Avhandlingsserie för
Gymnastik- och idrottshögskolan

Nr 17

Physical activity among patients with cardiovascular disease

- a predictor of hospital care utilisation and mortality in clinical work

THE SWEDISH SCHOOL OF SPORT AND HEALTH SCIENCES

Physical activity among patients with cardiovascular disease

- a predictor of hospital care utilisation and mortality in clinical work

Amanda Ek

Gymnastik- och idrottshögskolan 2020
ISBN 978-91-983151-8-9

Tryckeri: Universitetsservice US-AB, Stockholm 2020
Distributör: Gymnastik- och idrottshögskolan

With all my love to Christoffer,
Selma, Herman and Greta

ABSTRACT

Guidelines highlight the importance of physical activity (PA) in secondary prevention of cardiovascular disease (CVD) within the healthcare sector. Previous studies have mainly focused on the effects of PA at moderate-vigorous intensity performed within exercise-based cardiac rehabilitation (CR). However, only a minority of patients with CVD participate in exercise-based CR, and it is not known to what extent the guidelines for PA are implemented in clinical work. This leads to a knowledge gap in PA levels among patients with CVD, and the potential association of PA with hospital care utilisation and all-cause mortality. The overall aim of this thesis was to investigate PA and its importance for patients with CVD, and to what extent it is promoted during clinical work. The associations between self-rated PA level, changes in self-rated PA level, and sedentary time (SED) with hospital care utilisation and all-cause mortality were explored in three cohort studies (Studies I-III). Data were collected via questionnaires, medical records and national registers. Study I explored everyday PA, physical exercise and SED among patients with CVD (n=1148) prior to admittance to a cardiac ward at two of the hospitals in Stockholm. Studies II and III explored PA (of at least moderate intensity) post hospitalisation, and included 30 644 and 22 227 patients with myocardial infarction (MI), respectively, from the national SWEDHEART registry. Finally, in Study IV, healthcare professionals' (n=251) stated importance and clinical work to promote healthy lifestyle habits (alcohol consumption, eating habits, physical activity, and smoking) were explored in a cross-sectional study. All healthcare professionals working on cardiac departments in two hospitals in Stockholm were included.

The main findings were:

- PA level (everyday PA, physical exercise, total PA level) and SED pre and post hospitalisation for cardiac events were found to be significant predictors of hospital care duration, readmission and mortality. The effects of high PA level and low SED did not differ between CVD diagnosis, sex, age, or comorbid states such as individuals with and without diabetes mellitus type II, kidney dysfunction, hypertension or dyslipidaemia.

- There were no differences between individuals reporting a moderate or high level of PA or a medium or low level of SED, illustrating that “a little activity is better than nothing” and that the greatest health benefits would be achieved by increasing PA among the most inactive patients with CVD.

- Changes in PA level during the first year post MI are important. Increased PA lowered the risk of mortality, and decreased PA increased the risk of mortality in patients post MI.

- Healthcare professionals considered it important to promote lifestyle habits among patients within the healthcare sector in general, as well as in their own clinical work. However, there was a difference between stated importance and clinical practice as only a minority of healthcare professionals asked or provided counselling on healthy lifestyle habits. Our results indicated a relationship between promoting patients’ lifestyle habits in clinical work, and if they perceived clear organisational routines and objectives.

In conclusion, the results of this thesis have a clinical impact. Firstly, asking patients on a cardiac department about their PA level and SED may identify individuals in need of behavioural changes. By identifying and supporting individuals who need to increase their PA level, clinicians may potentially decrease the utilisation of inpatient care and also lower the risk of all-cause mortality among individuals with a CVD diagnosis. Secondly, this information is of great predictive value, and PA can be seen as an additional marker of disease severity.

List of scientific papers

This thesis is based on the following studies, referred to in the text by their Roman numerals:

I. Ek A., Kallings L., Ekström M., Börjesson M., Ekblom Ö. Predictive value of pre-hospitalisation physical activity level and sedentary time for hospital utilisation and all-cause mortality among patients with cardiovascular disease (in revision).

II. Ek A, Ekblom O, Hambraeus K, Cider A, Kallings LV, Borjesson M (2019) Physical inactivity and smoking after myocardial infarction as predictors for readmission and survival: results from the SWEDEHEART-registry. Clin Res Cardiol: 108 (3):324-332.

III. Ekblom O, Ek A, Cider A, Hambraeus K, Borjesson M (2018) Increased Physical Activity Post-Myocardial Infarction Is Related to Reduced Mortality: Results from the SWEDEHEART Registry. J Am Heart 7 (24):e010108.

IV. Ek A., Ekblom Ö., Ekström M., Börjesson M., Kallings L., The gap between stated importance of and clinical work in promoting healthy lifestyle habits, by healthcare professionals in a Swedish hospital setting: a cross-sectional survey (in revision).

CONTENTS

ABBREVIATIONS

ACS	Acute coronary syndrome
BMI	Body mass index
CAD	Coronary artery disease
CHD	Coronary heart disease
CI	Confidence interval
CR	Cardiac rehabilitation
CV	Cardiovascular
CVD	Cardiovascular disease
DALY	Disability adjusted life years
eGFR	Estimated glomerular filtration rate
HF	Heart failure
HR	Hazard ratio
HRQoL	Health-related quality of life
IHD	Ischemic heart disease
IQR	Interquartile range
LIPA	Light-intensity physical activity
LVEF	Left ventricular ejection function
MI	Myocardial infarction
MVPA	Moderate to vigorous physical activity
OR	Odds ratio
PA	Physical activity
PCI	Percutaneous coronary intervention
Riks-Hia	The Register of Information and Knowledge about Swedish Heart Intensive Care
SED	Sedentary time
SEPHIA	Secondary Prevention after Heart Intensive Care Admissions
STEMI	ST elevation myocardial infarction
SWEDHEART	Swedish Web-system for Enhancement and Development of Evidence-based care in Heart disease Evaluated According to Recommended Therapies

1 INTRODUCTION

As a physiotherapist meeting patients with cardiovascular diagnoses (CVD), I have always had great interest in promoting physical activity (PA) among patients within exercise-based cardiac rehabilitation (CR).

There is evidence that participation in exercise-based CR is positively related to decreased risk of premature cardiovascular mortality, hospital admission, and higher level of health-related quality of life (1). Both among the patients I met and in previous studies, rehabilitation is usually focused on patients presenting with ischemic heart disease (IHD) or heart failure (HF). Therefore, little is known about individuals with other cardiac problems such as cardiac arrhythmias, valvular heart disorder and inflammatory heart diseases. Additionally, not all patients are offered exercise-based CR, and some who are offered choose not to participate. Another important aspect is that exploring the PA performed within exercise-based CR does not give any information on the patients' total PA behaviour. Kaminsky et al. concluded that patients participating in exercise-based CR only reached the recommended amount of PA on the days they participated in rehabilitation sessions (2). Another study reported that PA levels decrease after the CR period had ended (3). This highlights the need to monitor patients' total PA level and sedentary time (SED) over the whole week, regardless of whether a patient is currently participating in exercise-based CR or not.

It is well known that PA levels change during an individual's lifespan. Major life events, such as suffering from chronic disease, may affect the amount of PA a person regularly undertakes. This aroused my interest to investigate PA levels at different time periods for patients with CVD, i.e. preceding, directly after, and one year after being hospitalised for CVD, in order to determine whether associations between PA and morbidity or mortality was continued to be seen. Additionally, by using repeated PA assessments, changes in PA behaviour could be linked to mortality.

Finally, knowing that the majority of patients should be offered exercise-based CR do not participate, made me interested in looking at healthcare professionals' clinical work and attitudes toward promoting physical activity.

My journey from physiotherapist with an interest in promoting PA among patients with IHD or HF, to a researcher has been long, challenging and rewarding. However, the objective has always been to make a difference for the patients. I hope this thesis will help spread the knowledge of the importance of exploring PA behaviour among patients with cardiovascular disease in order to predict future morbidity and mortality. By asking all patients about their PA, it is possible to provide individualised support for those who need to improve their PA level.

2 BACKGROUND

During the last few decades, the development of technology, e.g. accesses to computers and television, decreased use of non-motorized transportation as well as fewer occupations that involve PA, has led to a more sedentary lifestyle (4). This is alarming and the World Health Organisation (WHO) rank low PA as the fourth most important risk factor globally for all-cause mortality (5). Additionally, regular PA is an important factor in primary and secondary prevention of several non-communicable diseases, such as cardiovascular disease (CVD) (6, 7). Therefore, it is important to explore the associations between PA behaviour and CVD.

2.1 Cardiovascular disease

CVD is a group of disorders of the heart and blood vessels. CVD type is categorized as being due to atherosclerosis (Ischemic heart disease (IHD), cerebrovascular disease and disease of the aorta and arteries) or other CVDs (congenital heart disease, rheumatic heart disease, cardiomyopathies and cardiac arrhythmias) (8). Atherosclerosis is developed over many years and is the main cause of CVD. It is a complex process primarily affecting the innermost layer of the arterial wall through intimal inflammation, necrosis, fibrosis and calcification. This leads to thickening and hardening of the vessels and may cause obstruction of the flow or thrombosis (9).

In 2015, more than 85 million individuals across Europe were living with CVD. The incidence was approximately 11.3 million cases, almost equally distributed between men (5.4 million) and women (5.8 million). This shows an increase in cases since 1990. The increase in absolute number of CVD cases corresponded to an increase in the size of the total population, and in the number of elderly in particular (10). When controlling for these variables, the rate of CVD cases decreased by 9% and 5% in males and females, respectively (11). Despite a decrease in CVD incidence and mortality, the burden of CVD events and mortality is still high (8, 11, 12). In Europe, CVD is responsible for 45 % of all deaths (> 3.9 million deaths a year) (11) and IHD is the leading single cause of CVD mortality (8, 11). In Sweden, the adjusted decreasing incidence and mortality trend is similar to that of Europe as a whole. Despite this, in 2016, CVD was the most common cause of death and comprised 34 % of all mortality cases (13). In addition, the age-standardised rates of disability-adjusted life years (DALY) lost to CVD have decreased in Europe over the past 25 years. Nevertheless, in 2015, CVD was still responsible for 64.7 million DALYs in Europe, and the leading cause of lost DALY (11).

2.2 Risk factors for cardiovascular disease

CVD is multifactorial and there are several well-known risk factors. A risk factor is any exposure of an individual or population that leads to increased risk of developing future disease. Catapano et al. define cardiovascular risk as “the likelihood of a person developing a fatal or a non-fatal atherosclerotic cardiovascular event over a defined period” (14).

There have been changes in risk factors of CVD over time. In Europe during the last three decades, more than half the reduction in CVD mortality has been attributed to changes in risk factor levels in the population (15). This has been primarily attributed to the reduction of dyslipidaemia, lower blood pressure levels and a reduced prevalence of smoking and hazardous use of alcohol (11). However, this favourable trend is partly counterbalanced by an increase in other risk factors, mainly obesity and type 2 diabetes mellitus (11).

Many of the risk factors are closely related to each other with direct, indirect and intermediating effect. In addition, there is a cumulative effect of risk factors, meaning that adding more risk factors results in a non-proportionate increase in the risk of developing future cardiovascular disease. Yusuf et al. concluded that abdominal obesity, abnormal lipids, hypertension, diabetes, psychosocial factors, smoking, insufficient PA, hazardous use of alcohol and low consumption of fruits and vegetables together contribute to more than 90% of the population’s attributable risk of MI worldwide. This was found to be true for both sexes and all ages in all regions (16).

There are different methods of sorting risk factors of CVD. In this thesis, the risk factors are grouped as: “non-modifiable risk factors”, “socioeconomic status and health-related quality of life”, “intermediate risk factors” and “lifestyle habits” (Figure 1).

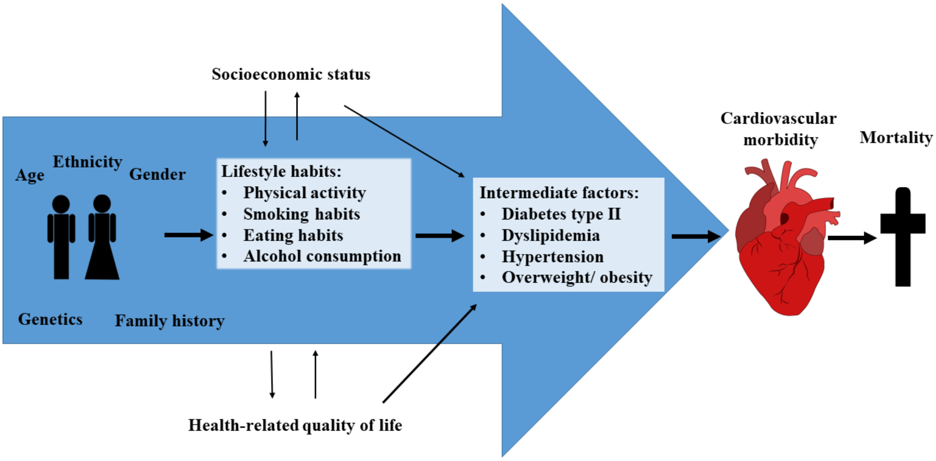

Figure 1. Illustration of cardiovascular risk factors and development of cardiovascular morbidity and mortality.

2.2.1 Non-modifiable risk factors

With increasing *age*, the risk of CVD becomes higher (17). This is important to take into consideration from a public health perspective since the proportion of people aged 65 or older will grow rapidly from 2016 to 2070 (10).

There are also *sex* differences. Men have a less favourable cardiovascular risk profile and tend to have an myocardial infarction (MI) earlier in life compared to women (18). According to the Swedish Register of Information and Knowledge about Swedish Heart Intensive Care Admissions (Riks-HIA), the mean age of patients suffering from MI in Sweden in 2017 was 69.2 for men and 74.6 for women (19). Women seem to be protected by the effect of natural oestrogen prior to menopause. Additionally there are also differences in a number of cardiovascular risk factors (see below) (20).

Family history of IHD is defined as occurrence of premature IHD (< 50 years) in a first-degree relative (parent or sibling) (21). This is a major risk factor for MI, particularly in young patients (16, 21). The higher risk among individuals with a family history may be due to the sharing of genes, environment and prevalence of traditional risk factors (21, 22). In patients with, versus without, a family history of IHD, Choi et al. found a higher rate of dyslipidaemia (64% vs 53%, respectively) and obesity (46% vs 38%, respectively) (22).

In recent years, a large number of gene variants that increase the risk of MI have been identified (23, 24). *Genetic factors* have been associated with CVD independently of family history or established risk factors (25). There are several known gene variants associated with CVD and the effect size differs from large but only affecting a small population, or small but widespread (26).

The global burden of CVD (prevalence of morbidity and mortality) has been found to vary (8) and there are differences in cardiovascular risk factors between different *ethnicities* (27, 28). However, how these differences contribute to variances in the prevalence of CVD is not known. In a tri-ethnic community-based cohort from North and West London, which included Europeans, South Asians and African Caribbeans, the incidence of IHD could not be explained by differences in risk factors (28). Meanwhile, DalCanto et al. stated that cardio-metabolic risk factors in different ethnicities could, in part, explain the CVD prevalence (27). Despite the diverse data, Yusuf et al. suggested that prevention of IHD can be based on similar principles throughout different ethnicities worldwide (16).

2.2.2 Socioeconomic factors and health-related quality of life

Socioeconomic status (SES) can be assessed through level of education, family income, household possessions and occupation. There is an association between SES and CVD risk in high-income countries. Previously, risk factors and CVD morbidity were more common in upper socioeconomic groups in high-income countries (8, 29, 30). This has changed during the last 50 years, and socioeconomically disadvantaged individuals now experience higher rates of CVD and CVD mortality. The inverse association between SES and CVD is the result of behavioural and psychosocial risk factors. A large case-control study including individuals from 52 different countries found the odds ratio (OR) for having an MI in individuals with a low education level compared to a high education level, adjusted for age, sex and region, was 1.56 (95% confidence interval 1.47 - 1.66). This association was also seen in fully adjusted models. There were no, or only weak, associations between the risk of MI and other socioeconomic factors, i.e. family income, number of possessions and non-professional occupation. (29). Differences in modifiable lifestyle factors (smoking, PA level, consumption of vegetables and fruits, alcohol use, and abdominal obesity) explained a large part of the socioeconomic gradient (29, 31). Other important factors were poorer health-seeking behaviours, having reduced access to medical care and social support, higher levels of stress at work and greater co-morbidity among lower SES groups (32).

Health-related quality of life (HRQOL) has been considered a relevant risk factor for CVD during recent years. Pinheiro et al. followed 22 229 adults with no history of CVD up to ten years. Individuals with lower self-rated quality of life were found to have increased hazard ratios (HR) of CVD (1.46; 95% 1.24–1.70) when adjusted for demographics, comorbidities and CVD risk factors (33). Additionally, *psychosocial stressors* (depression, financial stress, low locus of control, major life events, stress at work and at home) have been highlighted as important predictors of MI (34).

2.2.3 Intermediate risk factors

Diabetes mellitus type II, dyslipidaemia, hypertension and overweight/obesity are well-known diagnoses both closely associated with, and used to predict the development of CVD. They are also closely associated with lifestyle habits that will be further discussed in "2.2.4 Lifestyle habits" and "2.3.1 Association of physical activity level and sedentary behaviour with cardiovascular risk factors".

Diabetes mellitus type II is defined as the presence of a high level of fasting glucose. High levels of glucose cause damage to blood vessels, increasing the risk of CVD directly. Over the past 30 years, the prevalence of diabetes mellitus type II has increased across Europe. In 2017, 3.8 % of adults in Europe were diagnosed, although there is strong evidence that the number of individuals with diabetes is underestimated (11). Diabetes mellitus is associated with IHD, HF, hypertension and valvular heart disorder (35). Notably, the relative risk of CVD is higher for women with diabetes mellitus type II compared to men (20).

Dyslipidaemia is characterized by increased levels of triglycerides, total cholesterol, low-density lipoprotein (LDL) and low levels of high-density lipoprotein (HDL) (20). During the past 30 years, the prevalence of dyslipidaemia has decreased globally (11, 36). Abnormal lipids are associated with CVD due to the promotion of arterial plaque formation (11).

Hypertension is seen in approximately one third of the adult population worldwide and is considered one of the major cardiovascular risk factors (37). Hypertension affects the entire cardiovascular system. It accelerates atherosclerosis, reducing the vessel's ability to dilate and change the myocardial structure due to fibrosis and myocyte hypertrophy (38).

Overweight and obesity are associated with other CVD risk factors, e.g. dyslipidaemia, high blood glucose and low-grade systemic inflammation. There are different methods of assessing overweight/obesity such as body mass index (BMI) and waist circumference. BMI is calculated as body weight in kilograms divided by the length in meters squared (kg/m^2). Obesity is defined as ≥30 kg/m^2 (15). However, BMI does not give information about the distribution of body fat or the relative amounts of fat and muscle, which differ by sex and age. During recent years, waist circumference has been more commonly used. This is measured in a standing position, midway between the lower rib margin and the iliac crest. Abdominal obesity is defined as a high waist circumference > 88 cm in women and >102 cm in men (15). Individuals who are overweight or obese have a higher risk of CVD morbidity and mortality. On the other hand, in individuals with established CVD, an inverse relationship between being overweight and having increased CVD risk has been observed. This is referred to as the obesity paradox where a poorer prognosis is seen among individuals that are underweight (39).

2.2.4 Lifestyle habits

International and national guidelines emphasise the four lifestyle habits of physical activity (PA), smoking, eating habits and alcohol consumption as important factors in promoting public health (15, 40). This thesis primarily focuses on PA, but also includes hazardous use of alcohol, eating habits and smoking. PA will be further described in section “2.3 Physical activity level and sedentary time”.

High levels of *alcohol consumption* increase the risk of CVD by increasing levels of triglycerides, elevating blood pressure and increasing the risk of atrial arrhythmias and cardiomyopathy (41). Europe has the highest alcohol consumption in the world. The prevalence of heavy drinkers (≥60 grams of alcohol on at least one occasion during the past 30 days) was 47% among men and 14% among women in 2016 (42).

Eating habits are an important modifiable risk factor affecting both cardiovascular risk directly, and other risk factors indirectly. High consumption of trans fats and saturated fats increase the risk of atherosclerosis. Consumption of sodium increases the risk of hypertension. Fish, fruits, vegetables and dietary fibres have a protective effect on coronary outcomes (43). The WHO recommends ≥400 grams of fruit and vegetables a day, <5g of salt a day, and a limited intake of dietary sugar and fat. In addition, the WHO highlights the importance of balancing total energy intake with energy expenditure (44).

According to the Food and Agriculture Organisation of the United Nations, the supply of dietary energy and the amount of fat has increased in Europe. In addition, a large number of European citizens do not reach the recommended level of daily vegetable and fruit consumption. On average, a greater proportion of women than men (56 % vs 44%, respectively) reported consuming vegetables at least daily. The consumption of fruit was generally higher, 61% of women and 49% of men reported daily consumption (11).

Smoking is a well-know CVD risk factor. It enhances the development of atherosclerosis and the formation of thrombus through its effect on endothelial function, oxidative processes, platelet function, fibrinolysis, inflammation, modification of lipids and vasomotor function (45). There has been an increase in awareness of the negative effects of cigarette smoking worldwide leading to a decrease in smokers (46). Still, smoking remains a key public health issue in Europe. In 2015, the prevalence of smoking was 38% among men and 17% among women (11). Previous studies have concluded that the risk of MI among smokers is higher among women than men. However, men and women suffering from MI had the same positive effect of smoking cessation (20, 47) .

2.3 Physical activity level and sedentary time

2.3.1 Association between physical activity level, sedentary behaviour and cardiovascular risk factors

Regular PA and diet reduces or delays the incidence of *type 2 diabetes mellitus* in individuals at high risk (48, 49). However, while regular PA improves glucose uptake and insulin sensitivity (50-52), there is no firm evidence that PA alone influences the risk of type 2 diabetes mellitus (48).

Regular PA also affects *dyslipidaemia* by improving the serum lipid profile. However, more intense activity is required to elicit reductions in LDL cholesterol and triglyceride levels. For resistance training, it has been shown that increasing the number of sets and/or repetitions has a greater impact on lipid profile than increasing intensity (53).

A narrative review including 27 randomised controlled trials (RCTs) on individuals with *hypertension* concluded that regular medium-to-high-intensity exercise reduces blood pressure by a mean of 11/5 mm Hg. A similar blood pressure reduction was seen among individuals performing isometric resistance training, while dynamic resistance training had less effect (54). A meta-analysis exploring the effect of exercise and medication on individuals with hypertension (≥140 mmHg) concluded that there were no observed differences between the systolic blood pressure lowering effects of medications and exercise (55). Although blood pressure reduction was seen in individuals with both normal and elevated blood pressure, endurance training reduced blood pressure to a significantly higher degree in individuals with prehypertension compared to individuals with normal blood pressure (56).

The effect of regular PA in the prevention of *overweight and obesity* has been previously discussed. Most studies indicate that regular PA alone has only a small effect on body weight loss (less than 3 % of initial body weight). Nevertheless, together with caloric restrictions, the effect increases significantly. Furthermore, regular PA can contribute to a sustained weight loss and minimized weight gain over a lifetime (57).

In addition to the positive effect on traditional cardiovascular risk factors, regular PA has a positive effect on inflammatory factors and the vascular endothelium, leading to improved blood vessel structure and function. This contributes to a decreased risk of atherosclerosis and remodelling of blood vessels (58).

Conclusively, regular PA affects several CVD risk factors simultaneously, giving a greater risk reduction than pharmacological treatment of each risk factor separately. Moreover, PA has other health benefits, e.g. affects mental health/wellbeing, bone health, immune system and prevents cancer (6, 7, 59).

2.3.2 Definitions of physical activity and sedentary time

Physical activity is defined as “any bodily movement produced by the contraction of skeletal muscle that increases energy expenditure at basal level”(60). *Health-enhancing physical activity* (HEPA) is a subcategory of PA, defined as “any form of physical activity that benefits health and functional capacity without undue harm or risk.” This type of activity can be of higher intensity and has to be performed on a regular basis (61). *Exercise*, on the other hand is defined as “planned, structured, repetitive and purposive in the sense that the improvement or maintenance of one or more components of physical fitness is the objective” (60). Physical exercise includes both aerobic exercise and resistance training. Aerobic exercise includes activities primarily depending on the aerobic energy-generating process and aims to improve cardiorespiratory fitness. Resistance training, on the other hand, aims to maintain or increase muscle strength or muscle endurance. Furthermore, *sedentary behaviour* has been discussed to a greater extent the last decade and is defined as “activities that do not increase energy expenditure significantly above resting level” (62). Figure 2 illustrates a graphical outline of the different definitions and how they are interrelated.

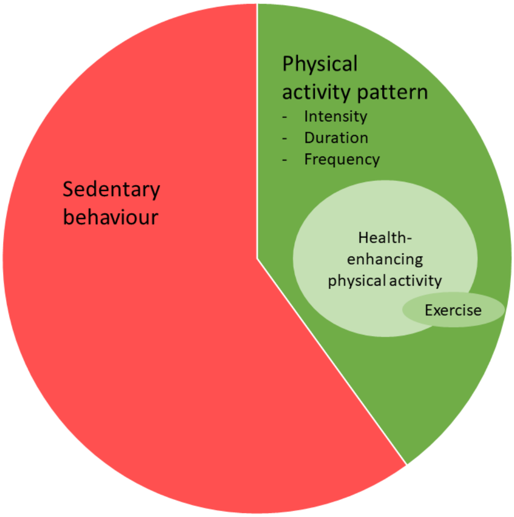

Figure 2. Graphical outline of the different definitions of PA and sedentary behaviour.

Note: The figure represents time spent awake and the size of the different behaviours is not proportional to time.

Resistance training is determined by number of repetitions, sets, frequency (times per week) and intensity. Intensity is often described as repetition maximum (RM), whereof 1 RM is the maximum amount of weight that a person can possibly lift in one repetition (63). When exploring aerobic exercise, duration (minutes of PA), frequency (number of sessions per day or week), intensity and type need to be taken into consideration. Intensity refers to the physiological demand of the aerobic exercise and can be categorised as sedentary, light PA (LIPA), moderate PA and vigorous PA. Moderate to vigorous intensity is often merged, defined as moderate-vigorous PA (MVPA). When defining intensity level, objective, subjective and descriptive measurements are used. Commonly used objective measurements of intensity are metabolic equivalents (METs), describing the energy consumption as multiples of the basal metabolic consumption and maximal oxygen uptake (VO_2). Meanwhile, the Borg RPE scale (6-20) is a subjective assessment, assessing perceived exertion (64). For patients diagnosed with IHD or HF, the Borg RPE scale is commonly used. The Borg RPE scale is correlated to both metabolic (lactate concentrations) and cardiac (heart rate) intensity parameters (65, 66). This relationship is independent of sex, age, exercise modality, PA level and IHD status (65). There is some variation among individuals in how they rate their fatigue. However, test re-test reliability appears to be consistent (67). Based on Norton's study (64), Table 1 gives an overview of the intensity levels: sedentary, light, moderate and vigorous as described by objective, subjective and descriptive assessments.

Table 1. Categories of physical activity intensity and the objective, subjective and descriptive measures associated with each category

Intensity	Objective	Subjective	Descriptive
Sedentary	≤1.5 METs, <20% VO_2max	Borg RPE: < 8	Activities that involve lying or sitting
Light	1.6-2.9 METs, 20-39 % VO_2max	Borg RPE: 8-10	Activities that do not cause a notable change in breathing rate, e.g. cooking or performing office duties
Moderate	3-5.9 METs, 40-59% VO_2max	Borg RPE: 11-13	Activities that should notably accelerate the heart rate, e.g. a brisk walk
Vigorous	≥ 6 METs, ≥60%VO_2max	Borg RPE: 14-16	Activities that lead to rapid breathing and increased heart rate, e.g. jogging

2.3.3 Physical activity recommendations

Global recommendations for promoting health and improving physical capacity in adults (≥18 years) are at least 150 minutes of moderate intensity aerobic exercise, or at least 75 minutes of vigorous intensity aerobic exercise, throughout the week. A combination of moderate and vigorous activities can also meet the recommendation (15, 68, 69). These recommendations, however, are the lowest suggested level. Importantly, there is a dose-response relationship between PA and health (7, 70). Exceeding the recommendations leads to a greater reduced risk for non-communicable diseases and mortality (70). Aerobic exercise should be combined with resistance training involving major muscle groups, on at least two days per week (15, 68). Furthermore, the Swedish Medical Society emphasizes that long-term sedentary behaviour should be avoided. Regular short breaks involving some muscle activity are recommended for individuals with a sedentary job, or who spend a lot of leisure time sedentary. The short breaks recommendation is for all individuals, even those meeting the physical activity recommendations. Additionally, individuals aged ≥65 years should undertake PA in order to enhance balance and prevent falls at least three days a week (71). The general recommendations should be seen from a population perspective, and individual adjustments are obviously needed in clinical work.

In this thesis, we use the term PA level. In **Study I**, PA is divided into everyday PA, physical exercise and total PA level. In **Studies II** and **III**, PA level includes all physical activities of at least moderate intensity. For further information, see SWEDEHEART and Lifestyle habits questionnaire.

2.3.4 Physical activity epidemiology

There are large variations in the population's PA levels and sedentary behaviour between different studies. This may be due to true differences between groups, but is more likely due to differences in methods used to assess PA.

In 2016, a large study including 1.9 million adults across 168 countries explored self-rated PA levels and reported that in age-standardised analyses, 27.5% of participants had insufficient PA levels (72). The prevalence of insufficient PA levels has been reported to have been stable since 2001.. Insufficient PA level was defined as adults not meeting the WHO recommendations of ≥ 150 min of moderate-intensity, or 75 min of vigorous-intensity PA per week, or any equivalent combination of the two (72). This level of insufficient PA is in line with a European study, with a prevalence of 28.6% (73). Guthold et al. saw that women had insufficient PA levels to a higher degree than men (31.7% and 23.4%, respectively). There were also differences between countries, with a higher prevalence of insufficient PA levels in high-income countries (36.8%) compared to low (16.2%) (72). Residence in rural areas, northern Europe, male sex, younger age and higher socioeconomic status (e.g. education level and ability to pay bills) were independently associated with higher self-reported PA levels (31, 72, 73).

Self-rated PA level has been found to significantly differ to PA level measured with an accelerometer. According to a Swedish study, 65% of all men and 61% of all women self-rated 30 min of daily PA. Nevertheless, when measuring with an accelerometer, just above 7% were physically active at least 30 minutes per day, in bouts of 10 min, on most days of the week (74).

Loyen et al. explored self-rated sedentary time (SED) among adult Europeans. Participants spent a median of five hours per day sitting and 18.5% spent ≥7.5 hours/day sitting. However, there were considerable variations in self-reported SED across countries as well as socio-demographics. Adults in northern European countries reported more time spent in sitting than in southern countries. Higher educational level and white-collar occupations were found to have the strongest correlation with higher levels of sitting time. In addition, higher PA level, women, living in rural areas or in small/medium sized towns, having ≥ 3 children, infrequent internet use, having difficulties paying bills, and being satisfied with life were associated with lower sitting levels (75). The prevalence of SED in Europe has been quite stable since 2002, in fact, even decreasing slightly (23.1% to 17.8%) (76). As for PA levels, the results differed between self-rated and objectively assessed. Ekblom et al. concluded in a Swedish population that more than 60% of time was spent sitting, with men and individuals with high educational levels spending a larger proportion of their time sitting (74).

Importantly, there is a weak association between MVPA level and SED, e.g. individuals with a high level of high intensity PA might also spend a lot of time being sedentary (77). However, for SED and LIPA, the association is stronger. This highlights the importance of assessing PA level and SED separately.

2.3.5 Methods of assessing physical activity and sedentary time

There is a need to assess PA in a standardized manner, as with other CVD risk factors such as blood pressure, blood lipids and glucose levels (2). There are a wide range of methods available for assessing PA. PA has traditionally been assessed using PA level, e.g. as a category- (“active/non-active”) or a low-to-high-variable. With increasing development in research, the term PA pattern is increasingly used. PA pattern takes intensity, frequency and duration into consideration. Nevertheless, both PA pattern and PA level are important and provide meaningful information. Methods of assessing PA can be broadly grouped as subjective (e.g. questionnaires and diaries) or objective assessments (e.g. doubly labelled waters technique, or device-based methods such as pedometers and accelerometers). When selecting a method it is important to consider the purpose of the study. No method is perfect or provides a complete description of the PA (e.g. duration, frequency, intensity and type of activity). Therefore a combination of methods is preferable (2, 78-80). Simplified, it could be said that there is an inverse relationship between ease of use and accuracy of assessment method. The simplest, least expensive PA assessment methods, (e.g. diary and questionnaire) provide only general estimates of PA and SED. They suffer from the largest potential errors due to social desirability and are difficult to estimate duration and intensity with. Meanwhile, the most accurate methods are labour-intensive, require training, cause the greatest burden on patients and clinicians, and are more expensive to administer (2). Table 2 gives an overview of different types of PA assessments and their advantages and disadvantages.

Table 2. Overview of physical activity assessment methods (2, 78-82)

Method	Provided information	Advantages	Disadvantage
Doubly- labelled Waters (DLW)	Energy requirement under daily living conditions	• Golden standard of assessment of energy requirement	• Complicated structure and time consuming data collection and data analyses • Expensive
Accelerometer	Acceleration of body movements in up to three directions	• Assesses duration, frequency and absolute intensity	• Does not asses all activities i.e. biking and resistance training • Might be affected by slow walking pace, unstable gait, body habitus • Does not give information of relative intensity
Pedometer	Number of steps	• Direct feedback to the individual	• Might be affected by slow walking pace, unstable gait, body habitus
Diary/log	Self-reported PA behaviour	• Low expense • Recorded close to real-time avoiding some recall issues • Can describe type of PA, context and previous PA behaviour	• The individual may change their PA when asked to record it • Difficulties in estimating; absolute intensity and duration of PA/SED
Questionnaire	An activity-ranking instrument of PA level	• Easy to use • Can describe type of PA, context and previous PA behaviour • Low expenses • Possible to use in large scale studies	• Lower concurrent validity compared to DLW and accelerometer • The individual may change their PA when asked to record it. • Difficulties in estimating; absolute intensity and duration of PA/SED

Questionnaires have been the most common method of assessing PA in research and clinical practice (78-80). There are several different questionnaires available for assessing PA level, focusing on different periods e.g. regular or last year, month or week. The most common period is PA during a regular week. However, it has been shown that this leads an overestimation of the PA level compared to asking for the last seven days (83). Furthermore, questionnaires using pre-specified categories, as apposed to asking for specific times of different physical activities, seem to have a greater validity (84). They have been used in major studies and have been shown to predict different health outcomes including death (85).

The most common method of assessing PA level among patients in cardiac rehabilitation programs has been to take a historical perspective of patients' PA habits via an informal question-and-answer approach. It is recommended that these data should be captured with a standardized questionnaire. Assessment of patients' current PA levels should be assessed with device based methods supplemented by subjective data (e.g. questionnaires) (2). Few studies have validated questionnaires on PA among patients with CVD. Three previous studies investigating different methods of measuring PA found an acceptable concurrent validity for PA level measured by questionnaire (r: 0.40-0.49) compared to PA measured with an accelerometer (86-88). Nonetheless, there are no validated PA level questionnaires in Swedish validated for patients with CVD.

2.4 Healthcare sector's role in promoting health lifestyle habits

In order to create a sustainable opportunity for a physically active lifestyle for all individuals, there is a need to work at national, regional and local levels. Important actors are governments, communities, academic institutions, the healthcare sector, professional associations and the private sector (89, 90).

The healthcare sector is a key player in promoting health in society. It has the advantage of reaching a large part of the population including vulnerable groups, such as the elderly, persons with low socioeconomic status and persons on sick leave (91). In addition, healthcare professionals are considered a trustworthy source of health-related information and most patients want to discuss their lifestyle habits with healthcare professionals (92, 93). The majority of patients in several studies have stated that lifestyle habits are important for their health and that they want to modify at least one lifestyle habit (92, 94-97). Most commonly reported lifestyle habits were smoking, PA, weight and eating habits (97, 98). Importantly, also healthcare professionals state that it is important to promote patients' lifestyle habits both in the healthcare sector in general and in their own clinical practice (99, 100).

The European guidelines on cardiovascular disease prevention in clinical practice (2016) emphasise that health promotion and primary and secondary prevention should be undertaken both within primary and hospital care (15). In secondary prevention, it is important to initiate appropriate interventions prior to hospital discharge and ensure that these are sustained and supported in other settings. Initiating this at the hospital highlights the importance of lifestyle habits to the patient. It is recommended that patients receive a clinical assessment to guide optimization of medical therapy, behavioural education for risk factor modification, and a referral to exercise-based cardiac rehabilitation. The education should be person-centred, providing explanations for each intervention. Early mobilization and exercise sessions should vary according to the individual's clinical status (15).

2.4.1 Physical activity in secondary prevention of cardiovascular disease

For individuals with CVD, PA during cardiac rehabilitation is key. The PA sessions should include a warm-up, physical exercise (combination of aerobic and resistance training), cool-down and stretching/flexibility. Progressive warm-up before and cool-down after may prevent injuries and adverse cardiac events (15, 101). Table 3 describes the general PA recommendations for patients with CVD. Importantly, the PA session should be adapted to the individual's physical capacity and risk profile with the aim of achieving and/or maintaining the highest level of possible fitness (101).

Table 3. Physical activity recommendations in secondary prevention of cardiovascular disease (101)

Aerobic exercise	**Resistance training (8-10 exercises)**
Intensity**:** Moderate-vigorous (Borg RPE: 12-17, VO_2: 40-89%)	***Number of repetitions:*** 10-15 (i.e. 10-15 RMs)
Duration: Each session lasting ≥30 minutes	***Number of sets:*** 1-3
Frequency: 3-5 times / week	***Frequency:*** 2-3 times/week

In order to achieve the PA recommendations for secondary prevention, individuals hospitalised for an acute coronary event, revascularisation or HF should be offered the opportunity to participate in exercise-based CR (15, 102). In Sweden, participation should be offered at least twice a week for ≥ 3 months (102). A Cochrane review concluded that among patients with coronary heart disease, participating in exercise-based cardiac rehabilitation decreased the risk of hospital readmission and cardiovascular mortality

(1). Nevertheless, there were no significant effects on all-cause mortality, MI, or revascularization (1). For patients with HF participating in exercise-based (CR), there was a decreased risk for mortality in ≥1 year follow-up (103). Additionally, European guidelines for cardiovascular disease prevention recommend that the amount of time spent being sedentary should be minimized by taking breaks from extended periods of sitting, reducing screen time and actively travelling (15). However, there are gaps in the knowledge of SED among patients with CVD and its potential association with utilisation of hospital care and mortality.

Despite international and national recommendations (15, 102, 104), PA is considered an underutilized resource in secondary prevention in Sweden, with approximately only 20% of patients diagnosed with MI participating in exercise-based CR (105). A Swedish study found that non-attendance in exercise based CR were higher among smokers, men, having a higher burden of comorbidities and a long distance to the cardiac department (106). This raises the importance of exploring PA levels and their association with future morbidity and mortality among patients with CVD, regardless of where or how the PA is performed.

3 RATIONALE FOR THIS THESIS

In Europe, the incidence of CVD is high and the leading cause of premature mortality and disability-adjusted life years (DALY) (11). This emphasizes the need for primary and secondary prevention of CVD. Regular PA, particularly exercise-based CR, has an important role in the prevention of CVD via its well-known positive effect of reducing several cardiovascular risk factors (52-54) and premature mortality among patients with IHD and HF (1, 103). This has led to guidelines for cardiovascular prevention highlighting the importance of promoting PA among patients with CVD within primary and hospital care (15, 102). Nevertheless, not all patients are offered exercise-based CR, and a recently published Swedish national survey stressed that approximately only 20% of individuals diagnosed with MI participate (105).

Additionally, SED has been separated from PA and discussed to a greater extent the last decades. However, little is known about SED among patients with CVD and its potential association with morbidity and mortality. This leads to the need for broader knowledge of PA levels and SED among patients with different types cardiovascular diagnoses, regardless of whether the PA is performed within the healthcare sector or not. Further, there is a need to explore whether PA level, when assessed in clinical work, can predict hospital care utilisation (e.g. hospital duration and readmission) and all-cause mortality among patients with CVD. Finally, there is a need to explore whether PA level and its association with hospital utilization and all-cause mortality differs among patients with various CVD diagnoses (e.g. cardiac arrhythmias, valvular heart disorder and inflammatory heart diseases).

Although there are international and national guidelines for cardiovascular prevention, there is limited knowledge as to what extent those guidelines are followed by healthcare professionals. In addition, information on attitudes among healthcare professionals towards promoting PA and other healthy lifestyle habits in patients within hospital cardiac care is lacking. Previous studies have mainly focused on attitudes and clinical work among healthcare professionals within primary care (99, 107, 108). Therefore, there is a need to explore healthcare professionals' clinical work and attitudes to promoting healthy lifestyle habits among patients within hospital cardiac care.

4 AIMS AND HYPOTHESIS

The overall aim of this thesis was to investigate PA and its importance for patients with CVD, and to what extent it is promoted during clinical work.

Specific aims:

- Explore self-rated PA levels (Studies I, II and III) and SED (Study I) among patients with different CVD diagnoses.

No hypothesis was stated for this explorative analysis.

- Investigate whether PA and smoking habits can predict utilisation of hospital care among patients treated on a cardiac ward:
    - Can preceding PA level and SED among patients with CVD predict hospital duration and readmission? (Study I)
    - Can PA level and smoking habits post MI predict one-year readmission? (Study II)

We hypothesised that:
PA (negatively), SED and smoking habits (positively) are associated with hospital care utilisation.

- Investigate whether PA level and SED can predict mortality among patients treated on a cardiac ward
    - Can preceding PA level and SED among patients with CVD predict all-cause mortality? (Study I)
    - Can PA level and smoking habits post MI predict all-cause mortality? (Study II)
    - Can changes in PA level during the first year post MI predict all-cause mortality? (Study III)

We hypothesised that:
PA (negatively), SED and smoking habits (positively) are associated with all-cause mortality during follow-up.

- Investigate stated importance among healthcare professionals on promoting healthy lifestyle habits (alcohol, eating habits, physical activity and tobacco) to patients treated in cardiology departments, and to what extent these attitudes are translated into clinical work.

We hypothesised that:
The majority of healthcare professionals working in hospital care are positive to, and provide counselling on, promoting healthy lifestyle habits in line with guidelines.

5 MATERIALS AND METHODS

5.1 Study design

Four studies were included in this thesis. **Studies I-III** were prospective cohort studies, while **Study IV** had a cross-sectional descriptive design. The design, population and main variables of **Studies I-IV** are presented in Table 4. **Studies I and IV** were carried out at the cardiology departments in two different hospitals in Stockholm, while **Studies II and III** were based on national data from cardiology departments nationwide.

Table 4. Overview of the four studies (design, population and main variables) included in this thesis

Study	Design	Population	Main variables
I	Cohort study	Patients with cardiovascular disease n =1148	***Exposure*** • Physical activity level - Everyday physical activity level - Physical exercise level - Total physical activity level • Sedentary time ***Outcome*** • Hospital duration • Readmission • Mortality
II	National cohort study	Patients with myocardial infarction n = 30 644	***Exposure*** • Physical activity level • Smoking status ***Outcome*** • Readmission • Mortality
III	National cohort study	Patients with myocardial infarction n = 22 227	***Exposure*** • Changes in physical activity level ***Outcome*** • Mortality
IV	Cross-sectional study	Healthcare professionals in cardiology departments n = 251	• Attitudes to promote healthy lifestyle habits [a] • Clinical work to promote healthy lifestyle habits [a] • Impacting factors

[a] Alcohol consumption, eating habits, physical activity and tobacco use

This thesis focussed on individuals with CVD, exploring their PA level at different periods of their lives and investigating how their PA level is associated with hospital care utilisation and mortality. **Study I** included patients with CVD, exploring PA (everyday PA, physical exercise and total PA) and SED pre hospitalisation on a cardiac ward. **Studies II and III** assessed self-rated PA levels among patients 6-8 weeks (**Studies II and III)** and one year post MI (**Study III**). **Study IV** differs from the previous studies, focusing on the healthcare professionals' clinical work and stated importance in promoting healthy lifestyle habits among patients within in and outpatient cardiac care. Figure 3 gives an overview of the four studies included in this thesis, describing the main variables and when data were collected.

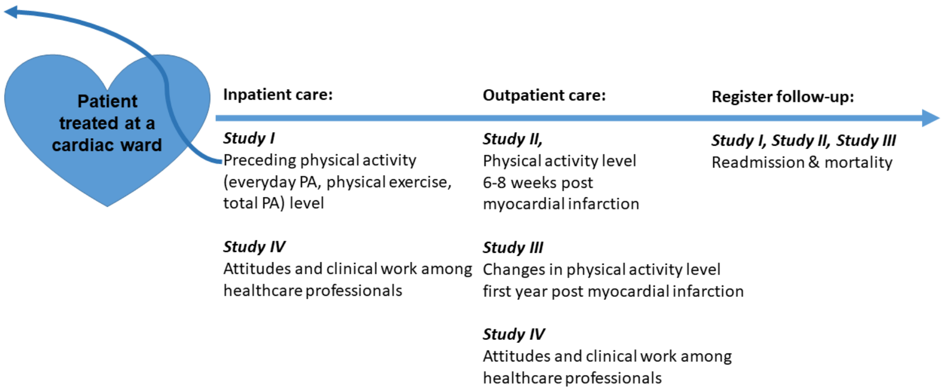

Figure 3. A flow chart of when the main variables were collected for each of the four studies included in the thesis.

5.2 Data collection and measurement

In this thesis, PA is treated as a potential predictor of morbidity and premature mortality (109). Figure 1 shows known risk factors for cardiovascular disease and mortality. This figure was used as the basis for choosing confounders for **Studies I-III**. In all three studies, we included the non-modifiable factors sex and age. In **Study I,** we included socioeconomic factors and the lifestyle habits alcohol consumption, eating habits and tobacco. In **Studies II and III**, we included other known risk factors (as confounding variables) such as HQoL, smoking, pharmacological treatment, percutaneous coronary intervention and disease severity (e.g. left ventricular ejection fraction, type of myocardial infarction and estimated glomerular filtration rate (eGFR)), all known to affect the risk of new cardiovascular events and mortality. Intermediate risk factors, such as diabetes type II, hypertension and hyperlipidaemia, were not included in the analysis due to their effect on (or early signs of) cardiovascular disease. However, in **Study II**, a subgroup analysis of these factors was performed.

Data collection for the four studies was undertaken by different sources such as medical records, national registers and questionnaires. Table 5 gives an overview of the data sources used in **Studies I-IV**. The Swedish personal identity number makes it possible to follow each individual from different national registers and medical records over time.

Table 5. Overview of data sources used in Studies I-IV

Data sources	**Study I**	**Study II**	**Study III**	**Study IV**
Medical records	x			
National registers				
Riks-HIA[a, b]		x	x	
SEPHIA[a, c]		x	x	
Income and Taxation Register[d]	x			
Swedish Education Nomenclature 2000[d]	x			
Swedish National Population Register[d]	x	x	x	
National Patient Registry[e]	x			
Questionnaires				
Healthcare professional questionnaire				x
Lifestyle habits questionnaire	x			

[a] Sub-register in SWEDEHEART (Swedish Web-system for Enhancement and Development of Evidence-based care in Heart disease Evaluated According to Recommended Therapies);[b] The Register of Information and Knowledge about Swedish Heart intensive Care Admission; [c] The Secondary Prevention after Heart Intensive Care Admissions; [d] From Statistics Sweden; [e] From The National Board of Health and Welfare

5.2.1 Medical records

For **Study I**, baseline data for age, date of admission, date of discharge, length of stay, main diagnosis at discharge and lifestyle habits from the cardiac ward were collected from medical records.

5.2.2 National registers

5.2.2.1 SWEDEHEART

The Swedish Web-system for Enhancement and Development of Evidence-based care in Heart disease Evaluated According to Recommended Therapies (SWEDEHEART) is an on-going quality registry for acute coronary and cardiac rehabilitation care. The purpose of SWEDEHEART is to support the improvement of care and evidence-based development of therapy of IHD (105, 110). SWEDEHEART consists of the following sub-registers:

- The Register of Information and Knowledge about Swedish Heart Intensive Care Admission (Riks-HIA).
- The Secondary Prevention after Heart Intensive Care Admissions (SEPHIA).
- Swedish Coronary Angiography and Angioplasty Registry (SCAAR).
- Swedish Cardiac and Swedish Transcatheter Cardiac Intervention Registry (SWENTRY).
- Swedish National Cardiogenetic Registry

Studies II and III are based on data from the sub-registers Riks-HIA and SEPHIA.

Riks-HIA started in 1995, and today all hospitals with acute coronary care in Sweden participate, with a median coverage of almost 96 % of patients younger than 80 years (105) . The registry focus on the quality of acute coronary care and includes the variables of demography, diagnostic procedures, diagnosis, coronary intervention, risk factors, pharmacological treatment and comorbidity (105, 110).

For **Studies II and III,** the following variables from inpatient care were used: age, sex, type of MI, left ventricular ejection function (LVEF), body mass index (BMI), percutaneous coronary intervention (PCI) and estimated glomerular filtration rate (eGFR). Type of MI was based on clinical assessment and patients were classified as having had an ST-segment elevation MI (STEMI), or a non-ST-segment elevation MI (NSTEMI). In **Study II,** LVEF was categorised into four groups: normal (>50%), mild impairment (40–49%), moderate impairment (30–39%), and severe impairment (< 30%). In **Study III**, LVEF was categorised into 50%, 49% to 40%, or ≤40%. The use of PCI during treatment was coded as yes or no. eGFR was based on serum creatinine values (sCr) calculated according to the Cockcroft–Gault formula (111). To separate normal or mildly decreased eGFR from moderately decreased or more pronouncedly decreased eGFR, eGFR was dichotomised at 60 mL/min/1.73 m2 (111). In addition, for **Study III** the date of the MI was included.

SEPHIA was developed in 2003-2004 (112) and gradually increased to include all 72 hospitals in Sweden by December 2018 . The registry provides information on the quality of cardiac rehabilitation for patients with MI in Sweden, and includes patients younger than 80 years (since January 1st 2018). Data are collected during two follow-up visits, at 6-10 weeks and approximately one-year post MI. The registry includes e.g. secondary prevention treatments, prevalence of risk factors, HQoL and eventual readmissions (105).

From the first follow-up visit, the following variables were obtained: health HQoL, prescribed pharmacological treatment, smoking status and PA level (**Studies II and III)**.

- HQoL was measured using the validated HQoL instrument EuroQol5D (EQ5D) (113). The EQ5D values were converted into a single summary index, ranging from − 0.594 to 1, where 1 represents the best possible health (114). The mean score in a Swedish population has been reported to be 0.84 (115). In **Study II**, patients were assigned to two groups based on this value (≤ 0.84 and > 0.84, respectively). Meanwhile, in **Study III**, the median was used due to non-parametric data distribution.

- Prescribed recommended pharmacological treatment, i.e. being treated with ACE-inhibitors, beta-blocking agent, statins or other lipid-lowering agents and antithrombotic agents, were dichotomized as '*yes*' or '*no*' answers.

- Smoking status was classified as: *never smoker*, *former smoker* (no smoking during the last month) and *current smoker*.

- PA level was assessed using a 7-day recall question: *"Number of physical activity sessions of at least 30 min (two 15-min sessions can be combined into a 30-min session) in the last 7 days, with an intensity of at least fast walking"*. The patients were questioned by a nurse, or answered a questionnaire, and reported a number between zero and seven. This question was specifically constructed for the SEPHIA registry and has not previously been tested for reliability or validity. In **Study II**, the answers were grouped into three categories: 0–1 sessions/week = low activity level, 2–4 sessions/week = medium activity level and 5–7 sessions/week = high activity level. The highest category corresponds to the internationally recommended level of PA for health, i.e. at least 150 min PA per week, of at least moderate intensity. For **Study III**, patients were classified as "inactive" if they reported none, or one session of PA per week. Patients reporting two or more sessions per week were classified as "active." Patients were further classified according to changes in activity level between the two follow-up visits as: *constantly being inactive, having reduced activity, having increased activity* or *being constantly active*. The decision to have dichotomised groups in **Study III** was based on the notion that four rather than nine groups would be easier to interpret, along with the risk that statistical power may be limited using nine groups.

From the second follow-up visit, the following data were collected from the SEPHIA registry:

- Data on readmission to hospital during the first year post MI were collected by patient interview or a review of medical records. Patients were grouped into yes or no regarding readmission due to CVD (i.e. angina pectoris, heart HF, MI, or stroke), or readmission due to non-CV diseases (**Study II**).
- Data on participation in exercise-based cardiac rehabilitation during the year following MI were collected by patient interview or a review of medical records (**Study III**).

5.2.2.2 Statistics Sweden

Statistics Sweden is a state agency managing several national registries e.g. *Swedish National Population Register, Swedish education nomenclature 2000* and the *Income and Taxation Register*. They are responsible for official and other government statistics, i.e. the development, production, coordination and dissemination of national statistics. The *Swedish National Population Registry contains* information on the Swedish population e.g. sex, age, date of birth, mortality and date of death. **In Studies I, II and III**, this register was used to identify individuals who were deceased, along with their date of death. For **Study I,** data from the registries *Swedish education nomenclature 2000* and the *Income and Taxation Register* were used to gain information on SES (education level and disposable income). *Swedish education nomenclature 2000* is a system for classifying education-concerning information such as education level. Education level consisted of seven different categories, which were further grouped into three categories: primary school (9 years), secondary school (10-12 years) and higher vocational education or University (> 12 years). The *Income and Taxation Register* was used to explore disposable income. Disposable income includes all income (taxable and partly tax free transfers) e.g. salary, capital income, retirement pension, sickness benefit, housing and child allowance. The median disposable income in Sweden in 2014 was 338 400 SEK. In **Study I**, the disposable income (in 2014) was divided into three groups: low, middle and high. Disposable income of < 60 % of the Swedish median was categorised as low, while a disposable income of twice the median was categorized as high.

5.2.2.3 The National Board of Health and Welfare

The National Board of Health and Welfare is a state agency responsible for managing several national registries e.g. *"National Patient Registry",* collecting and spreading knowledge to social services and healthcare, and ensuring safe and equal healthcare throughout Sweden.

In Sweden, it is mandatory for regions to report inpatient and outpatient visits to the National Patient Registry once a month. For **Study I**, data on readmission to hospital was obtained from the discharge date (September 1st 2015 to April 30th 2016) until December 31st, 2017.

5.2.3 Questionnaires

In 2011, the National Board of Health and Welfare published guidelines for Methods of Preventing Disease. These guidelines provide recommendations for methods of preventing disease by supporting patients in their efforts to change an unhealthy lifestyle habit (104). Simultaneously, the National board of Health and Welfare constructed a questionnaire that can be used in clinical practice to assess four lifestyle factors: physical activity, alcohol consumption, eating habits and smoking behaviour. This questionnaire was used in **Study I**. Additionally, the Board created a questionnaire to asses healthcare professionals' stated importance of clinical work in order to promote healthy lifestyle habits. This questionnaire was, in part, used in **Study IV**.

5.2.3.1 Lifestyle habits questionnaire

In **Study I**, patients answered the questionnaire (Appendix 1) constructed by the National Board of Health and Welfare while they were treated on a cardiac ward. The questions concerned their lifestyle habits pre-hospitalisation and the answers were recorded in their medical records. These questions included:

Physical activity level and *sedentary time*:

- *Physical exercise:* During a regular week, how much time do you spend exercising on a level that makes you short-winded, for example running, fitness class, or ball games? The questions consisted of six fixed answers, which were further categorised into three categories: low (0 minutes/week), medium (1-60 minutes/week) and high (≥60 minutes/week). Stratification was performed to create groups with meaningful sizes.

- *Everyday physical activity*: "During a regular week, how much time are you physically active in ways that are not exercise, for example walks, bicycling, or gardening? *Add together all activities lasting at least 10 min*". Seven fixed answers were available, which were further categorised into three groups: low (≤ 29 minutes/week), medium (30-149 minutes/week) and high

(≥ 150 minutes/week). The highest category corresponded to the internationally recommended level of PA for health, i.e. at least 150 min of PA per week, of at least moderate intensity.

The questions regarding physical exercise and everyday PA formed a validated index (3-19 points) of *total PA level* (84). This was obtained by multiplying category of exercise (one to six) by two (to account for a proposed higher intensity) and then adding the category of everyday PA (one to seven). The index of total PA level was categorised into three groups: low (3-6 points), medium (7-9 points) and high (10-19 points). These cut-offs were made in order to create three groups of approximately equal size. The same index has been used in previous surveys in order to assess the number of individuals who approximately achieve the PA recommendations. To achieve this recommendation, cut-off was set to nine.

- *SED* was assessed by the validated question: *"*How much time do you sit during a normal day, excluding sleep?"(116). There were seven answer options, which were later grouped into three categories: low (< 6 hours), medium (7-9 hours) and high (≥ 10 hours). The cut-off points were based on a meta-analysis suggesting that the risk of all-cause mortality increases if adults sit for a total of ≥7 hours. (117)

Smoking habits were categorised as "never smoker, "former smoker" (stopped smoking more than six months ago) and "current smoker" (additionally including individuals who stopped within the last 6 months".

Eating habits were explored by four questions on how often they ate vegetables, fruits/berries, fish/shellfish and sweets. The answers were divided into four categories (0-3). An eating index (0-12) was categorised based on the sum of the four questions: "0-4 considerably unhealthy eating habits", "5-8 moderately healthy eating habits", "≥ 9 follows the healthy eating habits recommendations".

Hazardous use of *alcohol* was assessed by the question "How often do you drink 4 (women)/5 (men) units of alcohol on a single occasion? One alcohol unit is equivalent to 10 millilitres of pure alcohol. There were six categorical answers. One or more occasions a month was categorised as hazardous use.

5.2.3.2 Healthcare professionals' questionnaire

In **Study IV,** a questionnaire (Appendix II) was developed for healthcare professionals from existing questionnaires (40, 99) (Table 6). The questionnaire concerned three areas:

- Stated importance and clinical work for improving patients' lifestyle habits (alcohol, eating habits, physical activity and tobacco use).
- Personal and organisational factors of potential importance.
- Expectations and future work.

In order to assess questionnaire face validity, pilot testing was performed on various healthcare professionals. The results led to no questions being changed.

Table 6. Questions used in the survey (translated by the authors)

Question		Response options
Core questions		
1.	In general, how important do you think it is to provide counselling to patients on the following lifestyle habits[#]?	Four-graded ordinal scale[†]
2.	In your own clinical work, how important do you think it is to provide counselling to patients on the following lifestyle habits[#]?	Four-graded ordinal scale[†]
3.	I ask patients about their lifestyle habits[#] in my clinical work	Six-graded ordinal scale[‡]
4.	To what extent are you counselling patients about the following lifestyle habits[#] in your clinical work?	Four-graded ordinal scale[§]
Organisational structure		
5.	Are there clear routines for counselling of lifestyle habits[#] in your workplace?	Four-graded ordinal scale[§]
6.	There are clear objectives for promoting patients' lifestyle habits[#]	Six-graded ordinal scale[¶]
7.	Top management has clearly stated that promoting patients' lifestyle habits[#] is a priority	Six-graded ordinal scale[¶]
Healthcare professionals' beliefs and requests		
8.	I think it has a positive effect on the patients' health if they change the following lifestyle habits [#]	Six-graded ordinal scale[‡]
9.	I think patients expect to be asked about the following lifestyle habits[#]	Six-graded ordinal scale[‡]
10.	As compared with your current practice, how would you like to change the extent to which you discuss the following lifestyle habits[#] with patients?	Five predetermined response options e[¥]

[#] Alcohol, eating habits, physical activity and tobacco. [†] 1. Very important, 2. Partly important, 3. Not very important, 4. Not important at all; [‡] 1. Always, 2. Almost always, 3. Usually, 4. Rarely, 5. Only in exceptional cases, 6. Never; [§] 1. To a great extent, 2. To some extent, 3. To a minor extent, 4. Very little/not at all; [¶] Totally agree 1. 2. 3. 4. 5. 6. Do not agree at all; [¥] 1. A lot less, 2. A little bit less, 3. To the same extent, 4. A little bit more, 5. A lot more.

Stated importance and clinical work to improve patients' lifestyle habits

Four questions were identified as core questions, focusing on stated importance (of the healthcare sector in general and own clinical work), and clinical work (asking and providing counselling) to promote patients' lifestyle habits (Table 6). The core questions were analysed for each of the investigated lifestyle habits (alcohol, eating habits, physical activity and tobacco use). For each question, the number of response categories varied between four and six (Table 6). Prior to data analysis, the response categories of the four core questions were dichotomised into two categories: the highest answer category (e.g. "very important", or "always", or "to a great extent") versus all other answer categories (see Table 6). Dichotomisation was performed in line with previous studies and evidence-based guidelines (15, 40, 99, 102).

Personal and organisational factors of potential importance

A further eight questions focused on personal (age, sex, profession, years in the profession and workplace) and organisational factors (perceived clear routines, clear objectives and strong management support). When analysing responses, profession was divided into physicians versus all other healthcare professionals; workplace was divided into inpatient and outpatient care; age was divided into under and over 40 years, and years in profession was divided into under and over nine years. The response categories for questions regarding organisational factors were, on analysis, divided into 'agree to a great extent' or 'totally agree', versus all other categories (Table 6). This was done in order to explore to what extent participants perceived these organisational factors as important. Further details about routines, objectives and management support were not part of this study.

Expectations and future work

We further explored healthcare professionals' expectations and future work using three questions. The first question aimed to investigate to what extent healthcare professionals perceived that lifestyle habits were important to health outcomes. The second question investigated how healthcare professionals perceived patient expectations of being asked about lifestyle habits. For those questions, the responses were categorised as 'Always' versus all other categories. The third question asked to what extent the healthcare professionals wanted to discuss lifestyle habits in the future. Prior to analysis, the responses were categorised into two groups: 'a lot more' and 'a little bit more', versus 'to the same extent', 'a little bit less' and 'a lot less' (Table 6).

5.3 Study populations

This thesis consists of three different study populations. **Study I** included patients with different CVD diagnoses treated on a cardiac ward (Stockholm cohort). **Studies II and**

III consisted of patients diagnosed with myocardial infarction (I.21) (SWEDEHEART cohort). The number of patients differed in **Studies II and III** due to different objectives and included variables. **Study IV** consisted of healthcare professionals who treated patients on a cardiac department.

5.3.1 The Stockholm cohort

Study I consisted of patients treated on cardiac wards at two hospitals in Stockholm, Sweden. Inclusion criteria were: patients who were subsequently discharged alive, 18 years or older, had a Swedish personal identification number and had been hospitalised for at least one day during weekdays between September 1st 2015 and April 30th 2016. Patients were excluded if they exhibited a reduced ability to participate, i.e. had a severe illness (such as a life-threatening CVD condition or dementia) or had poor Swedish language skills. In addition, individuals that did not have complete data were excluded. The diagnoses were further grouped into: IHD, HF, cardiac arrhythmia, valvular heart disorder, inflammatory heart diseases and other.

5.3.2 The SWEDEHEART cohort

Individuals included in **Studies II** and **III** were patients aged 18–74 years and diagnosed with their first MI, coded as I.21 according to the International Classification of Diseases, 10th revision (ICD 10). They were included in both the Riks-HIA and SEPHIA registries between 2004 and 2014. In addition, complete data on covariates and explanatory and outcome variables needed to be available for inclusion (described in 5.2.2.1 SWEDEHEART). In **Study II,** the standardised 5-year follow-up excluded individuals with less than 5 years of follow-up.

5.3.3 The healthcare professional population

All healthcare professionals working on a cardiac department and in contact with patients in March 2014, were invited to participate. Physicians, nurses, assistant nurses, physiotherapists, dieticians, occupational therapists, social workers, psychologists, and biomedical analysts were thus eligible for the study. Healthcare professionals who did not have patient contact or did not provide full information for all four core questions were excluded from the data analysis.

5.4 Statistical methods

An overview of the statistical methods used in **Studies I-IV** is provided in Table 7 . Statistical analysis was performed using SPSS 24.0 software (IBM Corp., Armonk, NY, USA).

Table 7. Statistical methods in alphabetical order used in Studies I-IV

Statistical method	**Study I**	**Study II**	**Study III**	**Study IV**
Attributable fraction (AF)		x		
Attributable risk (AR)		x		
Benjamini-Hochberg procedure	x[a]			
Bonferroni correction	x[a]			
Chi-square test	x	x	x	x
Cox regressions		x		
Cox regression with time-dependent covariate	x	x[a]	x	
Formal interaction analyses (Bland and Altman)	x	x	x	x
Independent sample t-test			x	
Logistic regression	x	x		x
Mann Whiney U test	x	x		
Multiple linear logistic regression	x			
Schönfelts residuals	x	x[a]	x	
Spearman's rho	x			x
95% Confidence interval	x	x	x	
99% Confidence interval				x

[a] Results only presented in the thesis.

In all studies, categorical variables are presented as frequencies and relative frequencies. Continuous non-parametric variables are presented as medians with interquartile ranges (IQRs), and parametric variables as means with standard deviations (SDs). Differences between included vs excluded individuals, and included vs drop-outs were examined using the Chi-square test for categorical variables, the Mann–Whitney U test for continuous non-parametric variables and Student's t-test for parametric variables. The level of significance was set to $p < 0.05$.

In this thesis for **Study I**, differences in PA level between different cardiovascular diagnosis groups were explored using the Benjamini-Hochberg procedure with Bonferroni correction**.**

The association between PA level (**Studies I** and **II**) and SED (**Study I**) with hospital readmission were analysed using logistic regressions. Results from the logistic regressions were presented as odds ratios (ORs) with 95% CIs. ORs were considered to be different from the reference group if the 95% confidence interval did not include 1. In **Study I**, ORs were analysed using three models: unadjusted, adjusted for age and sex, and fully adjusted (age, sex, diagnosis group, education level, disposable income, smoking status, alcohol consumption and eating habits). In **Study I,** in order to explore whether the diagnosis groups differed with regards to the effect of PA level and SED, an interaction term was added to our fully adjusted logistic regressions. In **Study II,** the first regression model was an unadjusted model, the second included age and sex and the third included all covariates (age, BMI, eGFR, sex, HQoL, LVEF, PCI, pharmacological treatment, smoking and STEMI).

In **Study I**, correlations between PA level, SED and inpatient duration were assessed using Spearman's partial rank order correlation. When the correlation was significant, the analysis continued with multiple linear regression including age, sex, diagnosis group, educational level, disposable income, smoking status, alcohol consumption and eating habits. Residuals of the natural logarithm (ln) of inpatient duration were found to be normally distributed.

Studies I-III explored the association between PA level, SED and mortality using Cox regressions**.** The Cox regressions were performed to explore any differences in time-to-mortality between patients according to PA level and SED. Results from the Cox regressions were presented as Hazard Ratios (HRs) with 95% CIs. HRs were considered to be statistically significant if the 95% confidence interval did not include 1. In both **Studies I and II,** the HRs were analysed using the same models as in the logistic regressions. In **Study III**, Cox regressions were performed for two models - adjusting for age and sex, and a fully adjusted model (age, BMI, date for MI, eGFR, sex, HQoL, LVEF, PCI, participation in exercise based CR, pharmacological treatment, smoking and STEMI). Additionally, in **Studies I** and **III**, the proportionality assumption was checked using the Schönfelts residuals methods. As a weak significance for all PA and SED categories was noted, an interaction term (time x PA and SED strata) was used in all analyses using Cox regression with a time-dependent covariate module.

Differences in HR and OR (**Studies I and II**) between high and medium PA level and low and medium SED, were analysed as interactions based on Altman et al. (118). CIs including zero were interpreted as having no difference.

In addition, in **Study II** the attributable risk (AR) of mortality in different PA categories or smoking status categories was calculated by subtracting the incidence of unexposed (medium PA level and high PA level or never smoker and former smoker, respectively) from the incidence of exposed (low PA level and smoker) patients. The attributable fraction (AF) was obtained by dividing the AR by the incidence of exposed patients.

In Study IV, in order to analyse differences in responses for the four core questions within and between the four lifestyle habits of alcohol, eating habits, physical activity and tobacco use, differences in paired proportions and their 99 % confidence intervals (CI) were calculated (119). CIs including zero were interpreted as having no difference. Additionally, to assess relationships between the core questions for stated importance and clinical work, Spearman's rho was used.

Further, in **Study IV**, unadjusted logistic regression was used to calculate odds ratios (OR) for whether personal or organisational factors related to stated importance or clinical work. To correct for multiple testing bias, the confidence interval (CI) was set to 99%.

Finally, in **Study IV**, to analyse whether current counselling practice related to the extent to which participants wanted to change to their future clinical work ('greater extent' vs. 'to the same extent or less'), a Chi-square test was used. The level of significance was set to $p < 0.05$.

5.5 Methodological considerations

During the work with this thesis, some methodological considerations arose. These will be further discussed in this section.

5.5.1 Self-reported physical activity level

The PA and SED questions used in this thesis are commonly used in clinical practice. Nevertheless, they have not been validated specifically for patients with CVD. Due to this, we performed a pilot-study to validate these questions, specifically for this thesis (unpublished). Participants began to be recruited to the validation study in October 2017, and data collection is ongoing. Participants were recruited from outpatient care at the Cardiac department in Stockholm.

Inclusion criteria for the validity study were individuals aged 18-75 years with newly diagnosed MI and registered in SEPHIA. Individuals who were physically disabled (wheelchair dependent) or with reduced ability to answer the questions were excluded. Individuals were informed and asked about their participation by the nurse at routine follow-up visits at the outpatient cardiac clinic. Prior to inclusion, individuals give their written consent to participate.

Initially, participants used a self-determined PA questionnaire, with the questions used in SEPHIA and recommended by the National Board of Health and Welfare. An accelerometer activity monitor (Actigraph wGT3X BT monitor, Pensacola, Florida, USA) was sent to the participant's home. Participants were encouraged to wear the monitors for ten consecutive days, 24 hours a day. During the same period, they noted if, when, what type and intensity of the PA performed, in a diary. In addition, the times they went to bed and woke up, and the time if they took off the accelerometer were noted. After the measuring period, participants returned the activity monitor and the diary by mail to the Swedish School of Sport and Health Science.

The accelerometers and data files were handled using the software Actilife 6.13 (ActiGraph llC, Pensacola, Fl, USA). Data were collected with a sampling rate of 30 Hz. Vector magnitude measurements were reported in counts per minute (cpm). The daily physical activity pattern was described using the following components: percentage wear time spent in sedentary time (SED, 0-199 cpm), light physical activity (LIPA, 200-2689 cpm) and moderate to vigorous physical activity (MVPA, ≥2690 cpm) (120, 121). Other variables included total volume of PA expressed as mean cpm over the study period (TPA), time spent in prolonged periods of MVPA (bouts of ≥10 consecutive minutes, with allowance for interruption of up to 2 min of <2690 cpm) and mean number of steps per day. Minimum requirement for inclusion in the analysis was 600 minutes of valid daily monitor wear on at least 8 days. The time between 10:00 PM and 6:00 AM was considered night and was excluded from the analysis.

Correlations between the Actigraph data and the PA and SED questions were calculated using Spearman's rho. The associations were interpreted as weak (Spearman's rho < 0.10), modest (Spearman's rho 0.1–0.3), moderate (Spearman's rho 0.3–0.5), strong (Spearman's rho 0.5–0.8) or very strong (Spearman's rho 0.8–1.0) (122).
Sixty-five individuals answered the questionnaire and provided complete accelerometer data. Correlations were modest to moderate (see Table 8). The strongest correlations were found for the physical exercise question recommended by the National Board of Health and Welfare and total PA recorded by the activity monitor, and for the PA question used in SEPHIA and MVPA in bouts of 10 minutes per day (rho=0.44). Reducing the number of response categories slightly reduced correlation strength. For dichotomised self-reported PA (as used in **Study III**), we performed Mann Whitney U-tests. Results showed significant differences for total PA ($p < 0.016$), steps per day ($p < 0.013$), MVPA in bouts min per day ($p < 0.023$), LIPA ($p < 0.038$) and proportion of time in SED ($p < 0.008$).

Table 8. Concurrent validity, expressed as correlation (Spearman's rho) for accelerometer derived and self-reported estimates of PA and SED

Questionnaire	**Time in SED**[a]	**Time in LIPA**[b]	**Time in MVPA**[c]	**Total PA**[d]	**Steps per day**[e]	**MVPA in bouts**[f]
The National Board of Health and Welfare						
Everyday physical activity	-0.15	0.11	0.22	0.20	0.261*	0.19
Physical exercise	-0.42**	0.34**	0.37**	0.44**	0.39**	0.26*
Sedentary time [g]	0.29*	-0.39**	-0.02	-0.13	-0.02	0.06
Categorised data *(3 categories)*						
Everyday physical activity	-0.11	0.06	0.23	0.20	0.26*	0.23
Physical exercise	-0.37**	0.32*	0.35**	0.40**	0.40**	0.28*
Total physical activity index	-0.42**	0.35**	0.38**	0.41**	0.39**	0.21
Sedentary time	0.26*	-0.36**	-0.01	-0.11	0.01	0.12
SEPHIA						
Physical activity	-0.24	0.13	0.35**	0.34**	0.36**	0.44**
Categorised data *(2 and 3 categories)*						
Physical activity (*2 categories)*	-0.34**	0.27*	0.25	0.31*	0.32*	0.29*
Physical activity (*3 categories)*	-0.26*	0.16	0.35**	0.35**	0.37**	0.41**

*. Correlation is significant at the 0.05 level (2-tailed). **. Correlation is significant at the 0.01 level (2-tailed).

[a] Sedentary time, proportion (%) of time. [b] light physical activity, proportion (%) of time; [c] moderate-vigorous physical activity, proportion (%) of time; [d] total volume of physical activity (vector magnitude) expressed as mean cpm over the study period, [e] mean steps per day [f] the mean daily time (in minutes) of MVPA in ≥10 minute bouts. [g] the scale was inverted form the original question.

5.5.2 Cox regressions with time-dependent covariates

In contrast to **Studies I** and **III**, in **Study II,** Cox regressions were made without time-dependent covariates. In this thesis, for **Study II,** results of the Cox regressions with and without the time-dependent covariate will be presented. The Schönfeldts residuals were only borderline significant, indicating that the HRs were almost proportional and therefore the effect of the time-dependent covariate was limited. The results are presented in "Physical activity level and smoking status as predictors of mortality post"

5.5.3 Sensitivity analysis

This thesis focuses on the link between PA level and CVD. This link consists of a series of mechanisms and mediators constituting the pathway to the disease. The inclusion of these mechanisms and mediators represents another field of research and is outside the scope of this thesis. However, it is interesting to investigate the link between PA level and CVD in subgroups based on these mechanism. Having high levels of LDL or being diagnosed with diabetes mellitus type II or hypertension are examples of intermediate risk factors affecting the association between PA level and mortality. Because of this, in **Study II,** a sensitivity analysis was performed comparing the effect of the association between PA level and survival using Cox regressions with time-dependent covariates. Individuals were categorised as: LDL-C <1.8 mmol/l and ≥1.8 mmol/l, and diagnosed with hypertension or diabetes mellitus type II or not. The results are shown in "Physical activity level and smoking status as predictors of mortality post".

In **Study I**, there was a risk that individuals with severe disease had a lower preceding PA level as well as a higher risk of premature mortality. Therefore, in this thesis, two additionally fully adjusted Cox regressions were performed, excluding individuals with short time survival (28 days and 49 days, respectively). Number of days were chosen based on recommendations from the National Board of Health and Welfare (28 days) and for comparison with **Study II** (49 days). The results are shown in "*Preceding physical activity level and sedentary time as predictors of mortality".*

5.6 Ethics

Suffering from a chronic disease can contribute to a personal crisis and a feeling of losing personal autonomy. The healthcare sector faces an important ethical issue of respecting the patient's autonomy and integrity while not exposing the patient to any harm. Healthy lifestyle habits are crucial in primary and secondary prevention of CVD, and both the WHO and Swedish government advocate a more health-oriented healthcare sector (89, 123). While it is arguable whether one should ask and record patients' lifestyle habits (124), previous surveys show that patients want to discuss their lifestyle habits with healthcare professionals (92, 93). Further, in order to provide support to individuals who need to change their unhealthy lifestyle habits, healthcare professionals need to start asking questions about lifestyle habits. It can even be considered unethical that individuals with an unhealthy lifestyle habit are not given the opportunity to change it. It is important though that healthcare professionals always focus on individual-centred counselling, are aware of the patient's desire to obtain support in order to increase their PA level, and don't engage in patient blame. The purpose of health-promoting counselling should be to increase patient autonomy, giving the patient the knowledge, support and tools to improve his or her own health (40).

In all studies, participants were informed that they had the right to cease participating in the study at any time. Their integrity was guaranteed since all data were coded and statistical analyses were performed at group level, making it unlikely that any individual could be identified. The patients (**Studies I-III)** were treated according to current routines within the healthcare sector and medical services regulation, and the research project did not add any risk of harm. **Studies I-III** contain data concerning patients' PA level, which could be perceived as being intrusive. We believe, however, that the benefits of increased knowledge about individuals in need of support to increase their PA level outweigh any possible damage. **Study IV** explores healthcare professionals' attitudes and clinical work with patients' lifestyle habits. There is a risk that healthcare professionals may feel that their professional opinions and abilities are questioned when answering the questionnaire on their clinical work. However, since participation is voluntary and no individuals can be identified when reporting the results, the risk of harm is considered to be small.

Ethical approval for the four studies was obtained from Stockholm's regional ethical review board: **Study I** (Dnr: 2016/1057-31/5), **Studies II-III** (Dnr: 2013/2067-31) and **Study IV** (Dnr: 2015/580-31/5). In addition, for **Study I**, Karolinska University Hospital approved data collection from medical records (Nr: 102227) and The National Board of Health and Welfare and Swedish Statistics approved the merge with their registers (Dnr: 14385/2018 and Nr: 246335, respectively). Further, ethical approval for the study validating the PA questions was obtained from Stockholm's regional ethical review board (Dnr: 2016/2409-31/1).

6 RESULTS

This section presents the main results. Detailed results for each study are given in the publications and manuscript at the end of the thesis.

6.1 Characteristics of study population

6.1.1 The Stockholm cohort

A total of 1816 individuals were treated on cardiac wards during the inclusion period. Of those, 204 individuals were not asked to participate or did not want to participate (dropout). Further, 464 individuals were excluded due to did not fulfill the inclusion criteria. This gave a study population of 1148 individuals (Figure 4).

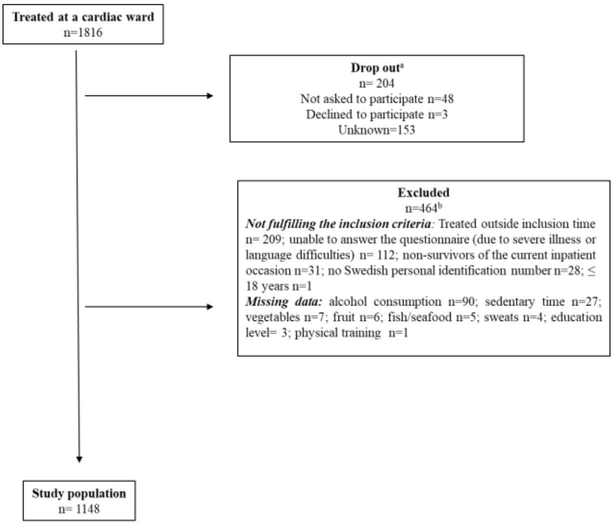

Figure 4. Recruitment of the Stockholm cohort.

[a] Individuals were regarded as drop-outs if they declined to participate for some reason, or were not asked. [b] Excluded due to not fulfilling one or several inclusion criteria.

The study population consisted of 61% men and the median age was 70 years. For further information on baseline characteristics and distribution for the different diagnosis groups, see Table 9.

Table 9. Baseline characteristics of the Stockholm cohort

	Total n=1148 (%)	**Ischemic heart disease n=396 (%)**	**Heart failure n=147 (%)**	**Cardiac arrhythmias n=282 (%)**	**Valvular heart disorder n=108 (%)**	**Inflammatory heart diseases n=59 (%)**	**Other [1] n=156 (%)**
Sex, *men*	703 (61)	279 (71)	105 (71)	153 (54)	61 (57)	32 (54)	73 (47)
Age, *median (IQR)*	70 (IQR 19)	69 (IQR 17)	74 (IQR 15)	69 (IQR 11)	82 (IQR 12)	58 (IQR 30)	62 (IQR 26)
Education level [2]							
Primary school	294 (26)	112 (28)	58 (40)	55 (20)	29 (27)	12 (20)	28 (18)
Secondary school	465 (41)	155 (39)	53 (36)	113 (40)	42 (39)	30 (51)	72 (46)
Higher vocational education/University	389 (34)	129 (33)	36 (25)	114 (40)	42 (34)	17 (29)	56 (36)
Disposable income [3]							
Low	600 (52)	207 (52)	102 (69)	117 (42)	77 (71)	33 (56)	64 (41)
Medium	492 (43)	168 (42)	44 (30)	146 (52)	26 (24)	22 (37)	86 (55)
High	56 (5)	21 (5)	1 (1)	19 (7)	5 (5)	4 (9)	6 (4)
Inpatient duration, *days*	2 (IQR 3)	3 (IQR 3)	3 (IQR 4)	2 (IQR 2)	3 (IQR 3)	3 (IQR 3)	1.5 (IQR 2)
Smoking [4]							
Never smoker	466 (41)	139 (35)	55 (38)	134 (48)	44 (41)	24 (41)	70 (45)
Former smoker	513 (45	159 (40)	76 (52)	126 (45)	56 (52)	25 (42)	71 (45)
Smoker	169 (15)	98 (25)	16 (11)	22 (8)	8 (7)	10 (17)	15 (10)
Eating habits [5]							
Considerably unhealthy eating habits	181 (16)	72 (18)	27 (18)	29 (10)	13 (12)	11 (19)	29 (19)
Moderately health eating habits	676 (59)	233 (59)	91 (62)	168 (60)	68 (63)	35 (59)	81 (52)
Follows the eating habit recommendations	291 (25)	91 (23)	29 (20)	85 (30)	27 (25)	13 (22)	46 (30)
Hazardous use of alcohol [6]	216 (19)	79 (20)	23 (16)	57 (20)	10 (9.3)	22 (37.3)	25 (16)

[1] Other, the four largest groups were :Chest or abdominal pain (n=52), other diseases in the circulatory system (n=49), syncope (n=32), respiratory disease (n=9). [2] Education level: Primary school (9 years), Secondary school (12 years), Higher vocational education/University (> 12 years). [3] Disposable annual income: low ≤203 040 SEK, medium= 203 041-676 799 SEK, high ≥ 676 800 SEK. [4] Smoking: never smoker, former smoker (including > 6 months after quitting), smoker current (including ≤ 6 months after quitting). [5] Eating habits (0-12 points): considerably unhealthy eating habits ≤4 points, moderately healthy eating habits =5-8 points, follows the eating habit recommendations ≥9 points. [6] Alcohol: ≥ 40 women/ ≥ 50 millilitres pure alcohol on the same occasion at least once a month.

Included individuals differed from drop-outs and excluded individuals regarding the main diagnosis at discharge. Furthermore, the drop-out group was significantly older than the included group (median age 73 years (IQR 19) vs 70 years (IQR 20), respectively). For further information regarding differences in diagnoses, see Paper I.

6.1.2 The SWEDEHEART cohort

A total of 48 718 patients were treated for MI in Swedish coronary care units and included in the SWEDEHEART register during the study period (**Studies II** and **III**). For **Study II**, a total of 30 614 individuals were included. Of these, 11066 patients were included in the standardised 5-year follow-up analysis, and complete data on readmission rates were available for 22049 individuals. **Study III** consisted of 22 227 individuals (Figure 5).

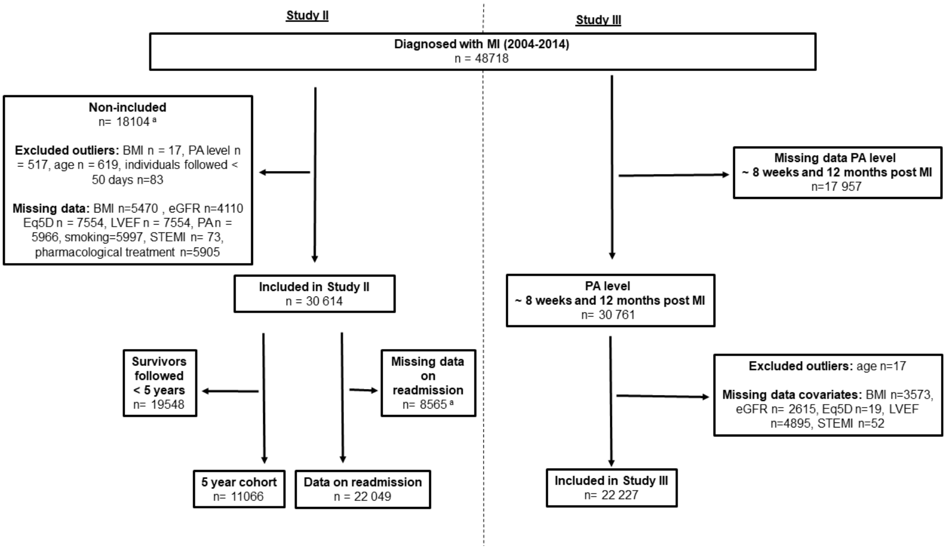

Figure 5. Recruitment of patients diagnosed with myocardial infarction in the SWEDEHEART cohort (**Studies II and III**)

Individuals included in **Studies II and III** had a median age of 63 years and 74 % were men. Participant characteristics are given in

Table 10. There were very small, albeit statistically significant, differences between included and excluded individuals. The only parameter that did not differ between the original SWEDEHEART population and the study population included in **Study III** was age. Furthermore, in **Study II,** there were no sex differences between the included

and excluded individuals in the five-year cohort. For more detailed information on differences between individuals with different PA levels, hospital readmission vs non-hospital readmission and survivors vs non-survivors, see Papers II and III.

Table 10. Baseline characteristics of the SWEDEHEART cohort

		Study II			Study III
	Original Swedeheart population n= 48718[i]	Study population n= 30614	5 year cohort n=11066	Readmission cohort n=22049	Study population n= 22 227
Sex, male	35566 (73)	22608 (74)	8140 (74)	16313 (74)	16421 (74)
Age, years	63 (IQR 13)	63 (IQR 12)	62 (IQR 12)	63 (IQR 13)	63 (IQR 14)
STEMI[a]	19874 (41)	12995 (42)	4780 (43)	9391 (43)	9435 (42)
PCI[b]	37739 (78)	24416 (79)	8394 (76)	17582 (80)	17714 (80)
LVEF[c]					
> 50%	27035 (56)	20394 (67)	7035 (64)	14749 (67)	14873 (67)
40-49%	8432 (17)	6176 (20)	2413 (22)	4460 (20)	4494 (20)
30-39%	4429 (9)	3192 (10)	1284 (12)	2274 (10)	2860 (13)
< 30%	1268 (3)	852 (3)	334 (3)	566 (3)	
Body Mass Index	27 (IQR 5)	27 (IQR 5)	27 (IQR 5)	27 (IQR 5)	27 (IQR 5)
Smoking status					
Never smoker	13859 (28)	9849 (32)	3427 (31)	7200 (33)	7280 (33)
Former smoker[d]	23830 (49)	17183 (56)	6325 (57)	12438 (56)	12533 (57)
Smoker	5032 (10)	3582 (12)	1314 (12)	2411 (11)	2414 (11)
HQoL[e]	0.85 (IQR 0.27)	0.85 (IQR 0.27)	).85 (IQR 0.27)	0.73 (0.25)	0.85 (IQR 0.27)
eGFR[f] <60 mL/(min x1.73m^2)	3642 (8)	2221 (7)	841 (8)	1542 (7)	1787 (8)
Full pharmacological treatment[g]	29135 (60)	21300 (70)	7197 (65)	15352 (70)	15479 (70)
Particpiate in exercise-based CR[h]	15 294 (43)	-	-	-	8288 (37)

Note: The same individual can be included in different sub-populations.

[a] ST elevation myocardial infarction [b] Percutaneous coronary intervention [c] Left ventricular ejection fraction.. [d] No smoking during the previous month. [e] Health-related quality of life. [f] Estimated glomerular filtration rate. [g] ACE-inhibitors, beta-blocking agent, statins or other lipid-lowering agents and anti-thrombogenic agents. [h] Started exercise-based CR post MI (measured at the second SEPHIA follow-up). [i] There was a small internal dropout in some variables.

6.1.3 The healthcare professional population

The study population consisted of 251 healthcare professionals, giving a response rate of 87 % (Figure 6). No significant differences regarding sex or profession were found between the non-included (dropouts, did not have patient contact, or did not answer the core questions) and the included study responders.

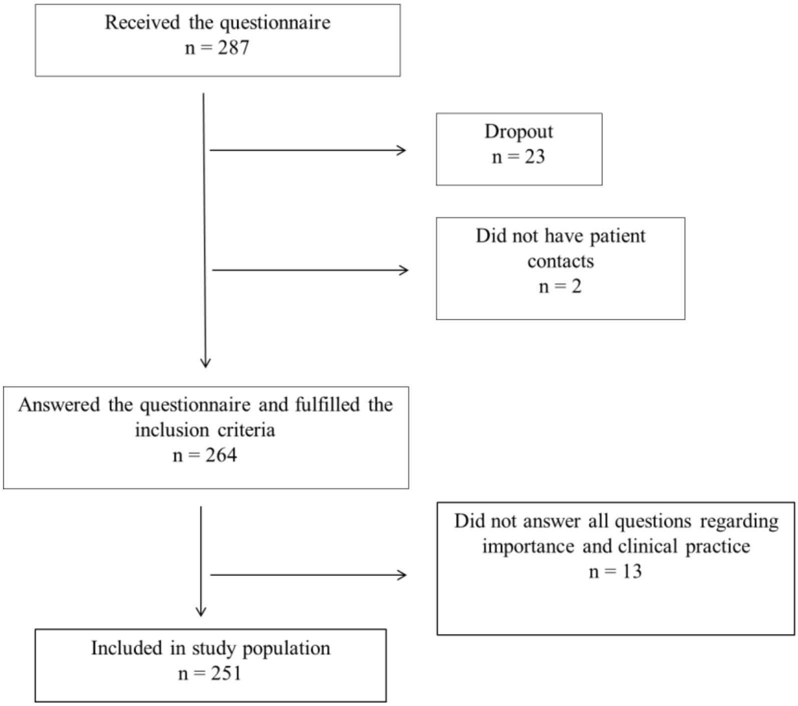

Figure 6. Flowchart of participant recruitment.

Among the included participants, the majority were women working in inpatient care. One third were physicians, and more than 40 % had worked less than ten years (Table 11). One fifth perceived that the cardiology department had clear routines for promoting healthy eating habits, tobacco cessation and physical activity. However, less than one tenth reported that they perceived clear routines for promoting healthy lifestyles in terms of alcohol consumption (Table 11). A minority reported perceiving clear objectives and management support, most frequently for tobacco cessation followed by the promotion of physical activity levels and eating habits, and less for the reduction of hazardous alcohol consumption (Table 11).

Table 11. Characteristics of participants divided into physicians vs. other healthcare professionals

	Total n=251 (%)	Physician n= 78 (%)	Other n= 173 (%)#
Workplace			
Inpatient cardiac care	199 (80)	59 (78)	140 (81)
Sex			
Female	196 (78)	33 (42)	163 (94)
Age			
≤39 years	111 (45)	31 (40)	80 (47)
Years in profession			
≤ 19 years	177 (71)	56 (72)	121 (70)
Perceived clear routines †			
Alcohol	18 (7)	9 (12)	9 (5)
Eating habits	49 (20)	13 (17)	36 (22)
Physical activity	53 (22)	16 (21)	37 (22)
Tobacco	49 (20)	20 (26)	29 (18)
Perceived clear objectives ‡			
Alcohol	33 (14)	16 (21)	17 (10)
Eating habits	47 (20)	16 (21)	31 (19)
Physical activity	63 (26)	24 (32)	39 (24)
Tobacco	88 (36)	47 (62)	40 (24)
Perceived strong management support ‡			
Alcohol	23 (10)	10 (14)	13 (8)
Eating habits	30 (13)	11 (15)	19 (12)
Physical activity	37 (16)	15 (20)	22 (14)
Tobacco	53 (22)	31 (42)	22 (14)

Note: There was an internal dropout in some questions as not all participants answered all questions.

Nurses, assistant nurses, physiotherapists, dieticians, occupational therapists, social workers, psychologists, biomedical analysts and unknown; † 'To a great extent' vs. 'to some extent', 'to a minor extent' and 'very little/not at all'; ‡ 1 ('Totally agree') vs. 2- 6 ('Do not agree at all').

6.2 Physical activity level and sedentary time

6.2.1 Physical activity level and sedentary time pre-hospitalisation

In the Stockholm cohort, individuals were more physically active in everyday PA, than performed physical exercise. More than half the group stated that they did not perform any physical exercise, yet more than one third had a high level of everyday PA and spent at least 150 minutes in everyday PA per week. When using the PA index to assess total PA level, approximately 44% were categorised as nine points or higher at the total PA index and considered as sufficiently physically active. In addition to exploring different types of PA, SED was investigated. Approximately half the study population stated that they had a medium or high level of SED (≥ 7 hours/day), which is considered as a risk of developing morbidity and premature mortality. There were differences in PA level (everyday PA, physical exercise and total PA) and SED between the various cardiovascular diagnoses, with individuals with HF and valvular heart disorder being more inactive and having higher levels of SED. Further details of differences are described in Table 12.

Table 12. Preceding physical activity level (physical exercise, everyday PA and total PA level) and sedentary time in the study population and by the different diagnosis groups

	Total n=1148	**Ischemic heart disease n=396[a]**	**Heart failure n=147[b]**	**Cardiac arrhythmias n=282[c]**	**Valvular heart disorder n=108[d]**	**Inflammatory heart diseases n=59[e]**	**Other[‡] n=156[f]**
Physical exercise, per week							
Low 0 min	640 (56)	232 (59)[f]	100 (68)[c e f]	135 (48)	81 (75)[a c e f]	27 (45)	65 (42)
Medium < 60 min	298 (26)	103 (26)	34 (23)	69 (25)	22 (20)	17 (29)	53 (34)
High 60-120 min	210 (18)	61 (15)[d]	13 (9)	78 (28)[a b d]	5 (5)	15 (25)[b d]	38 (24)[b d]
Everyday physical activity, per week							
Low < 30 min	241 (21)	76 (19)	60 (41)[a c e f]	41 (15)	28 (26)	10 (179)	26 (17)
Medium 30-149 min	500 (44)	172 (43)	55 (37)	135 (48)	47 (44)	22 (37)	69 (44)
High ≥ 150 min	407 (36)	148 (37)[b]	32 (22)	106 (38)[b]	33 (31)	27 (46)[b]	61 (39)[b]
Total activity level, per week[†]							
Low 3-6 points	409 (36)	142 (36)[c]	78 (53)[a c e f]	69 (25)	59 (55)[a c e f]	15 (25)	46 (30)
Medium 7-9 points	382 (33)	138 (35)	44 (30)	104 (37)	31 (29)	20 (34)	45 (29)
High ≥ 10 points	357 (31)	116 (29)	25 (17)	109 (39)[b d]	18 (17)	24 (41)[b d]	65 (42)[b d]
Sedentary time, per day							
High ≥ 10 hrs	313 (27)	96 (24)	60 (21)[a c f]	66 (23)	36 (33)	18 (30.5)	37 (24)
Medium 7-9 hrs	275 (24)	103 (26)	28 (19)	72 (26)	32 (30)	14 (23.7)	26 (17)
Low ≤ 6 hrs	560 (49)	197 (50)	59 (40)	144 (51)	40 (37)	27 (46)	93 (60)[b d]

Note: Each subscript letter (a-f) denotes a subset of diagnosis group category whose column proportions was significantly larger from each other with Bonferroni correction. [†] The questions regarding physical exercise and everyday PA formed an index (3-19 points) of total PA level. This was obtained by multiplying category of exercise (one to six) by two (to account for a proposed higher intensity) and then adding the category of everyday PA (one to seven). [‡] The four largest groups were: chest or abdominal pain (n=52), other diseases in the circulatory system (n=49), syncope (n=32) and respiratory disease (n=9).

6.2.2 *Physical activity level and changes in physical activity post myocardial infarction*

In the SWEDEHEART cohort (**Studies II** and **III),** approximately one fifth stated that they had a low *PA level* and were physically active at most once a week 6-8 weeks post MI. However, in **Study II**, half of the participants were categorised as achieving international PA recommendations. Stating that they performed 5–7 PA sessions (≥moderate intensity) per week of at least 30 minutes (Table 13). **Study III** showed that the majority did not change their *PA level* during the first year post MI (Table 13). There were differences in PA level between individuals included in **Studies II** and **III** compared to the original SWEDEHEART cohort (see Papers II and III) and between individuals with various PA levels, or changes in PA level (see Paper III).

Table 13. Overview of physical activity level and changes in physical activity level the first year post myocardial infarction

Study II		**Study III**				
Physical activity level, 6-8 weeks post MI		***Physical activity level, 6-8 weeks post MI***			***Physical activity level, ~12 months post MI***	
					Constantly inactive	**Increased activity**
Low[a]	6434 (21%)	**Low**[a]	4445 (20%)	→	2361 (11%)	1998 (9%)
Medium[b]	8815 (29%)				**Constantly active**	**Reduced activity**
High[c]	15 365 (50%)	**High**[d]	17782 (80%)	→	14450 (65%)	3418 (15%)

[a] Low= 0–1 sessions/week; [b] Medium= 2–4 sessions/week; [c, d] high= (was defined differently in Studies II and III) [c] 5–7 sessions/week, [d] 2-7 sessions/week.

6.3 Physical activity level and sedentary time as predictors of hospital care utilisation

6.3.1 *Correlation between preceding physical activity level, sedentary time and hospital duration*

In the Stockholm cohort, median inpatient cardiac ward duration was 2.1 days (IQR 3). There were bivariate correlations between inpatient duration and all PA and sedentary results. From the multiple linear regression, inpatient duration was 0.92, 0.91 and 0.91 days shorter for each higher category of physical exercise, everyday PA and total PA level, respectively. With one lower SED category, hospital duration was on average 0.92 days shorter (Figure 7).

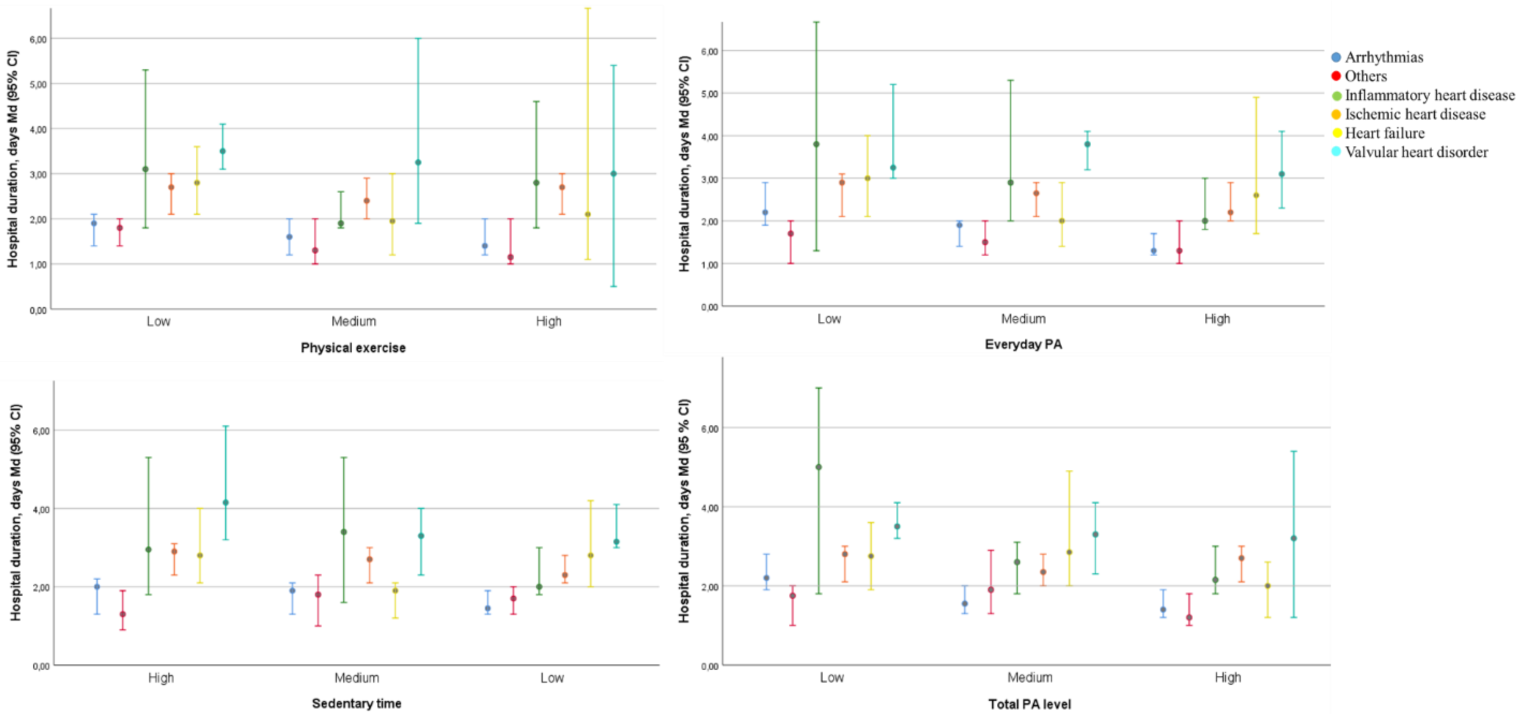

Figure 7. Duration of hospitalisation among individuals with different diagnoses, different physical activity levels (physical exercise, everyday PA, total PA), and sedentary time

6.3.2 Preceding physical activity level and sedentary time as predictors of hospital readmission

In the Stockholm cohort, of the total number of patients, 692 individuals (60 %) had at least one hospital readmission during the follow-up (median 338 days to first readmission or end of study). For information on differences between individuals with and without readmission, see Paper II.

Table 14 describes ORs for different PA and SED levels. In the unadjusted and adjusted analyses, the risk of being readmitted to hospital was lower for individuals reporting high or medium levels of everyday PA compared to low. For physical exercise, ORs were lower for individuals with high levels of exercise compared to individuals with low levels of exercise in the unadjusted model. For total PA level, individuals with high PA levels had lower ORs for readmission compared to individuals with a low total PA level in both the unadjusted analysis and the age and sex adjusted analysis. In the unadjusted and adjusted analyses, individuals reporting medium or low SED had a decreased risk of readmission compared to those with a high level of SED. The relationship between everyday PA, physical exercise, total PA level, SED and risk of readmission did not differ between the diagnosis groups (Table 14).

Table 14. Unadjusted and adjusted odds ratios (OR with 95% CIs) for readmission among patients (n=1148) diagnosed with CVD with different levels of physical activity and sedentary time

	Unadjusted	**Adjusted OR[a]**	**Adjusted OR[b]**
Everyday physical activity *(per week)*			
Low (≤ 29 minutes)	1.00 Reference	1.00 Reference	1.00 Reference
Medium (30-149 minutes)	*0.56 (0.40-0.78)*	*0.57 (0.41-0.80)*	*0.58 (0.41-0.82)*
High (≥ 150 minutes)	*0.44 (0.31-0.62)*	*0.47 (0.33-0.67)*	*0.48 (0.33-0.68)*
Physical exercise *(per week)*			
Low (0 minutes)	1.00 Reference	1.00 Reference	1.00 Reference
Medium (<60 minutes)	0.88 (0.66-1.17)	0.90 (0.67-1.20)	0.91 (0.68-1.23)
High (≥60 minutes)	*0.63 (0.46-0.86)*	0.80 (0.57-1.11)	0.83 (0.59-1.17)
Total physical activity level [c] *(per week)*			
Low (3-6 points)	1.00 Reference	1.00 Reference	1.00 Reference
Medium (7-9 points)	0.77 (0.58-1.03)	0.78 (0.58-1.04)	0.79 (0.59-1.06)
High (≥10)	*0.62 (0.47-0.84)*	*0.73 (0.54-0.99)*	0.75 (0.55-1.03)
Sedentary time *(per day)*			
High (≥ 10 hours)	1.00 Reference	1.00 Reference	1.00 Reference
Medium (7-9 hours)	*0.67 (0.50-0.90)*	*0.69 (0.51-0.93)*	*0.69 (0.51-0.93)*
Low (0-6 hours)	*0.56 (0.40-0.79)*	*0.57 (0.41-0.81)*	*0.58 (0.42-0.83)*

Note: significant differences, p<0.05, are indicated in *italics.*
[a] Adjusted for age and sex. [b] Adjusted for age, disposable income, eating habits, educational level, diagnosis group, hazardous use of alcohol, sex and smoking status. [c] The physical exercise and everyday physical activity question formed an index (3-19 points).

6.3.3 Physical activity level and smoking status post myocardial infarction as predictors of readmission

In the SWEDEHEART cohort, during the first year post-MI (**Study II**), there were a total of 2556 individuals (11.6%) with one or several readmissions to hospital due to CVD. There were 3224 (14.6%) patients with readmissions due to non-CVD. There were significant differences between individuals with and without readmission, although the differences were not clinically relevant (see Paper II).

The risk of readmission due to CVD or non-CVD related causes was lower for individuals with medium and high *PA levels* compared to low PA. This association remained in the adjusted models (Figure 8). There were no differences in the estimated OR between medium and high *PA levels*. In contrast, a significant association between *smoking status* and readmission for either CVD or non-CVD could not be shown in the unadjusted model. If anything, in the fully adjusted models, never smokers seemed to have a slightly higher risk of CVD and non-CVD readmission, with no differences between never smokers and former smokers (Figure 8).

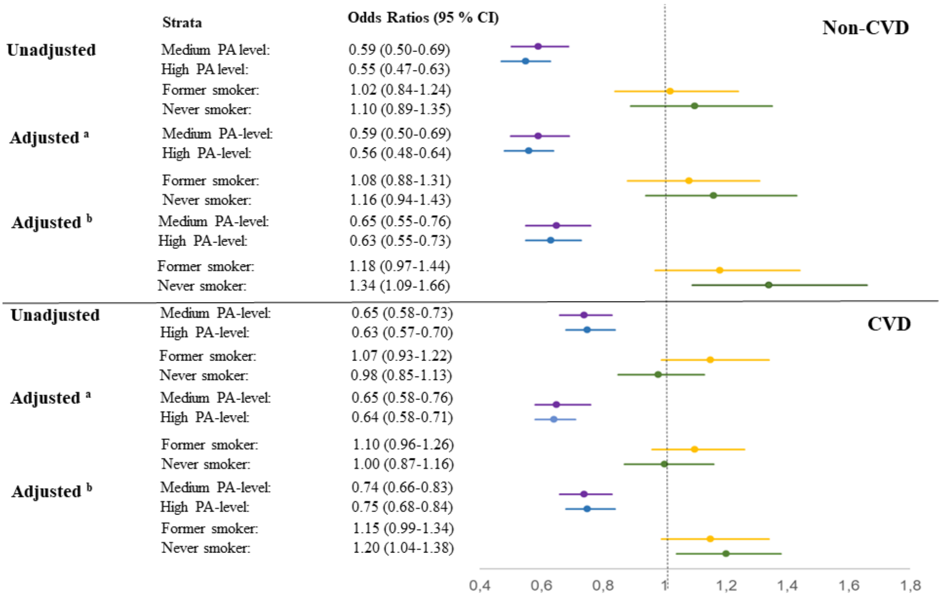

Figure 8. Odds ratios (OR with 95% CIs) for readmission (due to non-CVD n=3224, and CVD n=2556) among patients (n= 22 049) with different physical activity levels and smoking status.

[a] Adjusted for age and sex. [b] Further adjusted for ST elevation myocardial infarction, percutaneous coronary intervention, left ventricular ejection fraction, body mass index, health-related quality of life, estimated glomerular filtration rate and full pharmacological treatment.

6.4 Physical activity level and sedentary time as predictors of mortality

6.4.1 Preceding physical activity level and sedentary time as predictors of mortality

In the Stockholm cohort, the median follow-up time (i.e. time between the end of treatment on the cardiac ward and date of death or end of study) was 942 days. A total of

200 deaths occurred during the study period. Total risk time was 2962 person-years with an incidence of 68 cases per 1000 person-years. Incidence varied between different PA and sedentary groups (Figure 9). Differences at baseline between survivors and non-survivors are described in Paper I.

HRs of mortality were lower for individuals with high and medium everyday PA levels compared to those with low levels in the unadjusted and adjusted analyses. In the unadjusted analysis, mortality risk was lower in individuals with medium or high levels of physical exercise compared to those with low levels of physical exercise. The decreased risk remained in the adjusted analyses, except in the fully adjusted model for individuals with a high level of physical exercise (Figure 9). Further, for total PA level, the risk was lower for individuals reporting medium or high PA levels compared to low in both the unadjusted and adjusted models. Moreover, individuals with a low or medium level of SED had a lower HR compared to those with high SED, except for those individuals categorised as exhibiting a medium level of SED in the fully adjusted model (Figure 9). On looking at the risk of mortality between the diagnosis groups, no difference across PA and SED was found.

			Incidence	HRs 95% CIs
Unadjusted	Physical exercise [c]	Low	129	1.00 Reference
		Medium	44	0.49 (0.34-0.73)
		High	27	0.36 (0.21-0.63)
	Everyday physical activity [d]	Low	81	1.00 Reference
		Medium	68	0.62 (0.45-0.86)
		High	51	0.47 (0.33-0.68)
	Total physical activity [e]	Low	94	1.00 Reference
		Medium	73	0.68 (0.50-0.93)
		High	33	0.38 (0.25-0.57)
	Sedentary time [f]	High	75	1.00 Reference
		Medium	76	0.63 (0.45-0.90)
		Low	49	0.44 (0.32-0.62)
Adjusted [a]	Physical exercise [c]	Medium		0.56 (0.38-0.83)
		High		0.51 (0.29-0.89)
	Everyday physical activity [d]	Medium		0.72 (0.52-0.99)
		High		0.53 (0.37-0.77)
	Total physical activity [e]	Medium		0.70 (0.52-0.96)
		High		0.48 (0.32-0.73)
	Sedentary time [f]	Medium		0.63 (0.44-0.89)
		Low		0.46 (0.33-0.64)
Adjusted [b]	Physical exercise [c]	Medium		0.59 (0.40-0.89)
		High		0.58 (0.33-1.04)
	Everyday physical activity [d]	Medium		0.63 (0.45-0.87)
		High		0.47 (0.32-0.68)
	Total physical activity [e]	Medium		0.62 (0.45-0.85)
		High		0.58 (0.37-0.90)
	Sedentary time [f]	Medium		0.90 (0.62-1.30)
		Low		0.57 (0.41-0.80)

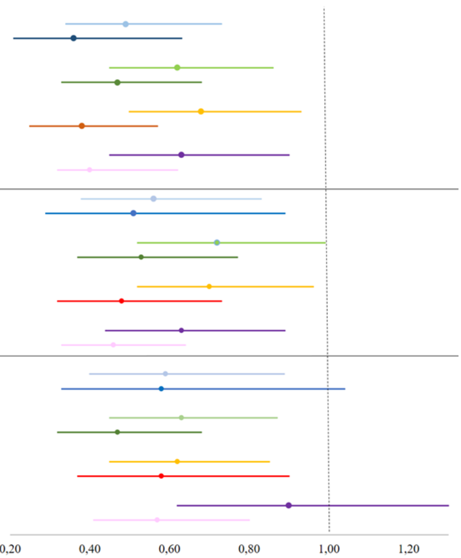

Figure 9. Incidence (cases per 1000 person years) and hazard ratios (HR with 95% CIs) for mortality (200 deaths) among patients (n=1148) with different PA levels treated on a cardiac ward.

[a] Adjusted for age and sex. [b] Adjusted for age, disposable income, eating habits, educational level, sex, diagnosis group, hazardous use of alcohol and smoking status. [c] Physical exercise, an average week: low (0 minutes), medium (<60 minutes), high (≥60 minutes). [d] Everyday physical activity,

an average week: low (≤ 29 minutes), medium (30-149 minutes), high (≥ 150 minutes). [e] Index of total physical activity level - the physical exercise and everyday physical activity question formed an index (3-19 points) of total physical activity level an average week: low (3-6 points), medium (7-9 points) and high (≥10). [f] Sedentary time, an average day: high (≥ 10 hours), medium (7-9 hours), low (0-6 hours).

As mentioned in the methodological considerations, in the Stockholm cohort, the fully adjusted analysis excluded individuals with short time survival in order to decrease the risk of reversed causality. A total of 19 and 28 individuals were excluded when the inclusion criteria was changed to survival for at least the first 28 and 49 days, respectively. This led to a slightly lower incidence of 61 and 51 cases per 1000 person years, respectively. In this fully adjusted analyses, as was seen in our previous analysis, HRs for medium and high everyday PA levels were lower than for low everyday PA levels. Additionally, HRs for both medium and high levels of physical exercise were lower than for low levels of physical exercise. This lower risk was also seen in the >28 days survival cohort among individuals with low, or medium levels of SED (Table 15).

Table 15. Hazard ratios (HR with 95% CIs) for mortality in the Stockholm cohort; individuals who survived ≥ 28 and 49 days respectively with different levels of physical activity and sedentary time

	Stockholm cohort n=1148 HR [a] (95% CIs)	**> 28 days survivors n= 1129 HR [a] (95% CIs)**	**>49 days survivors n= 1120 HR [a] (95% CIs)**
Physical exercise, per week			
Low 0 min	1.0 Reference	1.0 Reference	1.0 Reference
Medium < 60 min	*0.59 (0.40-0.89)*	*0.46 (0.30-0.69)*	*0.48 (0.32-0.74)*
High 60-120 min	0.58 (0.33-1.04)	*0.54 (0.31-0.96)*	*0.53 (0.30-0.96)*
Everyday physical activity, per week			
Low < 30 min	1.0 Reference	1.0 Reference	1.0 Reference
Medium 30-149 min	*0.63 (0.45-0.87)*	*0.62 (0.44-0.87)*	*0.61 (0.43-0.87)*
High ≥ 150 min	*0.47 (0.32-0.68)*	*0.48 (0.32-0.71)*	*0.48 (0.32-0.71)*
Total activity level, per week[†]			
Low 3-6 points	1.0 Reference	1.0 Reference	1.0 Reference
Medium 7-9 points	*0.62 (0.45-0.85)*	*0.71 (0.51-0.98)*	*0.71 (0.51-0.99)*
High ≥ 10 points	*0.58 (0.37-0.90)*	*0.43 (0.27-0.68)*	*0.44 (0.27-0.69)*
Sedentary time, per day			
High ≥ 10 hrs	1.0 Reference	1.0 Reference	1.0 Reference
Medium 7-9 hrs	0.90 (0.62-1.30)	*0.68 (0.47-0.99)*	0.70 (0.48-1.02)
Low ≤ 6 hrs	*0.57 (0.41-0.80)*	*0.42 (0.30-0.59)*	*0.43 (0.30-0.61)*

Note: Data for the Stockholm cohort are additionally reported in Figure 9. Significant differences, p<0.05, are indicated in *italics.*

[a] Adjusted for age, disposable income, eating habits, educational level, diagnosis group, hazardous use of alcohol, sex and smoking status.

6.4.2 *Physical activity level and smoking status as predictors of mortality post myocardial infarction*

In the SWEDEHEART cohort (**Study II)**, all variables at baseline differed statistically ($p < 0.05$) between survivors and non-survivors, although the difference was not clinically relevant (see Paper II). Patients with MI were followed for a median duration of 3.58 years. A total of 1702 deaths occurred during the study period. The total risk time was 120 443 person-years and the mortality rate was calculated as 14 cases per 1000 person years.

The AFs for patients with low PA levels, compared with patients with medium and high PA levels, were 61 and 64%, respectively. The HRs were lower for medium and high PA levels than for low PA level in both the unadjusted and adjusted models

Similar figures were found in the standardised 5-year follow-up group. There was no significant difference in HR between medium and high PA levels (Table 16). In addition to the results in **Study II,** Cox regressions with a time dependent covariate were added to the fully adjusted model in this thesis. This analysis showed no significant differences in HRs between models with and without time-dependent covariate (Table 16, Figure 10).

The AFs for smokers, compared with former and never smokers, were 43.4 and 55.5%, respectively. In unadjusted and adjusted analyses, HRs were lower among never smokers and former smokers than smokers, both in the complete study population and in the 5-year follow-up group (Table 16, Figure 10). Further, the risk of premature death was lower in never smokers compared to former smokers ($p < 0.05$) (Table 16).

Table 16. Incidence (cases per 1000 person years), unadjusted and adjusted hazard ratios (HR with 95% CIs) for post myocardial infarction mortality in the study population (1702 deaths) and in the five-year standardised cohort (754 deaths) with different physical activity levels and smoking status

		Study population (n = 30 614)				**Five-year mortality cohort (n = 11066)**		
Variable	**Incidence**	**Unadjusted HR**	**Adjusted HR[a]**	**Adjusted HR[b]**	**Adjusted HR[c]**	**Unadjusted HR**	**Adjusted HR[a]**	**Adjusted HR[b]**
Physical activity level[d]								
Low	28.37	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)
Medium	11.13	*0.39 (0.35-0.45)*	*0.42 (0.37-0.47)*	*0.52 (0.46-0.60)*	*0.47 (0.40-0.54)*	*0.40 (0.34-0.49)*	*0.44 (0.36-0.53)*	*0.55 (0.46-0.67)*
High	10.20	*0.36 (0.32-0.40)*	*0.37 (0.33-0.41)*	*0.50 (0.45-0.56)*	*0.39 (0.32-0.48)*	*0.34 (0.29-0.40)*	*0.35 (0.30-0.42)*	*0.50 (0.42-0.59)*
Smoking status								
Smokers	24.36	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)
Former smokers[e]	13.79	*0.56 (0.49-0.63)*	*0.45 (0.40-0.51)*	*0.50 (0.44-0.57)*	*0.50 (0.44-0.57)*	*0.56 (0.46-0.67)*	*0.56 (0.47-0.67)*	*0.50 (0.42-0.61)*
Never smokers	10.84	*0.45 (0.39-0.52) †*	*0.32 (0.28-0.37) †*	*0.38 (0.33-0.44) †*	*0.38 (0.33-0.44)*	*0.44 (0.36-0.55) †*	*0.44 (0.36-0.55) †*	*0.37 (0.29-0.46) †*

Note: significant differences, p<0.05, are indicated in *italics.*

[a] Adjusted for age and sex. [b] Further adjusted for ST elevation myocardial infarction, percutaneous coronary intervention, left ventricular ejection fraction, body mass index, health-related quality of life, estimated glomerular filtration rate and full pharmacological treatment. [c] Further adjusted with time-dependent covariate. [d] Physical activity level: low = 0-1 sessions/week; medium = 2-4 sessions/week and high = 5-7 sessions/week. [e] No smoking during the last month. † Differences (p < 0.05) between former smokers and never smokers.

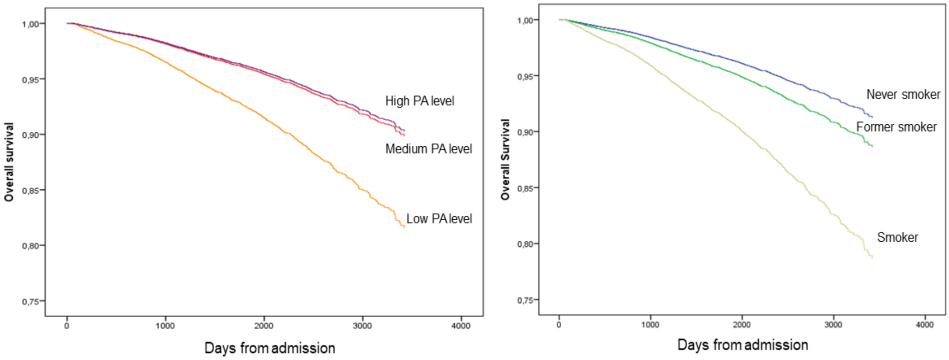

Figure 10. All-cause mortality in fully adjusted analyses among individuals with different physical activity levels and smoking status.

Study III showed that mortality was related to activity level both during 6-8 weeks of outpatient care, and at one-year follow-up. In the analysis adjusted for age and sex, active patients had lower mortality at both assessment periods, with HR 0.42 (0.38–0.48) and 0.41 (0.36–0.46) for the first and second assessment, respectively. In the fully adjusted analysis, corresponding HR values were 0.58 (0.51–0.67) and 0.53 (0.47–0.60), for the first and second assessment, respectively.

In order to explore whether the presence of different intermediate risk factors (LDL ≥1.8 mmol/l, diabetes mellitus type II and hypertension) affected the results, additional sensitivity analyses based on data from **Study II** were performed for the fully adjusted models with time-dependent covariates. No differences in the effect of PA within the different intermediators were found (Table 17).

Table 17. Fully adjusted hazard ratios (HR with 95% CIs) for post myocardial infarction mortality in the SWEDEHEART cohort (Study II, 1702 deaths) with different physical activity levels stratified by the intermediate risk factors (LDL ≥1.8 mmol/l, diabetes mellitus type II and hypertension)

	Low physical activity level [a]	**Medium physical activity level [b]**	**High physical activity level [c]**
LDL cholesterol, ≥1.8 mmol/l (n=25 707)			
Yes	1.00 Reference	*0.48 (0.40-0.58)*	*0.42 (0.32-0.54)*
No	1.00 Reference	*0.51 (0.32-0.83)*	*0.43 (0.22-0.84)*
Diabetes mellitus type II (n=30 273)			
Yes	1.00 Reference	*0.45 (0.33-0.61)*	*0.48 (0.32-0.71)*
No	1.00 Reference	*0.49 (0.41-0.59)*	*0.40 (0.31-0.51)*
Hypertension (n=30 185)			
Yes	1.00 Reference	*0.46 (0.37-0.57)*	*0.42 (0.32-0.56)*
No	1.00 Reference	*0.47 (0.38-0.58)*	*0.37 (0.28-0.50)*

Note: significant differences, $p<0.05$, are indicated in *italics.*

[a] Low = 0-1 sessions/week; [b] medium = 2-4 sessions/week; [c] high = 5-7 sessions/week.

6.4.3 Changes in physical activity level post myocardial infarction as a predictor of mortality

In the SWEDEHEART cohort, changes in PA level during the first year post MI were explored and its association to mortality (**Study III**). The mean follow-up time was 1635 days, or 4.2 years. A total of 1087 deaths occurred during the study period. Total risk time was 100 502 person-years and mortality rate was calculated as 11 cases per 1000 person years.

In the fully adjusted model, HRs for mortality were lower for the constantly active patients and those individuals with increased or decreased activity than those who were constantly inactive. However, HRs for patients who increased, and patients who decreased, their PA levels did not differ. Constantly active patients had lower HRs than individuals with decreased PA levels. Finally, HRs for patients who increased their PA levels did not differ from constantly active patients (Table 18, Figure 11).

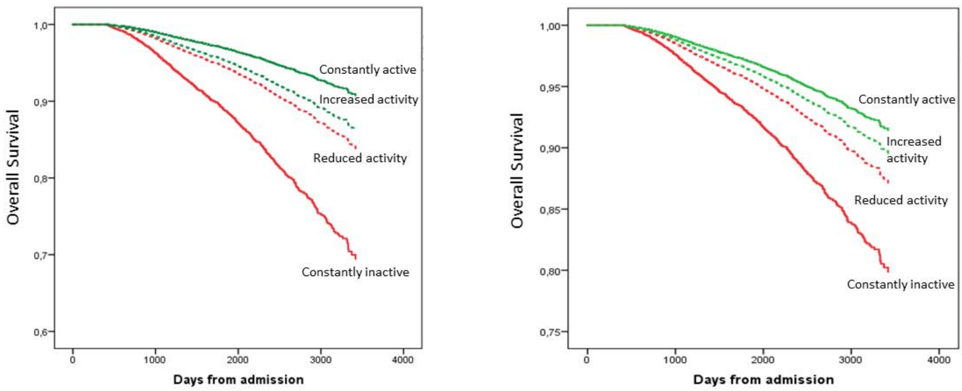

Figure 11. All-cause mortality adjusted for age and sex (left) and fully adjusted (right) among individuals with different physical activity levels.

Table 18. Unadjusted, age-sex adjusted and fully adjusted Hazard ratio (95% CI) for the four physical activity levels

	Constantly inactive	**Reduced activity**	**Increased activity**	**Constantly active**
Unadjusted mortality, cases per 1000 person years	28.5 (25.3–32.0)	12.7 (11.0–14.6)	11.5 (9.4–14.0)	7.5 (6.9–8.2)
Age-sex adjusted	1.00 (Reference)	*0.43 (0.35-0.53)*	*0.32 (0.24-0.43)*	*0.19 (0.14-0.26)*
		1.00 (Reference)	0.83 (0.62 to 1.12)	*0.54 (0.37-0.80)*
			1.00 (Reference)	0.82 (0.49-1.37)
Fully adjusted[a]	1.00 (Reference)	*0.56 (0.45-0.69)*	*0.41 (0.31-0.55)*	*0.29 (0.21-0.41)*
		1.00 (Reference)	0.82 (0.61-1.10)	*0.64 (0.43-0.94)*
			1.00 (Reference)	0.95 (0.57-1.61)

Note: significant differences, p<0.05, are indicated in *italics.*

[a] Fully adjusted for age, date of myocardial infarction, body mass index, estimated glomerular filtration rate, EuroQol-5 dimensions, left ventricular ejection fraction, sex, ST-elevation myocardial infarction, percutaneous coronary intervention, smoking status, pharmacological treatment, participation in exercise-based CR, and an interaction term for time x physical activity strata.

No interactions were found for the variables age, sex, STT changes, the use of percutaneous cardiac interventions, Eq-5D, eGFR, cardiac rehabilitation, smoking status, and pharmacological treatment. However, an interaction with LVEF was found, indicating that individuals with a low LVEF (<40%) were more affected by PA. They had a higher risk of mortality when reducing PA level compared to individuals with an LVEF of 40-

50 %. They also had a lower risk of mortality when increasing or maintaining PA level compared to those with an LVEF of 40-50%.

6.5 Stated importance and clinical work in promoting healthy lifestyle habits by healthcare professionals

6.5.1 Stated importance and clinical work to improve patients' lifestyle habits

Study IV investigated healthcare professionals (in a hospital setting) stated importance and clinical work to promote healthy lifestyle habits. The majority of participants emphasized the importance of providing counselling to patients with unhealthy lifestyle habits within the *healthcare sector in general*. Importantly, there were significant differences between lifestyle habits. The proportion of healthcare professionals stating 'high importance' of providing counselling varied between 69% and 94 % (Figure 12). More healthcare professionals stated that they regarded counselling on tobacco cessation to be important compared to alcohol counselling (difference of 12 %, CI: 4 % to 19%), physical activity counselling (difference of 13 %, CI: 5 % to 20 %) or counselling on healthy eating habits (difference of 25 %, CI: 16 % to 34 %) (Figure 12).

Further, the majority of healthcare professionals emphasized the importance of providing counselling to patients with unhealthy lifestyle habits within their *own clinical work*. Proportions of healthcare professionals rating 'high importance' of providing counselling varied between lifestyle habits, from 63% to 80 % (Figure 12). Counselling on tobacco cessation was more often rated as 'very important' compared to counselling on both alcohol consumption (difference of 13 %, CI: 3 % to 23 %) and healthy eating habits (difference 17 %, CI: 7% to 27%). Providing counselling on physical activity was considered to be more important than counselling on healthy eating habits in their own clinical work (difference of 13 %, CI: 3 % to 24 %) (Figure 12).

Only a minority of healthcare professionals reported that they *always asked* their patients about their lifestyle habits, with differences between the lifestyle habits ranging from 18 % to 41 % (Figure 12). A larger proportion of healthcare professionals always asked patients about tobacco use in comparison to alcohol use (difference of 21 %, CI: 11 % to 31%), eating habits (difference of 23 % CI: 14% to 34 %) and physical activity (difference of 12 %, CI: 2 % to 23 %). Further, a larger proportion always asked about physical activity in comparison to healthy eating habits (difference of 11 %, CI: 1% to 21%) (Figure 12).

Less than one fourth of the healthcare professionals actually *provided counselling* ‘to a great extent’ to individuals with unhealthy lifestyle habits. Counselling varied with lifestyle habit, ranging between 11% and 23 % (Figure 12). Counselling tobacco cessation was more commonly provided than counselling alcohol use, (difference of 12 %, CI: 3% to 20 %) or eating habits (difference of 9 %, CI: 0.3% to 18 %). In addition, participants provided physical activity counselling more often than alcohol counselling (difference of 10 %, CI: 1 % to 18%) (Figure 12).

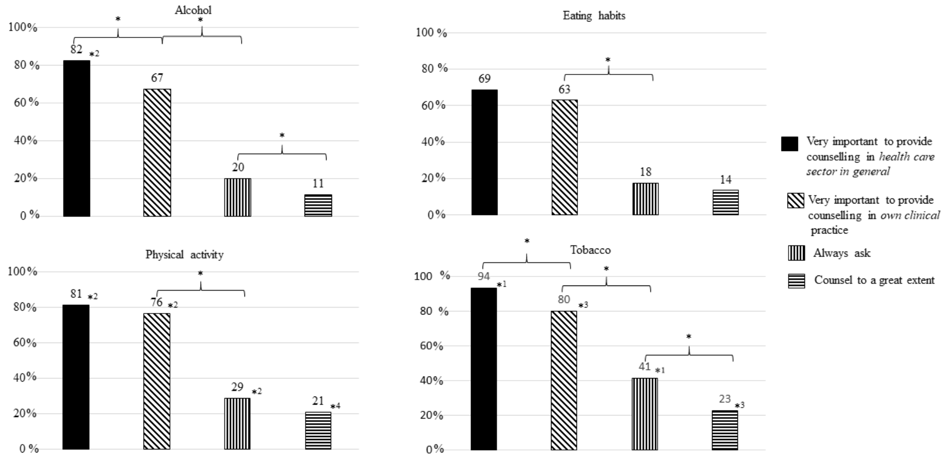

Figure 12. Differences in percentages (n=251) between stated importance and clinical work for different lifestyle habits.

***** denotes statistical detected difference at the 1% level. Differences between lifestyle factors within the same statement/question are indicated by 1-4: [1] > alcohol, eating habits and physical activity; [2]> eating habits; [3] > alcohol and eating habits; [4] > alcohol.

6.5.2 Differences between stated importance and clinical work for lifestyle behavioural changes

Figure 12 shows that for all lifestyle habits, there was a wide gap between the stated importance of the healthcare professionals’ own clinical work and to what degree they actually asked their patients about these habits (difference of alcohol 47 %, CI: 37 % to 57 %; difference of eating habits 45 %, CI: 35 % to 55 %; difference of physical activity 47 %, CI: 37 % to 57 % and difference of tobacco 39 %, CI: 8 % to 29 %). Moreover, for alcohol and tobacco, there were significant differences between all four core questions. The correlation between stated importance in general, and clinical work in (asking and counselling) was poor ($r < 0.3$) for all lifestyle habits. Regarding stated importance within own clinical work, and to what degree participants asked and counselled about the four lifestyle habits, the correlation was fair (r: 0.3-0.5).

6.5.3 Personal and organisational factors of potential importance

Table 19 describes the relationship between personal and organisational factors, and stated importance and clinical work. For stated importance in general, and stated importance in own work, only a few associations were found. Sex, profession and to what extent the healthcare professionals perceived clear routines and objectives were related to stated importance, but with differences between lifestyle habits.

For clinical work (asking and providing counselling), several factors were associated. These were mainly organisational factors (e.g. perceived clear routines, objectives and strong management support). Overall, it was more prevalent for physicians, individuals with more than nine years in the profession, and individuals working within outpatient care to ask about and provide counselling (Table 19).

Table 19. Unadjusted odds ratios (ORs with 99% CI) for personal and organizational factors relating to stated importance and clinical work with lifestyle habits

	Alcohol	**Eating habits**	**Physical activity**	**Tobacco**
Important in general				
Male	0.41 (0.16-1.03)	*0.23 (0.10-0.52)*	0.68 (0.26-1.76)	2.04 (0.28-14.89)
Doctor	0.59 (0.24-1.43)	*0.39 (0.18-0.81)*	1.60 (0.61-4.21)	7,31 (0.50-107.1)
Inpatient care	1.26 (0.45-3.54)	0.84 (0.34-2.07)	0.65 (0.21-2.03)	0,25 (0.02-3.70)
< Age (40 years)	0.76 (0.32-1.79)	0.75 (0.37-1.51)	0.72 (0.31-1.66)	1.36 (0.34-5.35)
≤ nine years, clinical work	0.67 (0.24-1.82)	0.69 (0.31-1.53)	1.04 (0.42-2.58)	1.11 (0.26-4.67)
Clear routines	1.10 (0.20-5.93)	1.84 (0.70-4.81)	1.21 (0.42-3.45)	3.96 (0.27-58.45)
Clear objectives	1.00 (0.29-3.48)	2.37 (0.85-6.63)	2.74 (0.83-9.08)	2.56 (0.47-13.82)
Management support	0.70 (0.17-2.79)	1.22 (0.44-3.43)	1.91 (0.45-8.07)	4.23 (0.29-62.80)
Important in own practice				
Male	1.11 (0.48-2.59)	0.48 (0.22-1.06)	1.50 (0.55-4.06)	2.36 (0.71-7.84)
Doctor	1.78 (0.81-3.93)	0.72 (0.35-1.49)	*3.66 (1.28-10.48)*	*9.33 (1.92-45.24)*
Inpatient care	2.07 (0.90-4.77)	1.08 (0.47-2.51)	0.89 (0.33-2.36)	1.76 (0.69-4.51)
Age (< 40 years)	0.96 (0.48-1.92)	1.17 (0.59-2.32)	1.22 (0.56-2.66)	1.55 (0.67-3.59)
≤ nine years, clinical work	1.00 (0.47-2.16)	0.93 (0.44-1.96)	1.21 (0.53-2.76)	1.48 (0.63-3.51)
Clear routines	2.50 (0.47-13.27)	*2.69 (1.00-7.22)*	2.76 (0.84-9.11)	6.96 (1.03-47.00)
Clear objectives	2.49 (0.74-8.40)	2.64 (0.98-7.11)	*8.65 (1.78-41.96)*	*11.03 (2.27-3.61)*
Management support	1.39 (0.39-4.98)	2.04 (0.63-6.57)	1.70 (0.50-5.78)	n/a
Always ask				
Male	1.72 (0.69-4.31)	0.51 (0.15-1.70)	0.81 (0.33-1.99)	1.49 (0.68-3.29)
Doctor	2.03 (0.88-4.71)	0.51 (0.18-1.45)	0.88 (0.40-1.93)	*3.09 (1.49-6.39)*
Inpatient care	0.63 (0.24-1.64)	*0.27 (0.11-0.68)*	0.46 (0.20-1.08)	0.87 (0.38-1.99)
Age (< 40 years)	0.65 (0.28-1.50)	0.52 (0.21-1.30)	0.81 (0.33-1.99)	1.06 (0.54-2.05)
≤ nine years, clinical work	0.47 (0.20-1.09)	*0.40 (0.16-0.96)*	*0.43 (0.20-0.93)*	0.79 (0.39-1.64)
Clear routines	2.09 (0.54-8.14)	*6.44 (2.51-16.53*	*6.47 (2.73-15.36)*	*4.11 (1.70-9.97)*
Clear objectives	*3.38 (1.23-9.33)*	*5.34 (2.07-3.76)*	*5.36 (2.39-12-06)*	*4.67 (2.24-9.73)*
Management support	2.35 (0.70-7.91)	1.51 (0.45-5.07)	*3.13 (1.22-8.04)*	*3.94 (1.68-9.27)*
Always provide counselling				
Male	2.63 (0.89-7.81)	0.58 (0.15-2.14)	0.95 (0.36-2.52)	2.19 (0.92-5.22)
Doctor	*2.93 (1.03-8.36)*	0.91 (0.32-2.58)	1.37 (0.59-3.17)	*3.06 (1.37-6.85)*
Inpatient care	0.69 (0.20-2.31)	*0.29 (0.10-0.79)*	0.45 (0.18-1.13)	0.61 (0.24-1.51)
Age (< 40 years)	0.56 (0.19-1.67)	0.47 (0.17-1.33)	0.54 (0.23-1.25)	0.73 (0.33-1.62)
≤ nine years, clinical work	0.51 (0.18-1.45)	0.40 (0.15-1.06)	0.58 (0.25-1.36)	0.86 (0.37-2.00)
Clear routines	2.43 (0.51-11.59)	*7.64 (2.74-21.29)*	*7.84 (3.17-19.37)*	*6.05 (2.48-14.79)*
Clear objectives	2.92 (0.88-9.75)	*8.47 (2.98-24.04)*	*10.93 (4.36-27.4)*	*4.05 (1.79-9.16)*
Management support	2.33 (0.56-9.65)	2.05 (0.60-7.03)	*4.06 (1.53-10.76)*	*3.55 (1.49-8.47)*

Note: significant differences, p<0.01, are indicated in italics.

6.5.4 *Expectations and future work*

In general, the healthcare professionals had a positive attitude towards lifestyle habits and the majority stated that lifestyle habits always were an important part of patient health (alcohol 81%, eating habits 65%, physical activity 77% and tobacco 87%). The majority also stated they would like to increase their work in promoting healthy lifestyle habits among patients and were most motivated to increase their work with physical activity, followed by eating habits, tobacco and alcohol (Figure 13). Wanting to increase their work with lifestyle habits was found to be independent of how much the healthcare professionals currently worked with patients' lifestyle habits ($p < 0.05$).

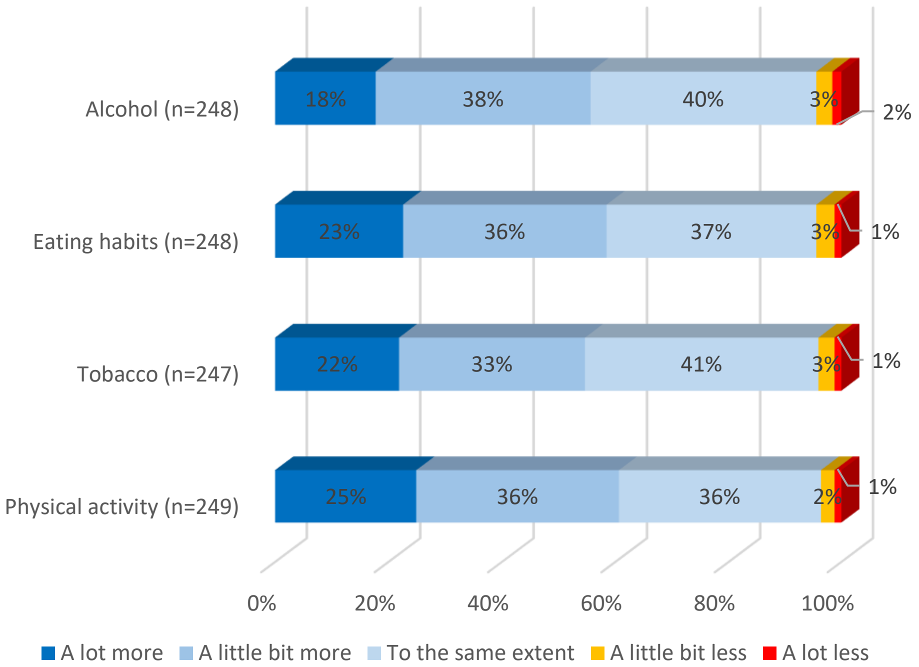

Figure 13. The proportion of to what extent healthcare professionals work with counselling of lifestyle habits in their current work.

A minority of healthcare professionals believed that patients always expected questions about their lifestyle habits (alcohol 14%, eating habits 11%, physical activity 14% and tobacco 30%). For all lifestyle habits, logistic regressions showed that healthcare professionals who thought that patients expected questions asked their patients to a higher degree (alcohol OR 2.92, 95% CI 1.06-8.08, eating habits OR 11.59, 95% CI 3.74-35.97, physical activity OR 6.67, 95% CI 2.43-18.30, tobacco OR 2.88, 95% CI 1.38-6.02) compared to healthcare professionals who did not.

7 DISCUSSION

In Europe, with an increasing population and a higher proportion of elderly, both the incidence and prevalence of CVD have increased (11). This emphasizes the need for primary and secondary preventive interventions, e.g. promoting PA and other lifestyle habits. The overall aim of this thesis was therefore to investigate the importance and use of PA in clinical practice for patients with CVD.

In summary, the results of this thesis found that a high proportion of patients with CVD had an insufficient level of PA and a high level of SED (Figure 14). Further, we found that PA level, SED and change in PA level (pre and post hospitalisation) were important predictors of health outcomes for patients with CVD. Finally, we found a strongly expressed opinion among healthcare professionals regarding the importance of promoting healthy lifestyle habits as a part of clinical work. However, we also found that in reality, healthy lifestyle habits were not often promoted in their clinical work.

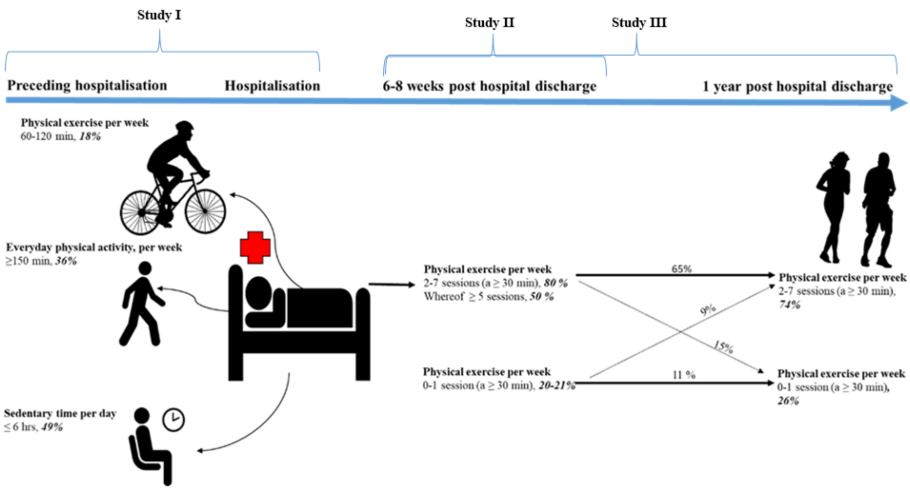

Figure 14. Illustration of PA levels (**Studies I-III**), pre and post hospitalisation among patients with CVD.

7.1 Physical activity level and sedentary time

Our first research question regarded PA level and SED in patients with CVD. The study populations used were slightly different, and this warrants some attention.

The study population in the Stockholm and SWEDEHEART cohorts differed in several aspects. The Stockholm cohort included all individuals with CVD treated on cardiac wards. This included older individuals (median age 70 years) with possibly more severe diseases and comorbidity than the SWEDEHEART cohort which included younger individuals (median age 63 years) diagnosed with their first MI. Additionally, the SWEDEHART cohort only included individuals who could attend outpatient follow-up sessions, and excluded individuals who died prior to follow-up, or had too severe illness or disability to attend the follow-up sessions. These differences in the study populations may have affected the results when comparing PA level, risk of readmission and mortality.

Studies I-III all explored levels of PA in patients with CVD. In the Stockholm cohort **(Study I)**, less than one fifth of patients stated that they achieved at least 60 minutes of at least moderate intensity physical activity (MVPA) a week. This is in contrast to **Study II** where half the study population reported a high level (≥150 minutes a week) of MVPA post MI, and thereby were considered achieving the international recommendations for PA. As mentioned above, the study population differed in the Stockholm and SWEDEHEART cohorts, with the Stockholm cohort likely suffering from comorbidity to a higher degree. The large Stability (Stabilization of Atherosclerotic Plaque by Initiation of Darapladib Therapy) study (n= 15 486) found a lower level of PA among patients with more comorbid conditions (125). However, Evenson et al., on exploring physical activity, saw no differences in PA level or SED between patients (n=680) with one or several CVD diagnoses (126). Another impacting factor of PA level could be that patients in the SWEDEHEART cohort could have been offered exercise-based CR at 6-8 weeks post MI. Karadikis et al. concluded that most studies assessing PA level post MI questioned patients on their PA habits while they were participating in exercise-based CR. This might contribute to a misleadingly high PA level. However, one survey has shown that only a minority of patients in Sweden participate in exercise-based CR post MI (105). In **Study III**, individuals participating in exercise-based CR had a higher PA level both at baseline and one-year follow-up. This is in line with a Norwegian study by Peersen et al. who reported a higher PA level among patients participating in CR compared to those who did not (127). However, a Danish study, in direct contrast, found no differences in PA level between individuals participating in CR and those who did not at four and 12 months follow-up (128).

PA level at a moderate to vigorous intensity level post MI in this thesis (**Study II**) is in line with the Danish study by Bertelsen et al., which explored PA levels among patients with acute coronary syndrome (ACS). In this study, approximately 50% of patients were categorised as achieving the PA recommendations (30 minutes/5 days a week) at four and 12 months post discharge (128). In EUROASPIRE IV (a multicentre European survey), Kotseva et al. reported a lower level of vigorous PA in patients (n=7998) with IHD, with approximately 40% performing vigorous PA for at least 20 minutes three or more times a week post hospital discharge (129). There were differences between sub-groups, with women, individuals with diabetes mellitus type II, and individuals with a lower education level reporting lower levels of PA (130-132).

In the Stockholm cohort (**Study I**), a broader perspective on PA behaviour was explored. In addition to physical exercise, everyday PA and SED were assessed. This is an important distinction from previous studies, which mainly focused on MVPA for patients within exercise-based CR (1, 103). **Study I** showed that patients were active predominately via everyday PA (e.g. walking, bicycling, or gardening), rather than physical exercise. Roughly, one third of patients stated that they spent more than 150 minutes per week in everyday PA. Although comparisons are difficult, a larger proportion of patients met recommendations via everyday PA compared to physical exercise, which is in line with previous studies among the elderly (133). Additionally, in the STABILITY study, the same pattern was seen with the majority of patients with stable coronary heart disease (CHD) (n = 15 486) across 39 countries reporting activities at a low or moderate intensity (134).

To explore total PA level in the Stockholm cohort (**Study I**), we used the validated PA index (combining everyday PA and physical exercise) (84). This showed that 44% of patients were considered to be sufficiently physically active pre hospitalisation. There are, to our knowledge, few studies exploring PA levels pre hospitalisation. We found two studies with conflicting results. In a Greek study, which included patients with ACS, 61% were categorised as inactive or had a low level of PA (< 150 metabolic equivalent [MET] minutes/ week) in the year prior to hospital admission (135). In contrast, Kaasenbrood et al. showed that PA levels were high, with only 14 % of their patients with CHD stating that they did not achieve the recommended PA level at hospital enrolment (136). It is more common for studies to explore PA levels post hospital discharge using different types of assessment. The majority of studies explored self-rated PA level using questionnaires. They found that post hospital discharge, the number of patients with IHD categorised as sufficiently physically active (≥150 minutes per week, of PA in at least a moderate intensity) varied between 17 and 60 percent (128, 137-143).

Evenson et al. explored PA levels in 680 patients with CVD. They assessed PA using questionnaires, and included questions on active transportation, household and leisure activities over the preceding 30 days. The patients most commonly reported being active in household activities, followed by leisure time activities at moderate intensity. The proportion achieving the PA recommendations ranged from 14.6% among patients with HF to 27.5% among patients with CHD (126). Differences in PA levels between patients with different CVD diagnoses were also seen in our Stockholm cohort (**Study I**), with patients with HF and valvular heart disorder having the lowest level of PA and highest level of SED. Three studies assessing number of daily steps via a pedometer in patients with CAD within or post CR, found that patients took a median of 6530-7000 steps per day. In addition, approximately 20% took more than 10 000 steps and were considered as achieving PA recommendations (144-146). Thorup et al. found that number of steps increased from hospital discharge (mean 5191, SD 3198) to one-year follow-up (mean 7890, SD 2629) among patients with ACS (147). A few studies explored PA level using accelerometers, and all concluded that time spent in MVPA was low (126, 148, 149). Evenson at al. reported that time spent in MVPA ranged from 8.6 minutes/day for patients with HF to 11.4 minutes/day for patients with angina (126). This is similar to another study that showed patients participating in exercise-based CR spent approximately 10 minutes in MVPA per day (149). Finally, Strauch et al. exploring PA levels in a small Swedish study, showed that elderly patients with coronary artery disease (CAD) spent approximately 19 minutes in MVPA a day.

In the SWEDEHEART cohort (**Study III**), we explored whether patients changed their PA levels in the first year post MI. The majority (76%) were categorised as having the same activity level on the different follow-up occasions. Meanwhile, 15 % decreased and 9 % increased their activity level. However, the study only explored changes between ≥2 sessions or below, not within groups (0-1 sessions vs 2-7 sessions). Previous smaller studies have shown similar results, with the majority of individuals with IHD having the same level of PA at discharge and up to five years post discharge (150-152).

Approximately half (51%) the Stockholm cohort (**study I**) stated that they spent 7 hours or more being sedentary. This is higher than national and European self-reported data in a general population, where the percentage reporting ≥7 hours of sitting was 44% and 19 %, respectively (76, 153). The high proportion of long SED is worrisome since previous studies showed health benefits with sitting less than 7 hours a day (154). There are to our knowledge few studies focusing on SED among patients with CVD. Evenson et al. concluded that compared to healthy individuals, patients with CVD spent more time (assessed with an accelerometer) in SED (9.6-10.1 vs 9.2 hours), and rated a higher daily duration of screen time exposure. The high level of SED is in line with two smaller studies on patients with coronary heart disease where participants rated their SED as approximately 10 hours per day (149), and the accelerometer estimated that the patients spent between 11-12 hours in SED daily (148, 149).

In summary, the generally lower levels of PA and higher levels of SED pre and post hospitalisation compared to healthy individuals (72, 126, 140, 153, 155), highlight the need to ask all patients treated on a cardiac department about their PA level and provide support when needed. Support to increase PA level should be individualised, and recommended methods to increase PA among patients could be exercise-based CR or physical activity on prescription (1, 156). Further, Kotseva et al. concluded that the majority of coronary patients reported that they increased their PA by following specific advice from a health or exercise professional, attending leisure centres/gyms/community walking groups, or increasing everyday physical activity (129).

7.2 Physical activity level and sedentary time as predictors of hospital care utilisation

Our second research question regarded the prediction of PA and SED levels on hospital care utilisation. We hypothesised that PA (negatively) and SED (positively) are associated with hospital care utilisation. In line with our hypothesis, the Stockholm cohort (**Study I**) showed that there was a dose-response relationship between PA level (negatively) and SED (positively) with the length of the current hospital stay. Although hospital stay duration can differ among patients with different CVD diagnoses, our results indicated that the association between PA level and SED and hospital stay duration did not differ with different diagnoses. The shortest inpatient duration was seen among individuals with the highest PA level or lowest SED. This is in line with a study focusing on the association between PA level and healthcare utilisation in general, concluding that individuals with the lowest PA level have extended inpatient duration (157). In the Stockholm cohort (**study I**), median inpatient duration was 2 (3 IQR) days on a cardiac ward. One higher step in self-assessed PA level, or lower SED level, was related to an approximately 0.9 days shorter hospital stay. Inpatient duration for patients with a similar diagnosis were 4.61 days on average in Sweden, 2016 (158). Based on our results, a change of one category of PA level or SED could hypothetically decrease the total hospital duration among patients with CVD in Sweden by nearly 20 %. While the non-experimental design of the study in this thesis reduces the ability to draw conclusions on effects of change or causality, a Canadian study on healthy elderly supports our results and concluded that an additional 20 minutes of walking per day in the least physically active group reduced the number of days spent in inpatient care (159). Our results in **Study I** are thus of great interest when there are, to our knowledge, no previous studies exploring the association between PA level and SED with hospital duration among patients with CVD.

The association between PA and readmission was explored by unadjusted and adjusted logistic regressions in both the Stockholm (S**tudy I**) and SWEDEHEART cohort (S**tudy II**). The proportion of individuals who were readmitted was lower in the SWEDEHEART cohort compared to the Stockholm cohort. In addition to the above-mentioned factors (e.g. differences in median age, comorbidity), the difference in readmission rate can, potentially, be explained by the slightly longer follow-up in the Stockholm cohort.

Results from the SWEDEHEART cohort (**Study II**) showed that individuals with a medium or high level (2-4 and 5-7 sessions per week) of PA (of at least moderate intensity) had a lower risk of readmission in the first year post MI. The same pattern was seen in the Stockholm cohort (**Study I**) when exploring everyday PA and SED. Thus these results were in line with our hypothesis. However, for physical exercise, there was no clear association with readmission in the adjusted analyses amongst the Stockholm cohort (**Study I**). To our knowledge, there are few previous studies assessing the association between PA level and health outcomes among patients with CVD. The STABILITY (Stabilization of Atherosclerotic Plaque by Initiation of Darapladib Therapy) study found no risk reduction in readmission following MI, stroke or major adverse cardiac events in fully adjusted analyses among individuals with higher PA levels (134). On the other hand, Biscaglia et al. found a lower risk of stroke among patients performing vigorous PA, although no decreased risk of MI (160). Papataxiarchis et al. concluded that in individuals with no prior CVD, the risk of a new CVD event was lower among those who completed one or more PA sessions per week compared to those who were inactive (135). In an American study (n= 4174), HRs for recurrent CHD were lower in patients performing 1-3 PA sessions per week and ≥4 PA sessions/week than inactive patients (161). Doukky et al., found no significant decrease in heart failure hospitalization among inactive patients diagnosed with heart failure (NYHA II-II) compared to active (162).

We could not find any studies exploring the association between SED, everyday PA or physical exercise separately, with readmission among patients with CVD, making **Study I** unique. This study showed that both PA level and SED may have independent effects on hospital duration and the risk of readmission. Further, **Study I** concluded that the predictive value of PA level and SED on future readmission holds for several different CV diagnoses. Interestingly, both **Studies I** and **II** concluded that there was no significant difference in the estimated OR of readmission between medium and high PA levels or medium and low SED, indicating that it is most important to target the most inactive patients for help with improving their PA. This may be an achievable strategy as even a small reduction in SED and increase in everyday PA for inactive individuals with CVD could improve health and decrease hospital utilisation in general.

Thus, this thesis highlights that self-reported PA level and SED in patients with CVD pre and post hospitalisation are important predictors of hospital stay duration and future readmission.

7.3 Smoking status as a predictor of readmission

In contrast to our hypothesis and previous studies among patients with MI, no significant association between smoking status and readmission due to either CVD or non-CVD could be shown in the unadjusted models (**Study II**). However, previous studies had a longer follow-up time (163, 164), which may indicate that smoking status is a better predictor of long-term rather than short-term readmission and survival. Another reason may be that smokers tend to develop CVD earlier (mean of 4 years earlier in the Study II cohort, data not shown) than former smokers and never smokers, and therefore may have a lower burden of other risk factors. Further, in our fully adjusted models, never smokers even appeared to have a slightly higher risk of readmission ($p<0.01$). To explore this association further, we performed a stepwise forward and backward logistic regression model and still found no explanations as to why never smokers had a higher readmission risk. Although several potential confounders have been controlled for in our study, there is always a risk of residual confounding, which may be of importance in this analysis.

7.4 Physical activity level and sedentary time as predictors of mortality

Our third research question regarded the association between PA and SED levels and mortality. Our hypothesis was that PA (negatively) and SED (positively) would be associated with all-cause mortality during follow-up. In line with our hypothesis, self-reported PA level (**Studies I-III**) and SED (**Study I**) pre and post hospitalisation were clinically relevant predictors of all-cause mortality. In **Studies I and II**, the largest risk reduction for all-cause mortality was found between patients with a low PA level/high SED, and those patients reporting a medium PA level/SED. A less pronounced additional risk reduction was found among those patients reporting a high PA level/low SED compared to those reporting a medium PA level/SED. Previous studies on patients with IHD showed similar a non-linear relationship between PA level and cardiovascular mortality (142, 160) and all-cause mortality (134, 141, 142, 160, 161, 165). Interestingly, Mons et al. reported a J-shaped association between PA level and cardiovascular mortality. Although the highest risk was among individuals with the lowest levels of PA, a substantially increased risk was seen in the most frequently physically active groups in the fully adjusted model (142). A study among patients with HF, found that physical inactivity was associated with higher risk of all-cause mortality and cardiac mortality compared to active (162).

In the unadjusted analyses, mortality differed between the three study populations with 68 cases per 1000 person years (**Study I),** 14 cases per 1000 person years (**Study II**) and 11 cases per 1000 person years (**Study III**). Possible impacting factors are mentioned at the start of the discussion, but differences in study methods, specifically patient recruitment and inclusion periods, may have had an impact on mortality incidence. When those patients in the Stockholm cohort who died within 49 days were excluded (**Study I**), mortality incidence decreased to 51 cases per 1000 person years, which is still higher than in **Study II**.

In the Stockholm cohort, a wider perspective of PA habits, such as distinguishing between physical exercise, everyday PA and SED, and its association with all-cause mortality was explored. Interestingly, everyday PA was more strongly related to mortality than physical exercise. There are few previous studies exploring the association of everyday PA (often including light intensity PA, LIPA) and all-cause mortality, illustrating a knowledge gap in the association between LIPA and all-cause mortality in individuals with CVD.

For SED, individuals in the Stockholm cohort (**Study I**) reporting "≤ 6 hours SED per day" had a lower mortality risk compared to individuals reporting "≥ 10 hours SED per day". This highlights the need for a more specific assessment of PA behaviour, including everyday PA and SED, in clinical work. There are, to our knowledge, few studies assessing SED among patients with CVD and exploring its association with mortality. However, Gorczyca et al. explored the association between self-reported SED and mortality among women pre and post MI. They observed an increased risk of all-cause mortality for every hour increase in sitting per day in women who regularly sat for eight hours or less per day, pre-MI (152). The association between high SED and a lower risk of cardiovascular or all-cause mortality was also seen in an international prospective study (CLARIFY) among 32 370 patients with CHD (160).

The Stockholm cohort (**Study I**) showed that an association between a high PA level, low SED level, and lower HRs of mortality followed for patients with different CVD diagnoses including IHD, HF, cardiac arrhythmias, valvular heart disorder, inflammatory heart diseases and others. This is an important finding since previous studies mainly focused on patients with HF or IHD (103, 142, 152, 160, 166). Further, it appears that the effect of PA for patients with MI did not differ by for example sex, age, smoking status, decreased kidney function (**Study III**) diabetes type II, hyperlipidaemia or hypertension (**Study II**).

Study III showed that a change in PA level during the first year post MI affected mortality risk. Patients who were initially inactive were found to reduce their mortality risk by increasing their PA level and interestingly the HRs did not differ significantly from the constantly active group. On the other hand, individuals who decreased their activity level during the first year post MI had a higher risk of premature mortality than those who remained physically active. This indicates that is important to continue being regularly physically active and that it is never too late to start being physically active to improve health. These results are in line with previous smaller studies identifying a lower mortality risk in patients with MI who increased their PA level, and an increased risk in those who decreased their PA level (151, 152). A recently published study by Moholdt et al. explored the association between changes in PA level and all-cause mortality among patients with IHD (n=3307). They assessed PA level (inactive, low or high) on two different occasions and had a follow-up of 30 years. They found that individuals reporting a high PA level over time had a 36% lower all-cause mortality risk compared with those who continued to be inactive. Moreover, compared to individuals who remained inactive, a significantly reduced all-cause mortality risk was observed in those who maintained a low PA level (HR: 0.81; 95% CI: 0.67 to 0.97), those who changed from a low PA level to being inactive (HR: 0.82; 95% CI: 0.70 to 0.96), and in those who changed from a high to low PA level (HR: 0.74; 95% CI: 0.60 to 0.92) (167).

Thus, the studies in this thesis underline the importance of routinely assessing patients' PA levels and SED in order to predict future all-cause mortality. In this context, PA level can be seen as an additional marker of disease severity.

7.5 Smoking as a predictor of mortality

Among individuals with different smoking status, the decreased risk of all-cause mortality was strongest for never smokers compared to smokers, which was in line with our hypothesis. Previous studies exploring the association between smoking and mortality have shown conflicting results. However, most studies are in line with our results indicating a higher risk of premature mortality among long-term smokers (163, 164, 168). The association was weaker among former smokers. This may be due to individuals who quit smoking at the time of their respective MI were considered former smokers. In addition, long-term endothelial dysfunction caused by smoking may persist in former smokers (169).

7.6 Healthcare professionals stated importance and clinical work to promote healthy lifestyle habits

The major finding of **Study IV** was that healthcare professionals working in cardiology departments considered lifestyle habits (alcohol, eating habits, physical activity and tobacco use) to be important within clinical work, although only a minority asked about lifestyle habits or provided counselling. This illustrates that there is a gap between stated importance and clinical work. However, the majority of healthcare professionals wanted to improve their work with patients' lifestyle habits. Our hypothesis stated that the majority of healthcare professionals working in hospital care would be positive to, and provide counselling on, healthy lifestyle habits in line with guidelines. For stated importance, our results proved our hypothesis, although for clinical work they did not.

Studies within primary care indicate that healthcare professionals consider health promotion and disease prevention to be important (99, 107, 108). There are, to our knowledge, only a few studies focusing on stated importance of health promotion and disease prevention among healthcare professionals within hospital care. Johansson et al. concluded that health promotion was considered less important among healthcare professionals working in hospitals compared to those working in primary care (170). In 2015, the National Board of Health and Welfare in Sweden published a survey (171) on stated importance and to what degree healthcare professionals from different parts of the healthcare sector provided counselling. The survey results differed from our results in that our study population stated a higher importance of promoting lifestyle habits in clinical work, and provided counselling to a higher degree. Interestingly, there was a difference between the survey results and our results in which lifestyle habits were stated to be an established part of clinical work. In our study, smoking cessation was reported to be the most established, followed by PA. Meanwhile in the national survey, physical activity was the most commonly mentioned lifestyle habit, followed by eating habits (171). Nevertheless, the finding that tobacco cessation was the lifestyle habit with highest stated importance and an established part of clinical work in **Study IV**, is in line with previous studies. Haynes explored patients' views on the advice they received from UK hospitals on changing lifestyle habits. This study demonstrated that the majority of patients were asked about tobacco use and fewer were asked about alcohol use, PA and eating habits (98). A similar pattern was seen in another study using medical records to explore lifestyle habits (96). The negative effects of tobacco on health have been known for a long time (172) and thus this may be the reason that asking about and counselling on tobacco use is more common than for the other lifestyle habits. However, the importance of regular physical activity, healthy eating habits and moderate use of alcohol has become more evident during the last few decades (16, 129, 173-177). Interestingly, a recently published study by Ogmundsdottir et al. focusing on cardiac rehabilitation in Sweden showed that healthcare professionals in cardiac departments stated that they assessed patients' lifestyle habits to a large degree (alcohol consumption 85%, eating habits 95%, physical activity 97% and smoking status 100%). Further, they stated that they offered counselling to a great extent (alcohol consumption 83%, eating habits 99%, physical activity 99% and smoking status 99%) (178). The large difference between this study and our results is notable. The differences may be due to different questions being asked, and that our study asked about whether the healthcare professionals asked all their patients within cardiac care. While, Ogmundsdottier et al. asked about the work with only those patients included in CR. Finally, our study focused on *all* healthcare professionals and *their* clinical work while Ogmundsdottir et al. asked one clinic employee who possibly answered about what the clinic *should* offer.

It is important to remember that all four investigated lifestyle habits have a cumulative impact on preventing new cardiovascular events (175). Regarding patients needs, previous studies indicated that only a minority of patients achieved the secondary prevention objectives of physical activity and eating habits compared to tobacco cessation following a cardiovascular event, and are in need of support (129, 139, 175). Additionally, the prevalence of unhealthy lifestyle habits in Sweden does not mirror the healthcare professionals' stated work with lifestyle habits in **Study IV**. In 2019, the Public Health Agency of Sweden concluded that not eating enough fruit and vegetables is the most prevalent unhealthy lifestyle habit (with 86% of men and 71% women not meeting recommendations), followed by insufficient PA (36%), hazardous use of alcohol (29% of men and 13% of women) and being a daily smoker (7%) (153). This highlights the importance of healthcare professionals regularly asking patients about all major lifestyle habits in order to identify individuals at risk.

In **Study IV**, we aimed to explore how personal and organisational factors affected healthcare professionals' stated importance of providing counselling and work with patients' lifestyle habits. For stated importance of providing counselling, there was a strong consensus among the healthcare professionals, but there was no clear pattern of affecting factors. Personal factors affecting stated importance and clinical work were mainly sex, profession and years in profession. A previous study showed that women considered the promotion of healthy lifestyles by the healthcare sector to be of greater importance than men (170). Our results were in agreement with this, with more female than male healthcare professionals stating that eating habits were of a "high importance" in their practice. In a previous study, physicians were more negative towards health promotion and preventive aspects of clinical work than other healthcare professionals (170). The study in this thesis differs in this regard, showing that in their own clinical work, physicians considered counselling on physical activity to be of greater importance compared with other healthcare professionals. Physicians also asked about tobacco and provided counselling on alcohol intake and tobacco cessation more often than other healthcare professionals. Douglas et al. showed that physicians more frequently asked patients about PA when it was associated with their disease, than talked about physical activity in general (179,). The clear association between the four lifestyle habits explored in this thesis and CVD may be a possible explanation as to why physicians in cardiac care are more positive towards improving their patients' lifestyle habits. In agreement with earlier studies, more years in the profession had a positive impact on clinical work with lifestyle habits (asking about eating habits and physical activity) (99, 108). In **Study IV**, lack of clear routines, clear objectives and strong management support (i.e. organisational factors) were seen as impacting factors to not work with behavioural changes in everyday clinical work. This is in line with a Swedish study exploring perceived barriers among healthcare professionals within primary and hospital care (170). Thus, more effort needs to be invested in the implementation of working with behavioural changes as a regular part of clinical work.

Finally, only a minority of the healthcare professionals stated that they thought patients expected questions regarding their lifestyle habits. This is in contrast to a large Swedish survey where the majority (97 %) of patients (n=1800) stated that they would like to be asked about their lifestyle habits (93). A study performed in England on patients acutely admitted to hospital reported that the patients wanted to be asked about their PA as long as it was associated with the hospital admission (92). This indicates that there is a gap between what patients want and what healthcare professionals believe patients want. Knowing that patients want to be asked about their lifestyle habits can hopefully lead to healthcare personnel asking about lifestyle habits more frequently. However, it is important to provide individually tailored counselling and explain how lifestyle habits can be associated with the patient's health and treatment outcomes (92, 93).

7.7 Strengths and limitations

Studies I-III are all prospective cohort studies. This study design explores associations over time but does not give information about causality, in this case between PA level/SED and hospital care utilisation or mortality. There is a risk of reversed causality due to the relative short follow-up, and that individuals with a better health status may have a higher PA level/lower SED. However, the size of the study populations made it possible to identify the effect of PA level and SED by adjusting for multiple possible confounders (**Studies I-III)** and sensitivity analyses (**Studies II-III**), and thereby reducing the risk of reverse causality. However, none of these methods are able to fully compensate for the lack of randomization (which is one of the most important differences between cohort studies and experiments). To adjust for the short median follow-up, we performed an analysis excluding patients with shorter follow-up times than 28 and 49 days (19 and 28 deaths, respectively, **Study I**), 5 years (n=11066, 754 deaths, **Study II**) and 2 years (n=3424, 151 deaths, **Study III**). The analysis using those populations was repeated and only limited and non-significant differences from studies not excluding individuals with short follow-up were noted. This may suggest that the effect of reverse causation was limited.

Even when adjusting for several known covariates (133, 180, 181), the association between PA level (**Studies I-III**) and mortality persisted in all three studies. However, there is always the possibility that other risk factors, not available in this study, could have had an impact on the results. Since almost all measurements have inherent measurement errors, even when controlling for a factor, some variance remains. This is called residual confounding. **A limitation in Study I** is that it does not provide any information on comorbidity, treatment given during inpatient care, pharmacological treatment or any changes in lifestyle habits - all known factors that can affect the risk of mortality (151, 152, 182, 183). However, by including variables such as renal function, EF and size of MI in our analysis (**Studies II-III**), and by performing stratified sensitivity analyses between patients with and without hypertension, diabetes mellitus type II and LDL-cholesterol ≥1.8 mmol/l (**study II**), we would say that we, to some extent, took CVD comorbidity into account in our analysis. Both **Studies II and III** lack data on socioeconomic variables, which is a limitation as they affect both PA level and risk of premature mortality (11, 29, 31, 125). Another limitation is the absence of eating habits. This was not included in the SWEDEHEART registry at the time of this study and could therefore not be accounted for. Three categories of smoking status were used in all three studies. However, a more precise measure such as pack-years may have reduced possible residual confounding regarding this variable. Also, no information on genetic predisposition was included in this thesis.

When exploring the association between PA level and mortality **(Studies I-III)**, there are intermediating factors or possible mechanisms. For instance, regular PA lowers elevated blood pressure, sets a more favourable lipid profile and improves glucose uptake and insulin sensitivity (50-54). These are all important mediators possibly responsible for the reduction of CVD morbidity and mortality. It would therefore be questionable to control for these factors in a regression analysis. Rather, these mediating factors must be treated as other than non-modifiable factors and factors related to lifestyle habits, socio-economic variables and HRQol. To control for possible mediators, special statistical methods are required, such as structural equation modelling or mediation/moderation analyses. We chose not to include such methods. Instead, we approached this issue using a stratified sensitivity analysis. It is possible that, despite controlling for covariates, excluding individuals with short follow-ups and performing a stratified analysis, being inactive serve as a proxy for the severity of the ongoing illness. However, if ongoing severe illness was a main reason for inactivity, the stratified analysis should indicate interaction between strata of for example diabetes mellitus type II or eGFR.

The sampling differed throughout the four studies. **Study I** included patients that agreed to answer questions regarding their lifestyle habits. **Study IV** comprised of healthcare professionals who agreed to answer questions of stated importance and clinical work with promoting patients' lifestyle habits. The fact that the study populations in both **Studies I** and **IV** consisted of individuals choosing to answer questions may have led to selections bias. However, in **Study I**, diagnosis was the only variable that differed between the included and non-included individuals, and there were no differences between the included and non-included healthcare professionals in **Study IV**. A strength in **Study I** is that it comprised of a fairly large population including patients diagnosed with different cardiovascular diseases of varying severity. It also had a high response rate (89 %). The eight-month inclusion period was chosen to represent normal clinical circumstances. However, it did not include patients treated on weekends. A limitation in **Study IV** is that the study population may be considered small and data were collected from only two major hospitals in Stockholm, Sweden. On the other hand, the response rate was high with a small internal dropout. This suggests that our sample may be representative of healthcare professionals working in cardiac departments in major hospitals. A strength of this study is its setting within a hospital department. Most previous studies on targeting lifestyle habits in clinical work have been performed within primary care (99, 107, 108). In this thesis (**Study IV**), all healthcare professionals (e.g. physicians, nurses and physiotherapists) with patient contact were included, giving a broader perspective. Finally, clinical work with lifestyle habits and affecting factors were described, showing possible areas of improvement in preventing cardiovascular morbidity and mortality.

Studies II-III consisted of individuals who were included in the national quality register SWEDEHEART. A strength with these studies is that data were collected from most of cardiac departments in Sweden, providing natural disease course data. In order to be included in **Studies I-III**, patients had to have complete data of covariates and explanatory and outcome variables, thereby excluding a high number of individuals. Nevertheless, including individuals with complete data decreases the risk of type II error and increases internal validity. In **Studies II-III**, included and non-included patients differed in several aspects of baseline characteristics. Although there were significant differences, they were not considered clinically relevant due to the small absolute differences and a high statistical power.

A limitation in **Studies I-III**, was that PA level and SED were based on self-assessed data. The self-rated PA data introduced an element of variability to the measurement. With device-based assessment of PA level, the association with hospital care utilisation and mortality would possibly be even stronger. Using self-reporting, the researcher tries to capture a ranking of activity level, but also the perceptions of the respondent. The relative importance of these two is sometimes hard to identify, and sometimes it is not of importance. Perception is sometimes more important than the actual phenomenon. Subjectively assessed PA level may lead to recall bias due to difficulties in estimating PA duration and intensity, interpreting the questions and social desirability (78). However, in our validity study (n=65), the PA questionnaire was evaluated in CVD patients using an accelerometer as criterion method. Concurrent validity was modest to moderate in PA assessed using the questionnaire compared to PA assessed using an accelerometer. In addition, reducing the number of PA response categories (as used in **Studies II** and **III**) slightly reduced the correlation. This correlation was similar to previous studies on the general population (116, 184). However, it is important to remember that hip-worn accelerometers when used to assess PA have disadvantages. For example, they are unable to measure cycling or resistance training as PA, both important factors in the rehabilitation of CVD patients. Further, accelerometers cannot provide information on relative intensity, i.e. activities that can be registered as light by the accelerometer can be perceived as moderate or even vigorous for a patient with decreased fitness. Aside from the limited concurrent validity, the predictive validity for mortality and hospital utilisation was shown to be strong in all three studies. Today, self-reporting is the most commonly used method of PA assessment in clinical practice. It is an inexpensive and easily administered method (78). Additionally, objective assessment is not possible when exploring PA level and SED preceding an event. A shortcoming of the PA assessment in **Studies II and III** is that it does not include information on sedentary behaviour and variations in PA intensity. Nevertheless, **Study I** provides data on physical exercise, everyday PA and SED, and showed that all these variables were strong predictors of hospital utilisation and mortality.

The fact that PA was subjectively grouped is a limitation. Our validity study also showed that validity decreased when grouping PA into fewer categories. However, in both **Studies I** and **II**, no significant differences in risk of hospital care utilisation or all-cause mortality was observed between individuals with a medium or high level of PA.

In **Study IV,** all data were self-reported, which is associated with risk of own interpretation, as well as risk of social desirability, i.e. individuals may rate importance and own clinical work higher because they know what the expectations are. In order to make the results comparable to the literature, the majority of questions were taken from previous studies (40, 99) and the questionnaire's face-validity was tested before the study began.

In **Studies I-III**, the outcome measurements i.e. inpatient duration, readmission and mortality, were all extracted from medical records or national registries. This is an advantage since previous studies have concluded difficulties in reporting "the correct" amount of healthcare utilisation (185). Additionally, validity of the registers used is considered high. Data from The Swedish National Population Register are updated on a monthly basis, and mortality and date of death data are highly consistent with the Swedish cause of death registry. Healthcare professionals are continually adding to the SWEDEHEART registry. On a yearly basis, comparisons made between medical record data and the SWEDEHEART registry are in agreement in 96% (110).

7.8 Clinical implications

The results from this thesis have several clinical implications. Today, in clinical practice, it is considered standard care to assess blood pressure, blood lipids and ask questions about smoking habits for predictive purposes. PA may be the only major cardiovascular risk factor that is not routinely assessed in clinical practice today. Results from this thesis illustrate that self-reported PA level and SED should be included as additional markers of disease severity as they give important predictive information. This underlines the importance of routinely asking patients about their PA level and SED in order to predict risk of future morbidity and mortality. Information on individual PA level is readily available from patients without any costly laboratory testing. In addition, this thesis shows that individuals who increased their activity level decreased their risk of premature death, implying that in order to promote health, it is never too late to support individuals to start being more physically active.

In order to improve clinical work and identify and support individuals with insufficient PA behaviour it is essential that healthcare professionals, politicians and other decision-makers understand its importance and are motivated. The results of this thesis (**Studies I-III**) could potentially contribute to this improvement by clarifying the association between PA level and SED with health-related outcomes such as hospital care utilisation and mortality. There is a need for further implementation of existing guidelines for CVD prevention. Our results in **Study IV** indicate that in order to improve clinical work by promoting PA and other healthy lifestyle habits in patients treated on a cardiology department, management should focus on giving strong support and providing clear objectives and clear routines.

It is only by asking all patients about their PA levels that we will be able to identify individuals with low levels of PA. Importantly, our results suggest that individuals with the lowest levels of PA and highest levels of SED will see the greatest health benefits when improving activity level or SED. This is important in clinical work as it may be easier for inactive individuals to improve their total PA level by increasing everyday activities and decreasing sedentary time, than to increase the amount of physical exercise they undertake. This is partly because for an inactive patient, PA at a low level may be of relatively higher intensity, and thus being health-enhancing. When healthcare professionals identify individuals who need to increase their PA levels, they can offer individual-based support. This can potentially decrease the utilisation of inpatient care and possibly lower the risk of all-cause mortality of patients with different CV diagnoses.

In summary, assessing baseline PA levels in clinical practice gives important predictive information, possibly increasing the motivation of healthcare personnel to work with lifestyle counselling. Individual PA levels can also be reassessed for further predictive information, and most importantly, increasing PA level is associated with improved health outcomes and reduced mortality. For this to happen, PA must be incorporated into standard clinical practice, needing structural and top-down support from management. Incorporating PA assessment and individualised prescription into national guidelines and quality registries will aid this process, with the potential to decrease (lifestyle-related) inequalities in healthcare.

7.9 Future research

Future research needs to develop valid methods of exploring PA levels among patients diagnosed with CVD within clinical practice. There are validated questionnaires in Swedish available for a “standard” population, but it is not yet known whether they are valid for patients with CVD. In the future, it will probably be more common to use both subjective and objective measurements of PA. These measure different parameters and can thereby complement each other. This thesis explored self-rated PA levels, but did not provide information on physical capacity. To date, it has been difficult to explore physical capacity (VO_2) among patients with CVD due to the majority being prescribed beta-blockers, which impacts heart rate during rest and activity. It is thus important to develop a valid physical capacity test for high-risk individuals medicated with beta-blockers.

Studies I-III in this thesis, and previous studies in the literature, show that few individuals reach the national recommendations of PA for secondary prevention of CVD (129, 139, 175). This thesis identifies reasons for this by indicating that promoting PA is not an established part of clinical practice. However, this is not the whole truth. Making behavioural changes is difficult and takes time. Riegel et al. concluded that self-care management (i.e. supporting patients in understanding their central role in managing their illness, make informed decisions about care, and engage in healthy behaviours) is important in achieving treatment objectives. Thus, greater emphasis should be placed on self-care in evidence-based guidelines (186). Additionally, it would be of great value to explore perceived barriers to lifestyle changes among patients with CVD in order to create individual-based interventions.

Moreover, results from this thesis need to be backed up by intervention studies carried out in hospital settings. It would be of interest for more studies to explore perceived barriers and facilitators to improving PA and other lifestyle habits among healthcare professionals. An appropriate method could be via focus group interviews, focusing on healthcare professionals' experiences. Additionally, organisational structures could be explored by examining existing documents and guidelines and observations in clinical practice.

8 CONCLUSIONS

This thesis has shown that:

- For patients with CVD, the risk of longer hospitalisation, readmission and mortality is lower among physically active patients **(Studies I, II and III)**.

- Both PA level (everyday PA, physical exercise and total PA level), and SED during the period preceding hospitalisation for cardiac events were predictors of hospital stay duration, readmission and mortality. Interestingly, everyday PA is a better predictor of readmission than physical exercise **(Study I)**.

- A higher level of PA 6-8 weeks post MI is associated with a lower risk of hospital readmission within 12 months, and all-cause mortality. For never smokers, there was a weaker association with reduced all-cause mortality, and no association with readmission within 12 months in the unadjusted analysis **(Study II)**.

- Patients who remained physically active during the first year post MI had the lowest risk of mortality. However, changes in PA level during the first year post MI are important. Risk of mortality was lower in patients who increased their PA, and greater in those who decreased their PA. The group with increased PA post MI did not differ in survival from the constantly active group, therefore it appears that it is not too late to start being active post MI **(Study III)**.

- Importantly, in **Studies I and II** there were no differences between patients reporting a moderate or high level of PA, or a medium or low level of SED, illustrating that "a little activity is better than nothing" and that most health benefits would be achieved by increasing PA among the most inactive patients with CVD.

- The effect of regular PA and low SED for patients with CVD does not seem to differ across subgroups, e.g. patients with different CVD diagnoses, or individuals with and without diabetes mellitus type II, hypertension or dyslipidaemia **(Studies I, II and III)**.

- There were differences in stated importance and clinical practice between the different lifestyle factors among healthcare professionals. Our results indicate that work with tobacco cessation is the most established **(Study IV)**.

- In general, healthcare professionals are positive towards, and consider it important to promote healthy lifestyle habits among patients within the healthcare sector in general, as well as in their own clinical practice. However, there is a wide gap between stated importance and clinical practice as only a minority asked or provided counselling on healthy lifestyle habits. Our results implicate that in order to close the gap between stated importance and clinical work to promote patients' healthy lifestyle habits, healthcare management must focus on and improve organisational routines and objectives **(Study IV)**.

9 SVENSK SAMMANFATTNING

Både internationella och nationella riktlinjer betonar att hälso- och sjukvården ska använda sig av fysisk aktivitet i sekundärpreventivt syfte för patienter med kardiovaskulär sjukdom. Tidigare studier som fokuserat på fysisk aktivitet för patienter som deltar i fysisk träning inom hjärtrehabilitering, har konstaterat att deltagande i fysiskt träningsprogram minskar risken för återinläggningar och kardiovaskulär död. Trots detta så är det endast en minoritet av patienterna med kardiovaskulär sjukdom som deltar i denna organiserade träning. Detta bidrar till att det saknas kunskap om såväl den totala fysiska aktivitetsnivån bland patienter med kardiovaskulärsjukdom, som dess eventuella samband med vårdtid, återinläggning och total dödlighet. Det saknas även kunskap om hälso- och sjukvårdspersonalens kliniska arbete med att främja fysisk aktivitet i linje med de sekundärpreventiva riktlinjerna.

Det övergripande syftet med den här avhandlingen var att undersöka om fysisk aktivitet används som en del av behandlingen för patienter med hjärtkärlsjukdom. Hur är fysisk aktivitetsnivån bland patienter med kardiovaskulärsjukdom samt dess eventuella samband med vårdtid och återinläggningar och total dödlighet? I tre kohortstudier (studie I-III) undersöktes sambandet mellan självskattad fysisk aktivitetsnivå, förändringar i fysisk aktivitetsnivå respektive stillasittande tid med vårdtid, återinläggningar respektive total dödlighet. Data samlades in via frågeformulär, journalsystem och nationella register. Studie I, undersökte vardagsmotion, fysisk träning och stillasittande tid före inläggning på hjärtvårdsavdelning bland patienter (n=1148) med kardiovaskulärsjukdom på två olika sjukhus i Stockholm. Studie II och III undersökte fysisk aktivitetsnivå det första året efter insjuknande i hjärtinfarkt och är baserade på det svenska kvalitetsregistret SWEDEHEART och inkluderar 30 644 respektive 22 227 individer. Via en tvärsnittsstudie (studie IV) undersöktes inställning till samt det kliniska arbetet med att främja patienters levnadsvanor (t.ex. fysisk aktivitet) bland hälso- och sjukvårdspersonal (n: 251) på en hjärtklinik från två olika sjukhus i Stockholm.

De huvudsakliga fynden var:

- Fysisk aktivitetsnivå (vardagsmotion, fysisk träning, total fysisk aktivitet) och stillasittande tid före och efter sjukhusvistelse för en hjärthändelse kan predicera vårdtid, återinläggningar och total dödlighet.
- Den positiva effekten av regelbunden fysisk aktivitet och låg grad av stillasittande tid för patienter skiljde sig inte åt mellan olika kardiovaskulära diagnoser, kön, ålder eller komorbiditetstillstånd, såsom individer med och utan diabetes mellitus typ II, njurdysfunktion, hypertoni och blodfettsrubbningar.
- Det fanns inga skillnader i risk för återinläggningar eller mortalitet mellan individer som rapporterade måttlig eller hög grad av fysisk aktivitet respektive låg eller måttlig grad av stillasittande tid. Detta tyder på att ”lite aktivitet är bättre än ingen” och de största hälsoeffekterna nås genom att öka aktivitetsnivån bland patienterna med lägst grad av fysisk aktivitet.
- Förändringar i fysisk aktivitetsnivå det första året efter insjuknande i hjärtinfarkt är viktigt. Risken för mortalitet sänks bland individer som ökar sin fysiska aktivitet och ökar bland dem som minskar sin fysiska aktivitetsnivå.
- Hälso- och sjukvårdspersonal är positiva till och anser att det är viktigt att främja levnadsvanor bland patienter inom hälso- och sjukvården både generellt och inom deras eget arbete. Trots detta är det stora skillnader mellan hur viktigt detta arbete anses vara och i vilken grad de är en del av det kliniska arbetet, då endast en minoritet frågar och erbjuder rådgivning i hög grad till sina patienter. Våra resultat indikerar att det är ett samband mellan i vilken utsträckning personalen frågar patienter om deras levnadsvanor och/eller ger råd, med i vilken utsträckning de upplever att kliniken har tydliga rutiner och mål.

Sammanfattningsvis är resultaten av denna avhandling av klinisk betydelse. Genom att fråga patienter på hjärtvårdsavdelning eller hjärtmottagning om deras fysiska aktivitet och stillasittande tid går det att identifiera individer med ett behov av att göra en beteendeförändring. Hälso- och sjukvårdspersonal kan potentiellt minska användandet av slutenvårdinsatser och även sänka risken för total dödlighet bland patienter med kardiovaskulärsjukdom, genom att identifiera och ge stöd till individer med ett behov av att öka sin fysiska aktivitetsnivå.

10 ACKNOWLEDGEMENTS

I would like to express my sincere gratitude to The Swedish School of Sport and Health Sciences, GIH, for enabling this doctoral thesis and for my PhD education. All colleagues: **PhD-students, teachers, researchers, administration, library, communication, reception and janitorial.** Thank you for always being supportive and encouraging, making it enjoyable to go to work!

I would especially like to thank the following persons who have contributed to this work and supported me during the research process. Without them this thesis would never have been completed:
First of all "the dream team" my three supervisors **Örjan**, **Mats** and **Lena**. No PhD-student could wish for a better team of supervisors. Thank you for all your support, inspiration and for sharing your knowledge and joy for science. You are a true inspiration and I would never have managed to do this without you.

Örjan Ekblom, my main supervisor. For always reminding me of how fun this work really is! I might even have started sharing your passion for statistics ☺.

Mats Börjesson, it has been an honour having you as my co-supervisor (although you were initially my main supervisor). Thank you for sharing all your clinical and research experience and always replying to e-mails in a second.

Lena Kallings, my co-supervisor. Soon I will have known you for a decade, starting with you being the main supervisor for my master theses in 2010. You have become somewhat of a mentor for me. Thank you for always believing in me and your endless support.

All study participants (patients and healthcare professionals), thank you for contributing to our efforts to investigate physical activity and its importance for patients with CVD, and to what extent it is promoted during clinical work.

All healthcare professional in Sweden contributing with their time and effort to register patients in the **SWEDEHEART registry**. Without you, national quality registries and studies based on these would not be possible.

Mattias Ekström, **Kristina Hambraeus** and **Åsa Cider**, it has been an honour to co-author scientific papers with you! The feedback from you taught me a lot. **Sofia Allfors**, thank you for your help with data collection of the validity study.

Camilla Norrbin and **Bim O'Reilly,** as a PhD-student I could never dream of better support during these years. Always working for our best and having the answers to all my questions.

Lee Nolan, thank you for helping me with language review, I really appreciate your meticulous work and your ability to identify important issues.

To my **previous and current roomies**:
Cissi, for always spreading positive energy wherever you go. Thank you for all nice and humble discussions sharing ups and downs in life. **Charlotte**, for being such an organized and determined person and forcing me to practice my English everyday ☺. **Elin,** you are a true inspiration. Always on the run but somehow finding the time for good discussions. There are few people that have the great combination of being a great researcher and being able to communicate your knowledge to your surroundings in a humble and understandable way. **Gustav**, being the best "bollplank" in the beginning of my PhD studies, especially when struggling to interpret some supervisors writing. **Jane,** a real fighter. It has be an honour to have you by my side for the majority of my PhD studies, always warm, happy and humble. **Lisa**, I am so happy that I got to share room with you the last months of my PhD, you are doing a great job combining your PhD studies with balancing family life. **Malin**, I could not share a desk with a better person (although I would have preferred to spend more time with you in the office). Thank you for great company during courses and conferences, we really need to go out for dinner soon.

Johanna Rosèn, one of the best things with GIH has been meeting you. Thank you for great lunches, sharing ups and downs with the PhD studies and in life. Soon, it is your turn, you will sparkle!

Jennie, I am so happy to have you in my life. Thank you for all the good talks, making me push my limits in the gym and our traditional gingerbread baking with the kids.

Marie, I am so happy to know you. Thank you for the cooperation with the students, but most of all thank you for all the great chats covering everything from PhD studies to where to go for a good dinner.

"**The twin moms**" (you know who you are), thank you for being there while taking the first shaking steps as a mother of twins. Always positive, humble and honest.

To **all my physiotherapist colleges at Karolinska University hospital**. Thank you for your support, you are the best colleges I could possibly have. **Johan Gäverth**, my manager at Karolinska University hospital. Thank you for always being positive and interested in my work, listening and giving excellent advice.

My previous and present physiotherapy colleges within cardiology from ***Ryhov hospital,*** Jönköping, *Södersjukhuset*, Stockholm and ***Karolinska university hospital***, Stockholm; **Helena, Elin, Victoria, Veronica, Pia, Annette** and **Karin** thank you for sharing all your knowledge and experiences with me. But mostly, thank you for always cheering me up and giving me new energy!

I am privileged having a big family. My parents **Gunilla** and **Anders**, thank you for everything that you do for me and my family: playing with the kids, mowing the lawn, renovating the house and so on ... A special thanks to my **mum**, the rock of our family. You are the best mum I could ever wish for and I love you! **Nils** my oldest younger brother, for your endless energy and all the help playing with my kids. **Johannes** my youngest brother, for your calmness, the best hugs and helping me out with the layout of all figures. **Agnes**, my sister and best friend. Thank you for being you: funny and smart! Thanks for always listening, giving feedback and encouraging me to get through my PhD studies. I would also like to thank my extended family, the family Lönn. I always appreciate time together with you.

Lastly I want to thank the love of my life **Christoffer**, thank you for bringing so much joy into my life and making everyday better. Without you this theses would be impossible. Thank you for the energy you give me and your endless support making me try things I never thought I could do. To my three kids **Selma**, **Herman** and **Greta**, I am so grateful being your mum. You make me happy and you are the smartest, funniest most loving persons I ever met. I love you ♥.

11 REFERENCES

1. Anderson L, Oldridge N, Thompson DR, Zwisler AD, Rees K, Martin N, et al. Exercise-Based Cardiac Rehabilitation for Coronary Heart Disease: Cochrane Systematic Review and Meta-Analysis. Journal of the American College of Cardiology. 2016;67(1):1-12.

2. Kaminsky LA, Brubaker PH, Guazzi M, Lavie CJ, Montoye AH, Sanderson BK, et al. Assessing Physical Activity as a Core Component in Cardiac Rehabilitation: A POSITION STATEMENT OF THE AMERICAN ASSOCIATION OF CARDIOVASCULAR AND PULMONARY REHABILITATION. Journal of cardiopulmonary rehabilitation and prevention. 2016;36(4):217-29.

3. Griffo R, Ambrosetti M, Tramarin R, Fattirolli F, Temporelli PL, Vestri AR, et al. Effective secondary prevention through cardiac rehabilitation after coronary revascularization and predictors of poor adherence to lifestyle modification and medication. Results of the ICAROS Survey. International journal of cardiology. 2013;167(4):1390-5.

4. Booth FW, Roberts CK, Thyfault JP, Ruegsegger GN, Toedebusch RG. Role of Inactivity in Chronic Diseases: Evolutionary Insight and Pathophysiological Mechanisms. Physiological reviews. 2017;97(4):1351-402.

5. World Health Organization. GLOBAL HEALTH RISKS Mortality and burden of disease attributable to selected major risks. Geneva; World Health Organization; 2009.

6. Abramson JL, Vaccarino V. Relationship between physical activity and inflammation among apparently healthy middle-aged and older US adults. Arch Intern Med. 2002;162(11):1286-92.

7. Kesaniemi YK, Danforth E, Jr., Jensen MD, Kopelman PG, Lefebvre P, Reeder BA. Dose-response issues concerning physical activity and health: an evidence-based symposium. Med Sci Sports Exerc. 2001;33(6 Suppl):S351-8.

8. Mendis S. Puska P. Norrving B. Global atlas on cardiovascular disease prevention and control
Policies, strategies and interventions. Geneva; 2011.

9. Bentzon JF, Otsuka F, Virmani R, Falk E. Mechanisms of plaque formation and rupture. Circulation research. 2014;114(12):1852-66.

10. Publications Office of the European Union. The 2018 Ageing Report, Economic & Budgetary Projections for the 28 EU Member States (2016-2070). Luxemburg; 2018.

11. Wilkins E. Wilson L. Wickramasinghe K. Bhatnagar P. Rayner M. Townsend N. European Cardiovascular Disease Statistics 2017 edition. 2017.

12. Fu M, Rosengren A, Thunstrom E, Mandalenakis Z, Welin L, Caidahl K, et al. Although Coronary Mortality Has Decreased, Rates of Cardiovascular Disease Remain High: 21 Years of Follow-Up Comparing Cohorts of Men Born in 1913 With Men Born in 1943. Journal of the American Heart Association. 2018;7(9).

13. The National Board of Health and Welfare. Statistics on Causes of Death 2017. 2018. Report No.: Art.no: 2018-10-18.

14. Catapano AL, Graham I, De Backer G, Wiklund O, Chapman MJ, Drexel H, et al. 2016 ESC/EAS Guidelines for the Management of Dyslipidaemias. European heart journal. 2016;37(39):2999-3058.

15. Piepoli MF, Hoes AW, Agewall S, Albus C, Brotons C, Catapano AL, et al. 2016 European Guidelines on cardiovascular disease prevention in clinical practice: The Sixth Joint Task Force of the European Society of Cardiology and Other Societies on Cardiovascular Disease Prevention in Clinical Practice (constituted by representatives of 10 societies and by invited experts): Developed with the special contribution of the European Association for Cardiovascular Prevention & Rehabilitation (EACPR). European heart journal. 2016.

16. Yusuf S, Hawken S, Ounpuu S, Dans T, Avezum A, Lanas F, et al. Effect of potentially modifiable risk factors associated with myocardial infarction in 52 countries (the INTERHEART study): case-control study. Lancet. 2004;364(9438):937-52.

17. Dhingra R, Vasan RS. Age as a risk factor. The Medical clinics of North America. 2012;96(1):87-91.

18. Anand SS, Islam S, Rosengren A, Franzosi MG, Steyn K, Yusufali AH, et al. Risk factors for myocardial infarction in women and men: insights from the INTERHEART study. European heart journal. 2008;29(7):932-40.

19. Jernberg T. Bäck M. Erlinge D. Friberg Ö. Johansson P. Leósdóttir M. Rück A. Svensson A. Walther S. SWEDEHEART Annual report 2017. 2018.

20. Pedersen LR, Frestad D, Michelsen MM, Mygind ND, Rasmusen H, Suhrs HE, et al. Risk Factors for Myocardial Infarction in Women and Men: A Review of the Current Literature. Current pharmaceutical design. 2016;22(25):3835-52.

21. Nielsen M, Andersson C, Gerds TA, Andersen PK, Jensen TB, Kober L, et al. Familial clustering of myocardial infarction in first-degree relatives: a nationwide study. European heart journal. 2013;34(16):1198-203.

22. Choi J, Daskalopoulou SS, Thanassoulis G, Karp I, Pelletier R, Behlouli H, et al. Sex- and gender-related risk factor burden in patients with premature acute coronary syndrome. The Canadian journal of cardiology. 2014;30(1):109-17.

23. Roberts R, Chen L, Wells GA, Stewart AF. Recent success in the discovery of coronary artery disease genes. Canadian journal of physiology and pharmacology. 2011;89(8):609-15.

24. Anand SS, Xie C, Pare G, Montpetit A, Rangarajan S, McQueen MJ, et al. Genetic variants associated with myocardial infarction risk factors in over 8000 individuals from five ethnic groups: The INTERHEART Genetics Study. Circulation Cardiovascular genetics. 2009;2(1):16-25.

25. Tada H, Melander O, Louie JZ, Catanese JJ, Rowland CM, Devlin JJ, et al. Risk prediction by genetic risk scores for coronary heart disease is independent of self-reported family history. European heart journal. 2016;37(6):561-7.

26. Mozaffarian D, Benjamin EJ, Go AS, Arnett DK, Blaha MJ, Cushman M, et al. Heart disease and stroke statistics--2015 update: a report from the American Heart Association. Circulation. 2015;131(4):e29-322.

27. Dal Canto E, Farukh B, Faconti L. Why are there ethnic differences in cardio-metabolic risk factors and cardiovascular diseases? JRSM cardiovascular disease. 2018;7:2048004018818923.

28. Tillin T, Hughes AD, Mayet J, Whincup P, Sattar N, Forouhi NG, et al. The relationship between metabolic risk factors and incident cardiovascular disease in Europeans, South Asians, and African Caribbeans: SABRE (Southall and Brent Revisited) -- a prospective population-based study. Journal of the American College of Cardiology. 2013;61(17):1777-86.

29. Rosengren A, Subramanian SV, Islam S, Chow CK, Avezum A, Kazmi K, et al. Education and risk for acute myocardial infarction in 52 high, middle and low-income countries: INTERHEART case-control study. Heart (British Cardiac Society). 2009;95(24):2014-22.

30. World Health Organization. Equity, social determinants and public health programmes. World Health Organization; 2010.

31. Lindgren M, Borjesson M, Ekblom O, Bergstrom G, Lappas G, Rosengren A. Physical activity pattern, cardiorespiratory fitness, and socioeconomic status in the SCAPIS pilot trial - A cross-sectional study. Preventive medicine reports. 2016;4:44-9.

32. Ski CF, King-Shier KM, Thompson DR. Gender, socioeconomic and ethnic/racial disparities in cardiovascular disease: a time for change. International journal of cardiology. 2014;170(3):255-7.

33. Pinheiro LC, Reshetnyak E, Sterling MR, Richman JS, Kern LM, Safford MM. Using health-related quality of life to predict cardiovascular disease events. Quality of

life research : an international journal of quality of life aspects of treatment, care and rehabilitation. 2019.

34. Rosengren A, Hawken S, Ounpuu S, Sliwa K, Zubaid M, Almahmeed WA, et al. Association of psychosocial risk factors with risk of acute myocardial infarction in 11119 cases and 13648 controls from 52 countries (the INTERHEART study): case-control study. Lancet. 2004;364(9438):953-62.

35. Peterson LR, McKenzie CR, Schaffer JE. Diabetic cardiovascular disease: getting to the heart of the matter. Journal of cardiovascular translational research. 2012;5(4):436-45.

36. Benjamin EJ, Blaha MJ, Chiuve SE, Cushman M, Das SR, Deo R, et al. Heart Disease and Stroke Statistics-2017 Update: A Report From the American Heart Association. Circulation. 2017;135(10):e146-e603.

37. Williams B, Mancia G, Spiering W, Agabiti Rosei E, Azizi M, Burnier M, et al. 2018 ESC/ESH Guidelines for the management of arterial hypertension: The Task Force for the management of arterial hypertension of the European Society of Cardiology and the European Society of Hypertension: The Task Force for the management of arterial hypertension of the European Society of Cardiology and the European Society of Hypertension. Journal of hypertension. 2018;36(10):1953-2041.

38. Susic D, Frohlich ED. Hypertension and the heart. Current hypertension reports. 2000;2(6):565-9.

39. Elagizi A, Kachur S, Lavie CJ, Carbone S, Pandey A, Ortega FB, et al. An Overview and Update on Obesity and the Obesity Paradox in Cardiovascular Diseases. Progress in cardiovascular diseases. 2018;61(2):142-50.

40. The National Board of Health and Welfare. National Guidelines for Methods of Preventing Disease (In Swedish with English summary). Västerås: The National Board of Health and Welfare; 2011.

41. Klatsky AL. Alcohol and cardiovascular diseases: where do we stand today? Journal of internal medicine. 2015;278(3):238-50.

42. World Health Organization Regional office for Europe. Fact sheet on alcohol consumption, alcohol-attributable harm and alcohol policy responses in European Union Member States, Norway and Switzerland. World Health Organization; 2018.

43. Mente A, de Koning L, Shannon HS, Anand SS. A systematic review of the evidence supporting a causal link between dietary factors and coronary heart disease. Arch Intern Med. 2009;169(7):659-69.

44. World Health Organization. Healthy diet, fact sheet N°394. World Health Organization; 2015.

45. Godtfredsen NS, Prescott E. Benefits of smoking cessation with focus on cardiovascular and respiratory comorbidities. The clinical respiratory journal. 2011;5(4):187-94.

46. World Health Organization. Prevalence of tobacco smoking. World Health Organization; 2015.

47. McEvoy JW, Blaha MJ, DeFilippis AP, Lima JA, Bluemke DA, Hundley WG, et al. Cigarette smoking and cardiovascular events: role of inflammation and subclinical atherosclerosis from the MultiEthnic Study of Atherosclerosis. Arteriosclerosis, thrombosis, and vascular biology. 2015;35(3):700-9.

48. Hemmingsen B, Gimenez-Perez G, Mauricio D, Roque IFM, Metzendorf MI, Richter B. Diet, physical activity or both for prevention or delay of type 2 diabetes mellitus and its associated complications in people at increased risk of developing type 2 diabetes mellitus. The Cochrane database of systematic reviews. 2017;12:Cd003054.

49. Tuomilehto J, Lindstrom J, Eriksson JG, Valle TT, Hamalainen H, Ilanne-Parikka P, et al. Prevention of type 2 diabetes mellitus by changes in lifestyle among subjects with impaired glucose tolerance. The New England journal of medicine. 2001;344(18):1343-50.

50. Biddle GJH, Edwardson CL, Henson J, Davies MJ, Khunti K, Rowlands AV, et al. Associations of Physical Behaviours and Behavioural Reallocations with Markers of Metabolic Health: A Compositional Data Analysis. International journal of environmental research and public health. 2018;15(10).

51. Jelleyman C, Edwardson CL, Henson J, Gray LJ, Rowlands AV, Khunti K, et al. Associations of Physical Activity Intensities with Markers of Insulin Sensitivity. Med Sci Sports Exerc. 2017;49(12):2451-8.

52. Amadid H, Johansen NB, Bjerregaard AL, Vistisen D, Faerch K, Brage S, et al. Physical Activity Dimensions Associated with Impaired Glucose Metabolism. Med Sci Sports Exerc. 2017;49(11):2176-84.

53. Mann S, Beedie C, Jimenez A. Differential effects of aerobic exercise, resistance training and combined exercise modalities on cholesterol and the lipid profile: review, synthesis and recommendations. Sports medicine (Auckland, NZ). 2014;44(2):211-21.

54. Borjesson M, Onerup A, Lundqvist S, Dahlof B. Physical activity and exercise lower blood pressure in individuals with hypertension: narrative review of 27 RCTs. Br J Sports Med. 2016;50(6):356-61.

55. Naci H, Salcher-Konrad M, Dias S, Blum MR, Sahoo SA, Nunan D, et al. How does exercise treatment compare with antihypertensive medications? A network meta-analysis of 391 randomised controlled trials assessing exercise and medication effects on systolic blood pressure. Br J Sports Med. 2019;53(14):859-69.

56. Cornelissen VA, Smart NA. Exercise training for blood pressure: a systematic review and meta-analysis. Journal of the American Heart Association. 2013;2(1):e004473.

57. Laskowski ER. The role of exercise in the treatment of obesity. PM & R : the journal of injury, function, and rehabilitation. 2012;4(11):840-4; quiz 4.

58. Thijssen DH, Maiorana AJ, O'Driscoll G, Cable NT, Hopman MT, Green DJ. Impact of inactivity and exercise on the vasculature in humans. Eur J Appl Physiol. 2010;108(5):845-75.

59. Kohrt WM, Bloomfield SA, Little KD, Nelson ME, Yingling VR. American College of Sports Medicine Position Stand: physical activity and bone health. Med Sci Sports Exerc. 2004;36(11):1985-96.

60. Caspersen CJ, Powell KE, Christenson GM. Physical activity, exercise, and physical fitness: definitions and distinctions for health-related research. Public Health Rep. 1985;100(2):126-31.

61. Cavill N KS, Racioppi F. . Physical activity and health in Europe. Evidence for action. 2006.

62. Pate RR, O'Neill JR, Lobelo F. The evolving definition of "sedentary". Exerc Sport Sci Rev. 2008;36(4):173-8.

63. Wernbom M, Augustsson J, Thomee R. The influence of frequency, intensity, volume and mode of strength training on whole muscle cross-sectional area in humans. Sports medicine (Auckland, NZ). 2007;37(3):225-64.

64. Norton K, Norton L, Sadgrove D. Position statement on physical activity and exercise intensity terminology. Journal of science and medicine in sport / Sports Medicine Australia. 2010;13(5):496-502.

65. Scherr J, Wolfarth B, Christle JW, Pressler A, Wagenpfeil S, Halle M. Associations between Borg's rating of perceived exertion and physiological measures of exercise intensity. Eur J Appl Physiol. 2013;113(1):147-55.

66. Borg GA. Psychophysical bases of perceived exertion. Med Sci Sports Exerc. 1982;14(5):377-81.

67. Fletcher GF, Balady GJ, Amsterdam EA, Chaitman B, Eckel R, Fleg J, et al. Exercise standards for testing and training: a statement for healthcare professionals from the American Heart Association. Circulation. 2001;104(14):1694-740.

68. World Health Organization. Global recommendations on physical activity for health. World Health Organization; 2010.

69. Arnett DK, Blumenthal RS, Albert MA, Buroker AB, Goldberger ZD, Hahn EJ, et al. 2019 ACC/AHA Guideline on the Primary Prevention of Cardiovascular Disease:

Executive Summary: A Report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines. Journal of the American College of Cardiology. 2019.

70. Arem H, Moore SC, Patel A, Hartge P, Berrington de Gonzalez A, Visvanathan K, et al. Leisure time physical activity and mortality: a detailed pooled analysis of the dose-response relationship. JAMA internal medicine. 2015;175(6):959-67.

71. Swedish Professional Associations for Physical Activity. Physical activity recommendations for adults (In Swedish). The Swedish Society of Medicine; 2011.

72. Guthold R, Stevens GA, Riley LM, Bull FC. Worldwide trends in insufficient physical activity from 2001 to 2016: a pooled analysis of 358 population-based surveys with 1.9 million participants. The Lancet Global health. 2018;6(10):e1077-e86.

73. Gerovasili V, Agaku IT, Vardavas CI, Filippidis FT. Levels of physical activity among adults 18-64 years old in 28 European countries. Prev Med. 2015;81:87-91.

74. Ekblom-Bak E, Olsson G, Ekblom O, Ekblom B, Bergstrom G, Borjesson M. The Daily Movement Pattern and Fulfilment of Physical Activity Recommendations in Swedish Middle-Aged Adults: The SCAPIS Pilot Study. PLoS One. 2015;10(5):e0126336.

75. Loyen A, van der Ploeg HP, Bauman A, Brug J, Lakerveld J. European Sitting Championship: Prevalence and Correlates of Self-Reported Sitting Time in the 28 European Union Member States. PLoS One. 2016;11(3):e0149320.

76. Milton K, Gale J, Stamatakis E, Bauman A. Trends in prolonged sitting time among European adults: 27 country analysis. Prev Med. 2015;77:11-6.

77. Katzmarzyk PT, Church TS, Craig CL, Bouchard C. Sitting time and mortality from all causes, cardiovascular disease, and cancer. Med Sci Sports Exerc. 2009;41(5):998-1005.

78. Ainsworth B, Cahalin L, Buman M, Ross R. The current state of physical activity assessment tools. Progress in cardiovascular diseases. 2015;57(4):387-95.

79. Troiano RP, Pettee Gabriel KK, Welk GJ, Owen N, Sternfeld B. Reported physical activity and sedentary behavior: why do you ask? Journal of physical activity & health. 2012;9 Suppl 1:S68-75.

80. Dowd KP, Szeklicki R, Minetto MA, Murphy MH, Polito A, Ghigo E, et al. A systematic literature review of reviews on techniques for physical activity measurement in adults: a DEDIPAC study. The international journal of behavioral nutrition and physical activity. 2018;15(1):15.

81. Westerterp KR. Doubly labelled water assessment of energy expenditure: principle, practice, and promise. Eur J Appl Physiol. 2017;117(7):1277-85.

82. Matthews CE, Hagstromer M, Pober DM, Bowles HR. Best practices for using physical activity monitors in population-based research. Med Sci Sports Exerc. 2012;44(1 Suppl 1):S68-76.

83. van Poppel MN, Chinapaw MJ, Mokkink LB, van Mechelen W, Terwee CB. Physical activity questionnaires for adults: a systematic review of measurement properties. Sports medicine (Auckland, NZ). 2010;40(7):565-600.

84. Olsson SJ, Ekblom O, Andersson E, Borjesson M, Kallings LV. Categorical answer modes provide superior validity to open answers when asking for level of physical activity: A cross-sectional study. Scandinavian journal of public health. 2016;44(1):70-6.

85. Grimby G, Borjesson M, Jonsdottir IH, Schnohr P, Thelle DS, Saltin B. The "Saltin-Grimby Physical Activity Level Scale" and its application to health research. Scand J Med Sci Sports. 2015;25 Suppl 4:119-25.

86. Guiraud T, Granger R, Bousquet M, Gremeaux V. Validity of a questionnaire to assess the physical activity level in coronary artery disease patients. International journal of rehabilitation research Internationale Zeitschrift fur Rehabilitationsforschung Revue internationale de recherches de readaptation. 2012;35(3):270-4.

87. Bahler C, Bjarnason-Wehrens B, Schmid JP, Saner H. SWISSPAQ: validation of a new physical activity questionnaire in cardiac rehabilitation patients. Swiss medical weekly. 2013;143:w13752.

88. Pfaeffli L, Maddison R, Jiang Y, Dalleck L, Lof M. Measuring physical activity in a cardiac rehabilitation population using a smartphone-based questionnaire. Journal of medical Internet research. 2013;15(3):e61.

89. The Swedish Government. Government proposition 2017/18:249 " Good and equal health - a developed publich health policy" (In Swedish). The Swedish Government, ; 2018.

90. ISPAH International Society for Physical Activity and Health. The Bangkok Declaration on Physical Activity for Global Health and Sustainable Development. Br J Sports Med. 2017;51(19):1389-91.

91. Kallings L. Physical Activity on Prescription -Studies on physical activity level, adherence and cardiovasular risk factors [Ph.D. Thesis]. Stockholm, Sweden: Karolinska Institutet; 2008.

92. Murphy JNF, Le Jeune I. Can an acute admission to hospital be an opportunity for healthcare professionals to provide physical activity advice? A qualitative study of patients' perspectives. Acute medicine. 2018;17(1):10-7.

93. The National Board of Health and Welfare. [This is how patients want to tell the healthcare sector about their life style habits, Results of a population survey 2016] (In Swedish). Stockholm: The National Board of Health and Welfare,; 2016.

94. Brotons C, Drenthen AJ, Durrer D, Moral I. Beliefs and attitudes to lifestyle, nutrition and physical activity: the views of patients in Europe. Family practice. 2012;29 Suppl 1:i49-i55.

95. Jerden L, Dalton J, Johansson H, Sorensen J, Jenkins P, Weinehall L. Lifestyle counseling in primary care in the United States and Sweden: a comparison of patients' expectations and experiences. Global health action. 2018;11(1):1438238.

96. Haynes CL, Cook GA. Audit of health promotion practice within a UK hospital: results of a pilot study. Journal of evaluation in clinical practice. 2008;14(1):103-9.

97. McBride A. Health promotion in the acute hospital setting: the receptivity of adult in-patients. Patient education and counseling. 2004;54(1):73-8.

98. Haynes CL. Health promotion services for lifestyle development within a UK hospital--Patients' experiences and views. BMC Public Health. 2008;8:284.

99. Weinehall L, Johansson H, Sorensen J, Jerden L, May J, Jenkins P. Counseling on lifestyle habits in the United States and Sweden: a report comparing primary care health professionals' perspectives on lifestyle counseling in terms of scope, importance and competence. BMC family practice. 2014;15:83.

100. Johansson H, Weinehall L, Emmelin M. "If we only got a chance." Barriers to and possibilities for a more health-promoting health service. J Multidiscip Healthc. 2009;3:1-9.

101. Vanhees L, Rauch B, Piepoli M, van Buuren F, Takken T, Borjesson M, et al. Importance of characteristics and modalities of physical activity and exercise in the management of cardiovascular health in individuals with cardiovascular disease (Part III). Eur J Prev Cardiol. 2012;19(6):1333-56.

102. The National Board of Health and Welfare. [National Guidelines for Cardiac Care] (In Swedish with English summary). Västerås: The National Board of Health and Welfare; 2018.

103. Long L, Mordi IR, Bridges C, Sagar VA, Davies EJ, Coats AJ, et al. Exercise-based cardiac rehabilitation for adults with heart failure. The Cochrane database of systematic reviews. 2019;1:Cd003331.

104. The National Board of Health and Welfare. [National guidelines for disease prevention methods 2011, Indicators Appendix] (In Swedish). Västerås: The Swedish National Board of Health and Welfare; 2011.

105. Jernberg T. BM, Erlinge D., Friberg Ö., Johansson P., Leósdóttir M., Rück A., Svensson A., Walther S. SWEDEHEART annual report 2018. 2019.

106. Borg S, Oberg B, Leosdottir M, Lindolm D, Nilsson L, Back M. Factors associated with non-attendance at exercise-based cardiac rehabilitation. BMC sports science, medicine & rehabilitation. 2019;11:13.

107. Brotons C, Bjorkelund C, Bulc M, Ciurana R, Godycki-Cwirko M, Jurgova E, et al. Prevention and health promotion in clinical practice: the views of general practitioners in Europe. Prev Med. 2005;40(5):595-601.

108. Luquis RR, Paz HL. Attitudes About and Practices of Health Promotion and Prevention Among Primary Care Providers. Health Promot Pract. 2014.

109. Schooling CM, Jones HE. Clarifying questions about "risk factors": predictors versus explanation. Emerging themes in epidemiology. 2018;15:10.

110. Jernberg T, Attebring MF, Hambraeus K, Ivert T, James S, Jeppsson A, et al. The Swedish Web-system for enhancement and development of evidence-based care in heart disease evaluated according to recommended therapies (SWEDEHEART). Heart (British Cardiac Society). 2010;96(20):1617-21.

111. Sederholm Lawesson S, Alfredsson J, Szummer K, Fredrikson M, Swahn E. Prevalence and prognostic impact of chronic kidney disease in STEMI from a gender perspective: data from the SWEDEHEART register, a large Swedish prospective cohort. BMJ open. 2015;5(6):e008188.

112. Hambraeus K. From Stenting to Preventing -Invasive and Long-term Treatment for Coronary Artery Disease in Sweden: Uppsala University; 2014.

113. Dyer MT, Goldsmith KA, Sharples LS, Buxton MJ. A review of health utilities using the EQ-5D in studies of cardiovascular disease. Health and quality of life outcomes. 2010;8:13.

114. Kind P. Hardman G. Macran S. UK population norms for EQ-5D. Working Papers 172chedp, Centre for Health Economics, University of York. 1999.

115. Burstrom K, Johannesson M, Diderichsen F. Swedish population health-related quality of life results using the EQ-5D. Quality of life research : an international journal of quality of life aspects of treatment, care and rehabilitation. 2001;10(7):621-35.

116. Larsson K, Kallings LV, Ekblom O, Blom V, Andersson E, Ekblom MM. Criterion validity and test-retest reliability of SED-GIH, a single item question for assessment of daily sitting time. BMC Public Health. 2019;19(1):17.

117. Chau JY, Grunseit AC, Chey T, Stamatakis E, Brown WJ, Matthews CE, et al. Daily sitting time and all-cause mortality: a meta-analysis. PLoS One. 2013;8(11):e80000.

118. Altman DG, Bland JM. Interaction revisited: the difference between two estimates. BMJ (Clinical research ed). 2003;326(7382):219.

119. Newcombe RG. Improved confidence intervals for the difference between binomial proportions based on paired data. Statistics in medicine. 1998;17(22):2635-50.

120. Aguilar-Farias N, Brown WJ, Peeters GM. ActiGraph GT3X+ cut-points for identifying sedentary behaviour in older adults in free-living environments. Journal of science and medicine in sport / Sports Medicine Australia. 2014;17(3):293-9.

121. Sasaki JE, John D, Freedson PS. Validation and comparison of ActiGraph activity monitors. Journal of science and medicine in sport / Sports Medicine Australia. 2011;14(5):411-6.

122. Muijs D. DOING quantitative research IN EDUCATION. London: Sage Publications; 2004.

123. World Health Organization. Ottawa charter for health promotion: an International Conference on Health Promotion, the move towards a new public health. 17– 21 November. Ottawa, Geneva; World Health Organization; 1986.

124. Canivet C. Patienterna bör få meddelande: »Uppgifter om levnadsvanor kommer att journalföras och sparas i dataregister«. Läkartidningen. 2012;109(5).

125. Stewart R, Held C, Brown R, Vedin O, Hagstrom E, Lonn E, et al. Physical activity in patients with stable coronary heart disease: an international perspective. European heart journal. 2013;34(42):3286-93.

126. Evenson KR, Butler EN, Rosamond WD. Prevalence of physical activity and sedentary behavior among adults with cardiovascular disease in the United States. Journal of cardiopulmonary rehabilitation and prevention. 2014;34(6):406-19.

127. Peersen K, Munkhaugen J, Gullestad L, Liodden T, Moum T, Dammen T, et al. The role of cardiac rehabilitation in secondary prevention after coronary events. Eur J Prev Cardiol. 2017;24(13):1360-8.

128. Bertelsen JB, Refsgaard J, Kanstrup H, Johnsen SP, Qvist I, Christensen B, et al. Cardiac rehabilitation after acute coronary syndrome comparing adherence and risk factor modification in a community-based shared care model versus hospital-based care in a randomised controlled trial with 12 months of follow-up. European journal of cardiovascular nursing : journal of the Working Group on Cardiovascular Nursing of the European Society of Cardiology. 2017;16(4):334-43.

129. Kotseva K, Wood D, De Bacquer D, De Backer G, Ryden L, Jennings C, et al. EUROASPIRE IV: A European Society of Cardiology survey on the lifestyle, risk factor and therapeutic management of coronary patients from 24 European countries. Eur J Prev Cardiol. 2016;23(6):636-48.

130. Bruthans J, Mayer O, Jr., De Bacquer D, De Smedt D, Reiner Z, Kotseva K, et al. Educational level and risk profile and risk control in patients with coronary heart disease. Eur J Prev Cardiol. 2016;23(8):881-90.

131. De Smedt D, De Bacquer D, De Sutter J, Dallongeville J, Gevaert S, De Backer G, et al. The gender gap in risk factor control: Effects of age and education on the control of cardiovascular risk factors in male and female coronary patients. The EUROASPIRE IV study by the European Society of Cardiology. International journal of cardiology. 2016;209:284-90.

132. Gyberg V, De Bacquer D, De Backer G, Jennings C, Kotseva K, Mellbin L, et al. Patients with coronary artery disease and diabetes need improved management: a report from the EUROASPIRE IV survey: a registry from the EuroObservational Research Programme of the European Society of Cardiology. Cardiovascular diabetology. 2015;14:133.

133. Li W, Procter-Gray E, Churchill L, Crouter SE, Kane K, Tian J, et al. Gender and Age Differences in Levels, Types and Locations of Physical Activity among Older Adults Living in Car-Dependent Neighborhoods. The Journal of frailty & aging. 2017;6(3):129-35.

134. Stewart RAH, Held C, Hadziosmanovic N, Armstrong PW, Cannon CP, Granger CB, et al. Physical Activity and Mortality in Patients With Stable Coronary Heart Disease. Journal of the American College of Cardiology. 2017;70(14):1689-700.

135. Papataxiarchis E, Panagiotakos DB, Notara V, Kouvari M, Kogias Y, Stravopodis P, et al. Physical Activity Frequency on the 10-Year Acute Coronary Syndrome (ACS) Prognosis; The Interaction With Cardiovascular Disease History and Diabetes Mellitus: The GREECS Observational Study. Journal of aging and physical activity. 2016;24(4):624-32.

136. Kaasenbrood L, Boekholdt SM, van der Graaf Y, Ray KK, Peters RJ, Kastelein JJ, et al. Distribution of Estimated 10-Year Risk of Recurrent Vascular Events and Residual Risk in a Secondary Prevention Population. Circulation. 2016;134(19):1419-29.

137. Ergatoudes C, Thunstrom E, Rosengren A, Bjorck L, Bengtsson Bostrom K, Falk K, et al. Long-term secondary prevention of acute myocardial infarction (SEPAT) - guidelines adherence and outcome. BMC cardiovascular disorders. 2016;16(1):226.

138. Christiansen MK, Jensen JM, Brondberg AK, Botker HE, Jensen HK. Cardiovascular risk factor control is insufficient in young patients with coronary artery disease. Vascular health and risk management. 2016;12:219-27.

139. Tang L, Patao C, Chuang J, Wong ND. Cardiovascular risk factor control and adherence to recommended lifestyle and medical therapies in persons with coronary heart disease (from the National Health and Nutrition Examination Survey 2007-2010). Am J Cardiol. 2013;112(8):1126-32.

140. Bellow A, Epstein JF, Parikh-Patel A. Lifestyle behaviors associated with secondary prevention of coronary heart disease among California adults. Preventing chronic disease. 2011;8(2):A31.

141. Moholdt T, Lavie CJ, Nauman J. Interaction of Physical Activity and Body Mass Index on Mortality in Coronary Heart Disease: Data from the Nord-Trondelag Health Study. The American journal of medicine. 2017;130(8):949-57.

142. Mons U, Hahmann H, Brenner H. A reverse J-shaped association of leisure time physical activity with prognosis in patients with stable coronary heart disease: evidence from a large cohort with repeated measurements. Heart (British Cardiac Society). 2014;100(13):1043-9.

143. Gong Y, Yang F, Hong T, Huo Y. Using a standardized follow-up program to improve coronary heart disease secondary prevention. Anatolian journal of cardiology. 2016;16(2):84-91.

144. Back M, Cider A, Gillstrom J, Herlitz J. Physical activity in relation to cardiac risk markers in secondary prevention of coronary artery disease. International journal of cardiology. 2013;168(1):478-83.

145. Brandstrom Y, Brink E, Grankvist G, Alsen P, Herlitz J, Karlson BW. Physical activity six months after a myocardial infarction. International journal of nursing practice. 2009;15(3):191-7.

146. Najem SA, Groll A, Schmermund A, Nowak B, Voigtlander T, Kaltenbach U, et al. Walking activity during ambulant cardiac rehabilitation is related to maximum working capacity, age, and smoking behavior. Vascular health and risk management. 2018;14:361-9.

147. Thorup C, Hansen J, Gronkjaer M, Andreasen JJ, Nielsen G, Sorensen EE, et al. Cardiac Patients' Walking Activity Determined by a Step Counter in Cardiac Telerehabilitation: Data From the Intervention Arm of a Randomized Controlled Trial. Journal of medical Internet research. 2016;18(4):e69.

148. Strauch S, Hagstromer M, Back M. Objectively Assessed Physical Activity in the Oldest Old Persons With Coronary Artery Disease. Journal of geriatric physical therapy (2001). 2018.

149. Freene N, McManus M, Mair T, Tan R, Davey R. Objectively Measured Changes in Physical Activity and Sedentary Behavior in Cardiac Rehabilitation: A PROSPECTIVE COHORT STUDY. Journal of cardiopulmonary rehabilitation and prevention. 2018;38(6):E5-e8.

150. Baumann M, Tchicaya A, Lorentz N, Le Bihan E. Life satisfaction and longitudinal changes in physical activity, diabetes and obesity among patients with cardiovascular diseases. BMC Public Health. 2017;17(1):925.

151. Steffen-Batey L, Nichaman MZ, Goff DC, Jr., Frankowski RF, Hanis CL, Ramsey DJ, et al. Change in level of physical activity and risk of all-cause mortality or reinfarction: The Corpus Christi Heart Project. Circulation. 2000;102(18):2204-9.

152. Gorczyca AM, Eaton CB, LaMonte MJ, Manson JE, Johnston JD, Bidulescu A, et al. Change in Physical Activity and Sitting Time After Myocardial Infarction and Mortality Among Postmenopausal Women in the Women's Health Initiative-Observational Study. Journal of the American Heart Association. 2017;6(5).

153. Public health agency of Sweden. Open comparisons in public health 2019 (In Swedish, with English summary). 2019.

154. Chau JY, Grunseit A, Midthjell K, Holmen J, Holmen TL, Bauman AE, et al. Cross-sectional associations of total sitting and leisure screen time with cardiometabolic risk in adults. Results from the HUNT Study, Norway. Journal of science and medicine in sport / Sports Medicine Australia. 2014;17(1):78-84.

155. Hummel SL, Herald J, Alpert C, Gretebeck KA, Champoux WS, Dengel DR, et al. Submaximal oxygen uptake kinetics, functional mobility, and physical activity in older adults with heart failure and reduced ejection fraction. Journal of geriatric cardiology : JGC. 2016;13(5):450-7.

156. Kallings LV, Leijon M, Hellenius ML, Stahle A. Physical activity on prescription in primary health care: a follow-up of physical activity level and quality of life. Scand J Med Sci Sports. 2008;18(2):154-61.

157. Woolcott JC, Ashe MC, Miller WC, Shi P, Marra CA. Does physical activity reduce seniors' need for healthcare?: a study of 24 281 Canadians. Br J Sports Med. 2010;44(12):902-4.

158. The National Board of Health and Welfare. [Databse of stastistics/diagnoses within inpatient care] (In Swedish). http://www.socialstyrelsen.se/statistik/statistikdatabas/diagnoserislutenvard2017.

159. Sari N. A short walk a day shortens the hospital stay: physical activity and the demand for hospital services for older adults. Canadian journal of public health = Revue canadienne de sante publique. 2010;101(5):385-9.

160. Biscaglia S, Campo G, Sorbets E, Ford I, Fox KM, Greenlaw N, et al. Relationship between physical activity and long-term outcomes in patients with stable coronary artery disease. Eur J Prev Cardiol. 2019:2047487319871217.

161. Booth JN, 3rd, Levitan EB, Brown TM, Farkouh ME, Safford MM, Muntner P. Effect of sustaining lifestyle modifications (nonsmoking, weight reduction, physical activity, and mediterranean diet) after healing of myocardial infarction, percutaneous intervention, or coronary bypass (from the REasons for Geographic and Racial Differences in Stroke Study). Am J Cardiol. 2014;113(12):1933-40.

162. Doukky R, Mangla A, Ibrahim Z, Poulin MF, Avery E, Collado FM, et al. Impact of Physical Inactivity on Mortality in Patients With Heart Failure. Am J Cardiol. 2016;117(7):1135-43.

163. Shen L, Peterson ED, Li S, Thomas L, Alexander K, Xian Y, et al. The association between smoking and long-term outcomes after non-ST-segment elevation myocardial infarction in older patients. American heart journal. 2013;166(6):1056-62.

164. Rallidis LS, Sakadakis EA, Tympas K, Varounis C, Zolindaki M, Dagres N, et al. The impact of smoking on long-term outcome of patients with premature (</=35years) ST-segment elevation acute myocardial infarction. American heart journal. 2015;169(3):356-62.

165. Ejlersen H, Andersen ZJ, von Euler-Chelpin MC, Johansen PP, Schnohr P, Prescott E. Prognostic impact of physical activity prior to myocardial infarction: Case fatality and subsequent risk of heart failure and death. Eur J Prev Cardiol. 2017;24(10):1112-9.

166. Park LG, Dracup K, Whooley MA, McCulloch C, Lai S, Howie-Esquivel J. Sedentary lifestyle associated with mortality in rural patients with heart failure. European journal of cardiovascular nursing : journal of the Working Group on Cardiovascular Nursing of the European Society of Cardiology. 2019:1474515118822967.

167. Moholdt T, Lavie CJ, Nauman J. Sustained Physical Activity, Not Weight Loss, Associated With Improved Survival in Coronary Heart Disease. Journal of the American College of Cardiology. 2018;71(10):1094-101.

168. Kang SH, Suh JW, Choi DJ, Chae IH, Cho GY, Youn TJ, et al. Cigarette smoking is paradoxically associated with low mortality risk after acute myocardial infarction. Nicotine & tobacco research : official journal of the Society for Research on Nicotine and Tobacco. 2013;15(7):1230-8.

169. Ambrose JA, Barua RS. The pathophysiology of cigarette smoking and cardiovascular disease: an update. Journal of the American College of Cardiology. 2004;43(10):1731-7.

170. Johansson H, Stenlund H, Lundstrom L, Weinehall L. Reorientation to more health promotion in health services - a study of barriers and possibilities from the perspective of health professionals. J Multidiscip Healthc. 2010;3:213-24.

171. The National Board of Health and Welfare. [National guidelines, evaluation 2014, for methods of preventing disease, indicators and data for assessments] (In Swedish). Västerås: The National Board of Health and Welfare; 2015.

172. Critchley J, Capewell S. Smoking cessation for the secondary prevention of coronary heart disease. The Cochrane database of systematic reviews. 2004(1):Cd003041.

173. Carlsson AC, Wandell PE, Gigante B, Leander K, Hellenius ML, de Faire U. Seven modifiable lifestyle factors predict reduced risk for ischemic cardiovascular disease and all-cause mortality regardless of body mass index: a cohort study. International journal of cardiology. 2013;168(2):946-52.

174. Minges KE, Strait KM, Owen N, Dunstan DW, Camhi SM, Lichtman J, et al. Gender differences in physical activity following acute myocardial infarction in adults: A prospective, observational study. Eur J Prev Cardiol. 2016.

175. Chow CK, Jolly S, Rao-Melacini P, Fox KA, Anand SS, Yusuf S. Association of diet, exercise, and smoking modification with risk of early cardiovascular events after acute coronary syndromes. Circulation. 2010;121(6):750-8.

176. Ek A, Ekblom O, Hambraeus K, Cider A, Kallings LV, Borjesson M. Physical inactivity and smoking after myocardial infarction as predictors for readmission and survival: results from the SWEDEHEART-registry. Clinical research in cardiology : official journal of the German Cardiac Society. 2018.

177. Ekblom O, Ek A, Cider A, Hambraeus K, Borjesson M. Increased Physical Activity Post-Myocardial Infarction Is Related to Reduced Mortality: Results From the SWEDEHEART Registry. Journal of the American Heart Association. 2018;7(24):e010108.

178. Ogmundsdottir Michelsen H, Sjolin I, Schlyter M, Hagstrom E, Kiessling A, Henriksson P, et al. Cardiac rehabilitation after acute myocardial infarction in Sweden - evaluation of programme characteristics and adherence to European guidelines: The Perfect Cardiac Rehabilitation (Perfect-CR) study. Eur J Prev Cardiol. 2019:2047487319865729.

179. Douglas F, Torrance N, van Teijlingen E, Meloni S, Kerr A. Primary care staff's views and experiences related to routinely advising patients about physical activity. A questionnaire survey. BMC Public Health. 2006;6:138.

180. Korda RJ, Soga K, Joshy G, Calabria B, Attia J, Wong D, et al. Socioeconomic variation in incidence of primary and secondary major cardiovascular disease events: an Australian population-based prospective cohort study. International journal for equity in health. 2016;15(1):189.

181. Menotti A, Puddu PE, Maiani G, Catasta G. Cardiovascular and other causes of death as a function of lifestyle habits in a quasi extinct middle-aged male population. A 50-year follow-up study. International journal of cardiology. 2016;210:173-8.

182. Huber CA, Meyer MR, Steffel J, Blozik E, Reich O, Rosemann T. Post-myocardial Infarction (MI) Care: Medication Adherence for Secondary Prevention After MI in a Large Real-world Population. Clinical therapeutics. 2019;41(1):107-17.

183. McManus DD, Nguyen HL, Saczynski JS, Tisminetzky M, Bourell P, Goldberg RJ. Multiple cardiovascular comorbidities and acute myocardial infarction: temporal trends (1990-2007) and impact on death rates at 30 days and 1 year. Clinical epidemiology. 2012;4:115-23.

184. Ekblom O, Ekblom-Bak E, Bolam KA, Ekblom B, Schmidt C, Soderberg S, et al. Concurrent and predictive validity of physical activity measurement items commonly

used in clinical settings--data from SCAPIS pilot study. BMC Public Health. 2015;15:978.

185. Bhandari A, Wagner T. Self-reported utilization of health care services: improving measurement and accuracy. Medical care research and review : MCRR. 2006;63(2):217-35.

186. Riegel B, Moser DK, Buck HG, Dickson VV, Dunbar SB, Lee CS, et al. Self-Care for the Prevention and Management of Cardiovascular Disease and Stroke: A Scientific Statement for Healthcare Professionals From the American Heart Association. Journal of the American Heart Association. 2017;6(9).

12 APPENDICES