 W (13.4%)¹⁹. It is difficult to compare the results from Study B relating to aerobic exercise capacity with previous research using behavioural change components in exCR, due to the lack of objective outcome measures of physical fitness. The improvements in HRQoL at the four-month follow-up found in Study B are consistent with the results of two recently published meta-analyses, which showed that several SF-36 domain scores improved after exCR^{41, 42}. Favourable changes in domains of SF-36 have also been reported for both men and women who participated in a group-mediated cognitive behavioural physical activity intervention. These scores improved also in men who received only routine exCR care, but to a lesser extent in women. The effects were greatest in patients with the lowest baseline values⁸⁵.

The patients in Study B had higher submaximal aerobic capacity, both at baseline and after completion of exCR, than patients registered in SWEDEHEART¹⁹. Patients in Study B also reported lower levels of anxiety and depression at baseline than those reported in a study by Hansen et al.¹³⁵ for a cardiac population and for a reference population¹³⁵. Further, HRQoL was higher than that of patients with CAD in previously published studies¹³⁶⁻¹³⁸. In addition, the baseline EQ-5D index was more favourable for patients in Study B than in the general Swedish population¹³⁹. This may be an effect of selection bias, as a study of this design requires selection of patients based on given inclusion/exclusion criteria, and more healthy patients with CAD with a potentially greater interest in their own health are more likely to participate in this kind of study. It is probable that patients who participate are more highly motivated and more receptive to exercise than patients with CAD in the general population. This may lead to the effects of the intervention being underestimated, since large differences cannot be expected when the values at baseline are already favourable. Consequently, further studies are needed to investigate the effects of a BMIP in more heterogeneous clinical populations of patients with CAD with broader physical and psychological profiles. The fact that HRQoL and psychological outcomes typically improve as the clinical course progresses after an index event related to CAD^{19, 140, 141} must also be taken into account when estimating the possible effects of an intervention of this kind.

The groups in Study B did not differ significantly in self-efficacy for exercise either within or between the groups. One possible explanation could be that the patients in both groups had high levels of self-efficacy for exercise at baseline. This is consistent with results from a previous study that reported the highest level of self-efficacy at the beginning of a CR programme¹⁴². Self-efficacy is one of the most widely known key factors for improving

adherence to exercise in all populations¹¹⁶, and is related to exercise behaviour during and following CR¹⁴³. Cederbom et al.⁷³ showed that self-efficacy for exercise improved for an individually tailored BMIP group of older women from the values obtained from receiving regular physical activity advice, but, consistent with Study B, self-efficacy between the groups was not significantly different⁷³.

Patient enablement has to our knowledge not been reported in patients with CAD. The levels of PEI that measured the self-rated effect on enablement after the intervention at four months in study B were similar to median values after treatment in other diagnostic groups¹⁴⁴. A PEI value greater than 6 indicates a meaningful effect in studies of primary care¹⁴⁵. The PEI values in the current study are consistent for both groups at the 12-month follow-up, which shows that adequate enablement remains. The concept of enablement represents patients' empowerment and ability to cope, understand, and manage with their illness¹⁴⁶. This aspect is important for patient's active role in their treatment, which in turn may have a positive impact on adherence¹¹⁶.

Design of the BMIP

A recent Cochrane review has shown no significant differences between the groups in sub-group analyses for theory-based interventions that aimed to increase adherence in a CR setting⁶³. Similarly, Study B showed no differences between the groups. Several explanations are available for this lack of difference, one of which is the selection of patients as discussed above. Another is the design of the BMIP. Certain elements of BCTs are already included in routine exCR, and it is possible that both groups were provided with sufficient support, and that the added value of a BMIP that included structured goal-setting, re-evaluation of the goals, self-monitoring and feedback, based on the CT⁷⁸ was not sufficient to make a difference.

Several BCTs have been identified as key factors in promoting adherence to exercise in patients with chronic disease and in older adults. These include social support, feedback, self-monitoring and goal-setting¹¹⁶. In patients with CAD, goal-setting⁸² and the provision of information are the most commonly used BCTs, but it has not been possible to identify the active ingredients of these behaviour change interventions⁸¹. The BCTs used in the behavioural medicine intervention in Study B were structured and comprehensive goal-setting, self-monitoring and feedback. Some elements were provided for those who received routine exCR care, such as general goal-setting for the exercise programme, some elements of general feedback, and the keeping of a record of exercise in a diary. The importance of social support from healthcare providers, peers and family members is one of the most frequently described factors that influences the participation of patients in exCR^{82, 103}, and such support was equal for all participants in Study B. Patients describe that sharing experience with

peers and the feeling of not being alone in suffering from a cardiac event as important aspects for attendance at and adherence to exCR. A further factor is trust in the expertise of the physiotherapists in providing motivation, advice and adequate information about exercise^{103, 117}. The provision of objective measures of their progress to patients is a further important factor associated with adherence to exercise¹¹⁶. In Study B, all patients performed tests of physical fitness at baseline, at the end of the intervention, and at the long-term follow-up. Patients in the BMIP group also received visual feedback on objectively measured physical activity levels on one occasion during the intervention.

Furthermore, routine exCR is a part of a comprehensive CR programme that involves lifestyle behavioural change, and that includes patients' adherence and self-management¹². In Study B, one physiotherapist was responsible for the BMIP, while the other physiotherapists involved in routine exCR care did not have insight into the content of the BMIP. However, it was difficult to know in detail what information, support, and encouragement the physiotherapists and other caregivers within the CR programme gave to patients in both groups.

The fact that what some patients described as a barrier could be described by other patients as a facilitator, one example of which is the nature of the exCR setting¹¹⁷, highlights the need to adapt and tailor the exercise programme to the preferences and needs of the individual patient^{12, 116, 147}. This also applies to components of the behavioural medicine intervention.

In Study B, all participants in the intervention group received a BMIP with the same content, and tailoring to meet individual needs for example by providing more frequent feedback, was indeed limited in the context of an RCT. Nor was it possible to adapt and tailor the design of the BMIP for factors associated with non-attendance at exCR in an individual, such as the individual's psychological profile. Thus, it may be possible to improve several aspects when considering behavioural medicine interventions in exCR.

Exercise maintenance

Results from study B indicated a non-significant tendency towards positive long-term effect on submaximal aerobic exercise capacity in the BMIP group and a deterioration in the RC group between the end of the intervention and the 12-month follow-up. It is possible that the effect in the BMIP group arose from sustained effects of the behavioural change. It can be speculated that the self-regulatory BCTs used in Study B gave participants in the BMIP group the opportunity to develop self-regulatory skills that they used after the end of the intervention to maintain their exercise behaviour. However, it is important to point out that this result shows only a trend that may support future hypotheses on the long-term effects of a BMIP in exCR. Self-regulatory BCTs such as goal-setting, self-

monitoring¹⁴⁸ and follow-up prompts¹⁴⁹ have been found to be effective to maintain physical activity in other patient groups with chronic disease or obesity^{148, 149}. Adopting effective behavioural change strategies is also important for maintaining long-term positive lifestyle behavioural change in patients with CAD¹⁵⁰. Qualitative studies have shown that goal-setting is an important strategy for continued exercise after completion of a phase 2 exCR programme in patients with CAD^{117, 151}. Other important factors are self-monitoring techniques and social support from family and friends¹⁵¹. Patients also stated that lack of support and guidance from the healthcare provider made the maintenance of exercise more challenging after the end of an exCR programme^{117, 151}. Patients expressed a desire for clearer support from the physiotherapists about how or when to exercise, the availability of further advice if necessary, and the offer of long-term follow-up¹¹⁷. In Study B, patients in the BMIP group were offered a structured and comprehensive follow-up meeting at the end of the intervention to set a specific long-term exercise goal and to discuss potential future barriers, facilitators and strategies related to future adherence to exercise. A long-term follow-up for outcome assessment was conducted for all patients in Study B at 12 months, but no active intervention was given in the intervening period.

Sánchez-Delgado⁵⁰ concluded in a systematic review that the understanding, availability, and use of maintenance CR programmes must be increased⁵⁰. Efforts should certainly also be made to increase attendance at and adherence to phase 2 exCR, since the maintenance phase is based on healthy behaviours achieved in previous phases of CR. Increased knowledge of factors that predict adherence to phase 2 exCR programmes is needed, in order to develop and integrate these factors into future programmes. Since the need for active self-regulation changes over time and the course of the process of behavioural change¹⁵², it is important that patients are given tools for continued exercise also once the programme has ended. The possible long-term effects of a BMIP in exCR needs further investigation.

Methodological considerations

The SWEDEHEART registry, which was used in Study A, forms an important basis for research on cardiac disease and cardiac interventions. One strength of a registry-based study of this kind is that it examines a large sample that mirrors the real-world population, which means that the results can be more readily generalised. The large amount of data in Study A made it also possible to analyse important structural factors related to non-attendance at exCR, and to obtain new information in this field. However, although SWEDEHEART collects data from nearly all patients with MI younger than 80 years in Sweden, the population is not completely unselected. The 20% of patients who have suffered an MI and who are not followed up in SEPHIA have a higher prevalence of cardiovascular risk

factors and a greater history of cardiovascular disease than the patients included in the registry^{19, 55}. Study B was designed as a randomised controlled trial, which is regarded as the gold standard for examining whether a particular treatment is effective. One limitation of this design is that it may introduce selection bias. Patients included in Study B were predominately male, of Swedish background, and without major comorbidities that would interfere with participation in the study. Furthermore, the patients included showed favourable outcome measures already at baseline, and were motivated to take part in an exCR intervention. This means that the findings of Study B cannot be fully generalised. This highlights that it is difficult to reach patients who would benefit the most from exCR interventions, and the need for further investigations in broader CAD populations.

The use of an upper age limit in both Study A and Study B was a further limitation. In Study A, the SWEDEHEART registry contained data from patients younger than 75 years at the time of the data collection. In Study B, we chose an age limit of 75 years because it corresponded to the age limit used in the SWEDEHEART registry at the time for inclusion in the study. The age limit in SWEDEHEART was increased to 80 years in 2018, as a consequence of longer life expectancy and better survival after MI. According to the SWEDEHEART registry, the mean age of registered patients who suffered an MI in Sweden in 2019 was 71 years¹⁹. High age also acts as a barrier for uptake in exCR^{56, 57, 102, 110}, which declines significantly after age 70 years¹⁵³.

The proportion of males included in Study B was slightly higher (80%) than the proportion of males included in Study A (75%), which reflects the distribution of men and women included in the SWEDEHEART registry at the time of data collection. The incidence of CAD is higher in men than in women³, and it is probable that more men than women participate in studies of this kind. Women are, however, under-represented in exCR programmes in many countries^{56, 57, 102, 110}, a finding that was not confirmed for a Swedish context in Study A.

The SWEDEHEART registry, used in Study A, ensures a high validity of the data since the registry has high coverage, and the data are entered using highly standardised data collection procedures. The data in the registry agree with data from medical records to better than 95%⁵⁵. The variable “participation in an exercise training programme” is, however, often based on self-reported information, which is not always validated through medical records. This is a limitation in the study. The logistic regression model used in Study A explained 7.6% of the variance when distance to the CR centre was included as an independent variable. It is possible that the amount of variance in non-attendance at exCR that the models explain would be larger when more variables are included. The SEPHIA registry does not, for example, provide information about socioeconomic status,

culture/ethnic aspects, the incidence of anxiety or depressive symptoms, and previous levels of physical activity.

A strength of Study B was the use of BCTs that were based on a theoretical framework, which has been positively associated with adherence and physical outcomes in interventions in other patient groups⁶⁵, and for patients with CAD^{64, 67}. Furthermore, the current BMIP was designed and adapted for implementation into routine exCR care, and components that required additional education were excluded.

Another strength of Study B was the use of all components of the FITT principle when assessing exercise adherence. Moreover, the long-term follow up at 12 months enabled analysis of exercise maintenance. Organisational aspects meant that it was not possible to blind the physiotherapists to the group allocation of patients, which is a weakness. Patients were, however, not informed of their group allocation; the test procedure was validated between the physiotherapists involved; and standardised test protocols were used.

In Study B, within and between group differences were analysed with the paired samples t-test and the independent samples t-test, respectively. The use of a mixed-design ANOVA with time and group interaction is another appropriate method that we considered using to analyse differences between groups over time. However, preliminary analysis of the different methods did not reveal any differences in the results, and we thus saw no reason to deviate from the published study protocol for Study B.

Other methodological limitations in Study B are the use of a single-centre design, and that the sample size calculation was performed on the primary outcome, submaximal aerobic exercise capacity, and not on the secondary psychological outcomes and HRQoL. Furthermore, the per-protocol analysis was limited by the small number of patients in each group. Finally, home-based exercise adherence was evaluated with self-reported exercise diaries. Self-reporting is commonly used due to its practicality, low cost and low participant burden^{154, 155}, but the accuracy of recall is limited, and the method suffers from response bias^{155, 156} and a risk of over- or underestimation of physical activity¹⁵⁵. Self-reported measures of physical activity have been higher than directly measured levels of physical activity in some studies, and lower in others¹⁵⁵.

CONCLUSIONS

- Individual and structural factors associated with non-attendance at exercise-based cardiac rehabilitation in a large Swedish cohort of patients post-myocardial infarction were identified as having a distance greater than 16 km to the hospital, belonging to a county hospital, having a higher burden of comorbidities, being male, and being retired.
- Distance to the hospital was the strongest predictor for non-attendance at exercise-based cardiac rehabilitation, which emphasises the need to widen the accessibility of exercise-based cardiac rehabilitation.
- The individual factors associated with non-attendance at exercise-based cardiac rehabilitation in a Swedish context were similar to those identified in previous studies from other countries, with the exception that female gender was associated with a higher attendance at exercise-based cardiac rehabilitation.
- Exercise adherence was higher when a behavioural medicine intervention in physiotherapy, (including structured specific goal-setting, re-evaluation of goals, self-monitoring and feedback), was added than it was for routine exercise-based cardiac rehabilitation care alone.
- Adherence to the exercise-based cardiac rehabilitation programme was low in both groups (31% in the group that had the behavioural medicine intervention in physiotherapy in addition to routine care, and 19% in the group that had only routine care).
- The behavioural medicine intervention in physiotherapy gave no additional value above that of routine exercise-based cardiac rehabilitation care alone for physical fitness, psychological outcomes or HRQoL.
- The patients included in the current RCT had a higher submaximal aerobic capacity, better psychological profile, and higher HRQoL than the general population of patients with coronary artery disease, thus reducing the room for improvement and potentially also limiting the value of a behavioural medicine intervention in physiotherapy added to routine exercise-based cardiac rehabilitation.

Clinical implications

- Special attention to the individual and structural factors identified in this thesis may help to identify patients with an increased risk of non-attendance at exercise-based cardiac rehabilitation in a Swedish context.
- Knowledge of factors affecting attendance at exercise-based cardiac rehabilitation can be used to direct and tailor interventions to the patient.
- The results of the intervention study confirm previous difficulties in clinical practice of trying to achieve a behavioural change to exercise in a variety of patient populations, and also in the secondary prevention of CAD.
- Adherence was low in both groups, but was higher in the group for which a behavioural medicine intervention in physiotherapy was added, indicating that there is room for improvement of such interventions within exercise-based cardiac rehabilitation.

Implications for future research

- Low attendance and adherence at exercise-based cardiac rehabilitation remain a matter of major concern that should be given a high priority in future research.
- A consistent definition for exercise adherence to exercise-based cardiac rehabilitation, including all components of the FITT principle, should be used in future research.
- Factors that predict adherence to exercise-based cardiac rehabilitation programmes need to be further explored.
- Further research that evaluates reliable and valid objective methods to measure exercise adherence is needed.
- The results of the present thesis can inform the development and evaluation of new behavioural medicine interventions in exCR, tailored to meet individual needs in a broader population of patients with coronary artery disease, with the overall aim to increase exercise adherence and rehabilitation outcomes.
- The effect of alternative models to traditional hospital-based exercise-based cardiac rehabilitation, designed to increase accessibility, attendance at and adherence to exercise-based cardiac rehabilitation needs to be further explored.

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