Fear of movement in patients with cardiovascular disease

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Fear of movement in patients with cardiovascular disease

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"Depending on the circumstance,
you should be:
hard as a diamond,
flexible as a willow,
smooth-flowing like water,
or as empty as space."

- Morihei Ueshiba-
Founder of Aikido


Amsterdam UMC

Chapter 1

General introduction

GENERAL INTRODUCTION

Cardiovascular diseases (CVD's) are the leading cause of death globally. In 2019, an estimated 17.9 million people died worldwide of CVD's, representing 32% of all global deaths (1). Physical activity (PA) improves functional capacity and quality of life, and is a cornerstone of secondary prevention of cardiovascular disease and a core component of cardiac rehabilitation (CR). Patients are advised to perform at least 150-300 min a week of moderate-intensity or 75-150 min a week of vigorous-intensity aerobic PA (2, 3). After cardiac hospitalization, only 17% of patients perform the recommended amount of PA (4). Self-reported avoidance of PA, after cardiac hospitalization, is related to major adverse cardiac events such as, readmission to the hospital for ischemic cardiac disease, cardiac mortality or all-cause mortality, and should thus be targeted (5, 6). An explanation for these low PA- levels is anxiety related to PA that is frequently reported after cardiac events (7). Specifically, fear of movement (kinesiophobia) is an important barrier for patients to achieve adequate levels of PA, but is not well investigated in patients with CVD. Kinesiophobia is defined as "an excessive, irrational and debilitating fear of movement and activity, resulting from a feeling of vulnerability to painful injury or re-injury" (8). In patients with coronary artery disease (CAD) kinesiophobia is present in 20% of the patients, 3 to 10 months after hospital discharge, and is associated with lower step-count and reduced quality of life (9). Moreover, kinesiophobia, in patients with CAD, is associated with non-adherence to cardiac rehabilitation (CR), despite its well-known benefits such as reduced mortality and hospital readmissions and improved psychological wellbeing (2, 10, 11).

The concept `kinesiophobia' is based on the fear avoidance model (FAM), a biobehavioral model that describes how individuals develop chronic musculoskeletal pain (CMP) as a result of `avoidance based pain related fear' (12). A recent systematic review reports that high levels of kinesiophobia in patients with CMP are associated with greater levels of pain intensity, disability and low quality of life (13). Unfortunately, little is known about kinesiophobia in patients with CVD, especially in the first phase (3 months) after hospital discharge. Research is urgently needed to identify patients with kinesiophobia after a cardiac hospitalization. Therefore, the development and validation of a measurement tool to objectify kinesiophobia in patients with CVD is crucial. Identifying kinesiophobia in patients with CVD helps to adequately refer patients to CR, where patients can be exposed to PA under the supervision of a specialized physiotherapist. In addition, the biological, psychological and social factors associated with kinesiophobia, and the impact of kinesiophobia on CR-initiation needs to be thoroughly studied. Gaining insight in these factors, will guide the development of strategies to target or prevent kinesiophobia. Moreover, the impact of kinesiophobia on objectively measured PA after cardiac hospitalization, is unknown. To gain insight in the (reciprocal) relationship between kinesiophobia

and PA, which in turn guides the development of treatment strategies, research with a longitudinal study design is critical.

PART 1: Measuring fear of movement in patients with cardiovascular disease

This part of the thesis describes the development, and validation, of a measurement tool to objectify kinesiophobia in patients with CVD. The Tampa Scale for Kinesiophobia (TSK) was originally developed to measure kinesiophobia in patients with chronic musculoskeletal pain and comprises the constructs: `fear of injury', `perception of danger', `avoidance of exercise' and `dysfunctional self' (14-17). Current studies have evaluated the validity of the TSK for patients with CVD (TSK-Heart) (18-20). Screening for kinesiophobia at hospital discharge, using the TSK-Heart, will help us to identify and adequately refer patients with high levels of kinesiophobia to CR. In addition, the TSK-Heart can be used to evaluate the effectiveness of CR-interventions targeting kinesiophobia. **Chapter 2** provides an overview of the translation, reliability, validity and factor structure of the TSK-NL Heart and levels of kinesiophobia at the start of CR. **Chapter 3** describes the responsiveness of the TSK-NL Heart, from the start of CR to 3 months follow up. In addition, we present candidate predictors of kinesiophobia at three months follow up.

PART 2: The course of kinesiophobia in patients with cardiovascular disease

In this part of the thesis, the course of kinesiophobia after cardiac hospitalization discharge is described. First, we extensively studied patients' experiences and beliefs, related to kinesiophobia. In addition, we assessed patients' needs in the first phase after hospital discharge. Studies show that irrational health beliefs and illness perceptions predict non-adherence to CR-programs (21, 22). However, it's unknown which specific health beliefs and illness perceptions are related to kinesiophobia, which in turn can lead to low PA-levels and/or non-adherence to CR. Insight in the experiences and needs of patients with high levels of kinesiophobia, in the first phase after hospital discharge, helps to identify modifiable factors to improve PA and the uptake of CR.

Research shows that high levels of kinesiophobia are, cross sectionally, associated with low PA-levels, reduced quality of life and non-adherence to CR (8, 9). In patients, hospitalized for acute cardiovascular disease, kinesiophobia is correlated with age and inversely correlated with educational level (23). More insight is needed in the biological, social and psychological factors related to kinesiophobia, to identify patients who are at risk of developing kinesiophobia and to guide the development of interventions to prevent or target kinesiophobia. In order to better understand the relationship between kinesiophobia and biological, psychological, social factors, and the initiation CR, a comprehensive methodological approach is needed, in which kinesiophobia can be modeled as dependent (factors related to kinesiophobia) and independent variable (impact of kinesiophobia on CR-initiation).

The relation between kinesiophobia and objectively measured PA has not been prospectively studied in patients with CVD. Although cardiac patients with high levels of kinesiophobia take significantly fewer steps than those with lower levels of kinesiophobia, the relationship between kinesiophobia and objectively measured PA has only been studied cross sectionally (6).

Prospective studies that investigate the association between kinesiophobia and objective measured PA are currently lacking, and cross sectional studies report contradictory findings. For instance, Carvalho et al. report that no association was found between kinesiophobia and objectively measured PA in patients with low back pain (24). In contrast, Bäck et al. revealed that, in patients with CAD, high levels of kinesiophobia were associated with lower step count (9). After renal transplantation, the relationship between kinesiophobia and physical activity is largely meditated by self-efficacy (25). A thorough longitudinal investigation of the complex (reciprocal) mechanisms, by which kinesiophobia and objectively measured PA impact each other, is needed to better understand kinesiophobia. Therefore, studies with a prospective design are necessary to: 1) determine which biological, psychological and social factors are associated with kinesiophobia, 2) assess the impact of kinesiophobia on CR-initiation, 3) assess the relationship between kinesiophobia and objectively measured PA. **Chapter 4** describes the perspectives and needs of patients with high levels of kinesiophobia. **Chapter 5** presents a comprehensive path analysis in which we explored predictors of kinesiophobia and the influence of kinesiophobia on initiation of CR. **Chapter 6** describes the complex relationship between levels of kinesiophobia and PA-levels, using a random intercept cross lagged panel model.

PART 3: Bridging the gap from hospital discharge to the start of cardiac rehabilitation

In this part of the thesis we describe the development of an intervention to bridge the gap from hospital discharge to the start of CR. Although early enrollment in CR is advised, patients with coronary artery disease (CAD) generally have to wait 4 to 6 weeks after hospital discharge before starting physical CR (due to a waiting list or intervention type) (26, 27). This waiting period constitutes a 'gap' between hospital discharge and the start of CR. Since patients are often discharged within 2 to 4 days, there is little time for patient education, while patients are often in need of tailored medical information and support from a health care provider (28). In addition, psychological distress is present in a substantial part of patients entering CR (symptoms of kinesiophobia are present in 45%, symptoms of anxiety in 28% and depression in 18%) (29, 30), which negatively impacts adherence to CR. A potentially promising strategy for the provision of information and social support, directly after hospital discharge, is the use of a remote coaching program. A major advantage of remote coaching is accessibility since patients can participate from the confines of their own living room. In addition, remote coaching programs, as part of a CR program, improves patients' physical capacity, clinical status and psychosocial health (31). Moreover, remote coaching has the

potential of improving self-efficacy, which in turn is associated with improved CR adherence (32-34). After hospital discharge, the use of a remote coaching program is potentially well suited for patients with kinesiophobia, or symptoms of anxiety or depression. However, the design of a remote coaching program for patients with kinesiophobia (and other forms of psychological distress) in the early phase after hospital discharge, is currently lacking. **Chapter 7** describes the development of an early remote coaching program, using the intervention mapping protocol.

AIMS AND OUTLINE OF THIS THESIS

The overall aim of the work, described in this thesis, is to explore kinesiophobia in patients with CVD by assessing factors associated with kinesiophobia, to explore the impact of kinesiophobia on the uptake of CR and objectively measured PA, and to develop an intervention to target or prevent psychological distress.
The specific aims of this thesis are to:

1. Investigate the psychometric properties of the Tampa Scale for Kinesiophobia in patients with cardiovascular disease (TSK-NL Heart).
2. Study the perspectives and needs of patients with high levels of kinesiophobia.
3. Study which biological, psychological and social factors are associated with kinesiophobia and the uptake of cardiac rehabilitation.
4. To assess the relation between kinesiophobia and objectively measured physical activity.
5. To develop an intervention targeting psychological distress in the early phase after hospital discharge.

The outline of the thesis is shown in **Figure 1**. It describes the approach we used to achieve the goals of this thesis.

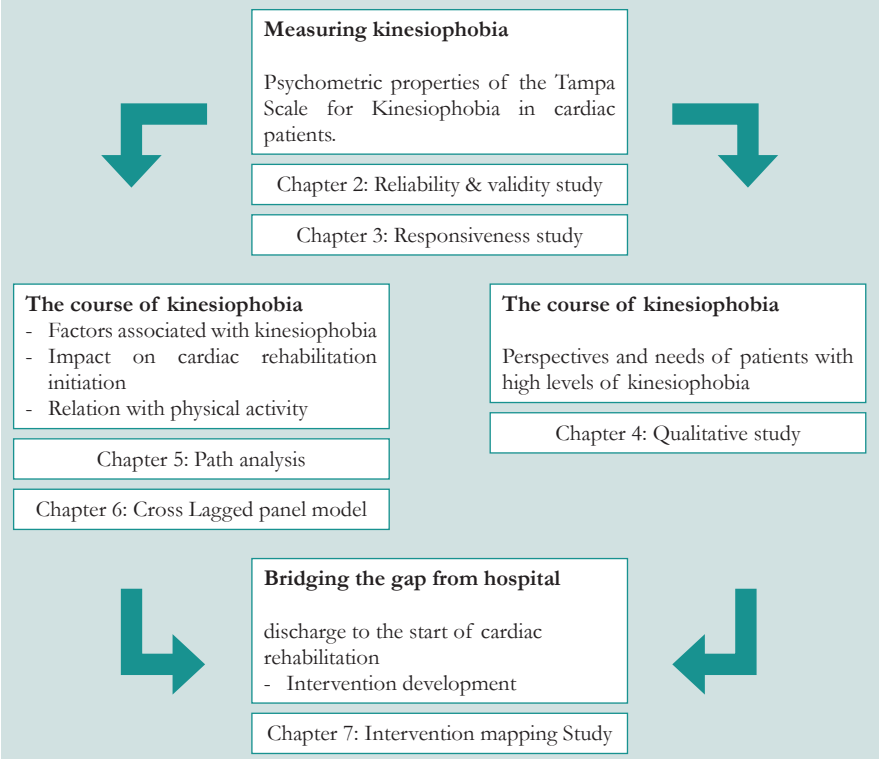

Figure 1. Outline of this thesis

This research project started with the development and investigation of the TSK-NL Heart, with special attention for the psychometric properties. Subsequently, the course of kinesiophobia was studied with a qualitative approach investigating the perspectives and needs of patients with kinesiophobia after cardiac hospitalization. A quantitative approach was used to study which biological, psychological and social factors are associated with kinesiophobia, and to assess the impact of kinesiophobia on CR-initiation and objectively measured PA.
The last part describes the development of an intervention, based on the findings from our studies, to target kinesiophobia in the early phase after hospital discharge.

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PART 1

Measuring kinesiophobia in patients with cardiovascular disease


FILA
ILONKA

Chapter 2

Fear of movement in patients attending cardiac rehabilitation: a validation study

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ABSTRACT

Objectives: To determine the psychometric properties of a questionnaire to assess fear of movement (kinesiophobia): the Tampa Scale for Kinesiophobia (TSK-NL Heart), and to investigate the prevalence of kinesiophobia in patients attending cardiac rehabilitation.

Methods: A total of 152 patients were evaluated with the TSK-NL Heart during intake and 7 days later. Internal consistency, test-retest reliability and construct validity were assessed. For construct validity, the Cardiac Anxiety Questionnaire (CAQ) and the Hospital Anxiety and Depression Scale (HADS) were used. The factor structure of the TSK-NL Heart was determined by a principal component analysis (PCA).

Results: After removal of 4 items due to low internal consistency, the TSK-NL Heart showed substantial reliability (intraclass correlation coefficient; ICC: 0.80). A strong positive correlation was found between the TSK-NL Heart and the CAQ (r_s: 0.61). Strong positive correlations were found between the TSK-NL Heart and de HADS (Anxiety) (r_s: 0.60) and between the TSK-NL Heart and the CAQ (r_s: 0.61). The PCA revealed a 3-factor structure as most suitable (fear of injury, avoidance of physical activity, perception of risk). High levels of kinesiophobia were found in 45.4% of patients.

Conclusion: The 13-item TSK-NL Heart has good psychometric properties, and we recommend using this version to assess kinesiophobia, which is present in a substantial proportion of patients referred for cardiac rehabilitation.

INTRODUCTION

Physical activity (PA) is one of the cornerstones of secondary prevention of cardiovascular disease, and a core component of cardiac rehabilitation (CR) (1). Nevertheless, the percentage of cardiac patients performing the recommended amount of PA has been reported to be as low as 17% (2). A potential explanation for the low levels of PA might be the anxiety that is frequently reported after cardiac events (3). Specifically, fear of movement, also known as kinesiophobia, might be an important barrier for patients to achieve adequate levels of PA. Kinesiophobia is defined as "an excessive, irrational and debilitating fear of movement and activity, resulting from a feeling of vulnerability to painful injury or re-injury" (4). Bäck et al. reported that up to 20% of patients with coronary artery disease (CAD) develop kinesiophobia (5).

The setting of CR might be suitable, not only to identify patients with kinesiophobia, but also to develop and test interventions targeting patients with high levels of kinesiophobia. Since avoidance of PA is related to major adverse cardiac events (4), participation in CR is even more important for these patients.

Kinesiophobia can be measured using the Tampa Scale for Kinesiophobia (TSK), which is based on the fear avoidance model created by Kori et al. (6). The TSK is predominantly used in patients with musculoskeletal complaints and was adapted by Bäck et al. (7) for use in patients with CAD by replacing "fear of pain" with "fear of a heart incident" (TSK-Heart) (7). The TSK-Heart has been translated into several other languages (8, 9). However, a comprehensive external validation, including a rigorous factor analysis, and population prevalence of kinesiophobia in a large contemporary group of patients attending CR, is lacking.

The aim of this study was therefore to cross-culturally validate the TSK Heart (English to Dutch), to assess the psychometric properties of the TSK Heart, and to assess the prevalence of kinesiophobia in patients referred for CR.

METHODS

Study design

A prospective study was performed with 2 time-points at Capri Cardiac Rehabilitation Rotterdam (CCRR) and Cardiovitaal Cardiac Rehabilitation Amsterdam (CCRA).

Ethical considerations

A waiver of approval was granted by the Medical Ethics Committee of the Erasmus University Medical Centre, Rotterdam (MEC-2017-1096).

Cross-cultural validation

A forward translation of the TSK-Heart was performed by NtH and IdU, and reviewed by a professional English teacher (academic level). All comments regarding the translation were independently processed by NtH and IdU. After

consensus was reached, the questionnaire was reviewed by HvdBE. After the last comments were processed by NtH and IdU, the final version was reviewed in several rounds by an expert panel consisting of cardiac patients (n = 12) and CR healthcare professionals (n = 8). The panel of healthcare professionals consisted of 2 cardiologists, 2 physical therapists, 2 cardiac nurses and 2 psychologists. The expert panel was asked to respond to the relevance and formulation of the separate items on a standardized form. After each round a new version of the TSK-NL Heart was created until consensus was reached.

Patients

In order to adequately analyse all psychometric properties and to analyse differences in kinesiophobia between subgroups, this study aimed to include 150 participants.

For this study we used an "all-comers design". All patients who were referred to CR, in CCRR or CCRA, between July 2018 and February 2019 were invited to participate in the study. Patients were eligible to participate if they were able to read and understand the Dutch language and had a valid e-mail address. Delayed participation in CR (>10 months post-event) was an exclusion criterion. All patients who agreed to participate gave written informed consent.

Procedures

Data were collected during the intake for CR (T0) and 5-7 days post-intake (T1). Patients started CR after T1. At T0 the following baseline data were collected: age, sex, cardiac diagnosis, cardiac disease history and co-morbidities. Furthermore, patients were asked to complete the following questionnaires at T0 and T1.

TSK-NL Heart. This questionnaire measures fear of movement. It consists of 17 questions with a 4-point answer scale. Minimum score is 17 and maximum score 68. A cut-off score of 37 points is used to define "low levels of kinesiophobia" (<37 points) and "high levels of kinesiophobia" (≥37 points) (7).

Cardiac Anxiety Questionnaire (CAQ). Cardiac anxiety is defined as anxiety symptoms that are triggered by specific cardiac-related stimuli and symptoms (10). The CAQ is 18-item questionnaire with a 5-point Likert scale (0–4) with a maximum score of 72. The CAQ reflects the subscales: fear, attention, avoidance of physical exercise and safety-seeking behaviour (10).

Hospital Anxiety and Depression Scale (HADS). The HADS consists of 7 items measuring anxiety (HADS-A) and 7 items measuring depression (HADS-D). A 4-point Likert scale (0–3) is used. For both subscales a score of 0–7 is defined as "no anxiety/depressive disorder", a score of 8–10 is defined as "possible anxiety/depressive disorder", and a score of 11–21 is defined as "likely anxiety/depression disorder"'. The HADS is a widely used tool to assess anxiety and depression in various patient groups (11). For this study we only used HADS-A.

Data were collected using a software package (Castor EDC at CCRA and GemsTracker at CCRR) for distribution of questionnaires between July 2018 and February 2019.

Statistical analysis

Descriptive statistics were used for demographic data. Continuous data were presented as mean and standard deviations (SD), if data were normally distributed. For categorical data median and range were used. All statistical analyses were performed using IBM® SPSS® v. 25.0 software.

Internal consistency

Homogeneity and the contribution of each item to the test were assessed by Cronbach's α at T0. A Cronbach's α value of 0.70 and a minimal corrected item correlation of 0.25 per item were classified as sufficient (12). Items with a corrected item correlation below 0.25 were excluded from the exploratory factor analysis.

Test-retest reliability

A test-retest procedure was performed on the sum score of the TSK-NL Heart and on all 17 items separately between T0–T1. If items were removed due to low internal consistency, the adjusted sum score was used. Test-retest reliability was assessed by computing the intraclass correlation coefficient (ICC) with a 2-way mixed model. The strength of reliability was classified as slight (0.00–0.20), fair (0.21–0.40), moderate (0.41–0.60), substantial (0.61–0.80), or excellent (0.81–1.00) (13).

Construct validity

External measure. Construct validity was assessed by investigating the correlation between the sum score of the TSK-NL Heart, and the sum score of the CAQ and of HADS-A at T0. The correlations were computed using the Spearman's rank correlation. Strength of correlation was defined as small (0.00–0.29), moderate (0.30–0.49), or strong (0.50–1.00) (14).

Exploratory factor analysis. The factor structure of the TSK-NL Heart was assessed with a principal component analysis (PCA) at T0. To check whether the data were suitable for factor analysis, the "Kaiser-Meyer-Olkin Measure of sampling adequacy" (KMO) was used. A KMO value > 0.8 indicates good sample adequacy (15). Bartlett's test of sphericity was performed to test whether the variables were unrelated and thus unsuitable for structure detection. Small values (< 0.05) reject the null hypothesis that the variables are unrelated, (15) and thus justify proceeding with the PCA. An Oblimin rotation was used to assess the data, since it was expected that the components were correlated (15). Kaiser's criterion (eigenvalue > 1) was used to determine the number of components. Subsequently, the explained variance of the various components was assessed. A total explained variance of ≥ 60% was considered satisfactory (16).

Prevalence of kinesiophobia

The distribution of kinesiophobic scores at T0 was explored by creating amplitude probability distribution functions (APDF) for the study population as a whole. The distribution of scores in the following sub-groups was then assessed: (i) acute

and elective hospitalization; (ii) interventional procedures, surgical procedures and medication only. Interventional procedures included: percutaneous cardiac intervention (PCI), transcatheter aortic valve implantation (TAVI), electro cardioversion (ECV), internal cardiac defibrillation procedure (ICD), and ablation. Surgical procedures included: aortic replacement, coronary artery bypass grafting (CABG) and CABG combined with mitral valve replacement (MVR) or aortic valve replacement (AVR). High kinesiophobic traits were defined as a TSK-NL Heart sum score ≥ 37 (9). If items were removed from the analysis due to low internal consistency, this cut-off point was proportionally re-scaled.

RESULTS

Cross cultural validation

In the first round, 129 comments were made by the expert panel, mainly about formulation and interpretability of the items. The panel gave 51 suggestions to improve formulation of the items. After the second round the number of comments decreased to 57, and 25 suggestions were made to improve the items. After the third round there were no further comments and suggestions. After consensus was reached, the final version of the TSK-NL Heart was developed.

Psychometric properties

A total of 152 patients were included in this study. All patients completed the TSK-NL Heart at T0. In total, 131 patients also filled in the TSK-NL Heart at T1. Baseline characteristics are presented in **table 1**.

Table 1. Population characteristics

Characteristics	
Male (%)	107 (70.4)
Mean Age (SD)	61.5 (11.6)
Referral Diagnosis (%)*	
Acute Coronary Syndrome	
STEMI	34 (22.4)
NSTEMI	30 (19.7)
Unstable AP	1 (0.7)
Stable AP	29 (19.1)
Valvular Disease	21 (11.8)
Congestive Heart Failure	12 (7.9)
Acute Aortic Syndrome	5 (2.9)
Ventricular Tachycardia	
With ICD	4 (2.6)
Without ICD	3 (2.0)

Table 1. *Continued*

Characteristics	
Supraventricular Tachycardia	
Atrial Fibrillation	17 (6.6)
Atrial Flutter	2 (1.3)
A specific thoracic pain	3 (2.0)
Intervention**	
PCI	65 (42.8)
CABG	22 (14.5)
Valve Procedure	20 (13.2)
ICD implantation	8 (5.3)
ECV	4 (2.0)
Ablation	5 (3.2)
Aortic replacement	3 (1.9)
Admission	
Acute	79 (52.0)
Elective	73 (48.0)
Procedure	
Surgical	38 (25.0)
Interventional	82 (53.9)
Medication only	32 (21.1)
Cardiac disease history and comorbidities	
Myocardial infarction	21 (13.8)
Angina pectoris	8 (5.3)
OHCA	1 (0.7)
Hypertension	54 (35.5)
Heart failure	5 (2.9)
Hypercholesterolemia	34 (22.4)
Diabetes	20 (13.2)
Obesity	4 (2.6)
Stroke	2 (1.3)
TIA	5 (3.2)
COPD	11 (7.2)
OSAS	9 (5.9)
Rheumatic disease	8 (5.2)
Musculoskeletal disorder	10 (6.6)
Oncological disease	9 (5.9)
Renal failure	4 (2.6)

Table 1. *Continued*

Characteristics	
CAQ score Median (range)	25 (48)
HADS Anxiety Median (range)	5 (19)
HADS Anxiety Categories (%)	
No Anxiety disorder	103 (67,8)
Possible Anxiety disorder	17 (11.2)
Likely Anxiety disorder	24 (15.8)
Missing	8 (5.3)

*multiple diagnoses possible ** multiple interventions possible
Abbreviations: STEMI = ST-Elevation Myocardial Infarction, NSTEMI = Non ST-Elevation Myocardial Infarction, AP = Angina Pectoris, ICD = Internal Cardiac Defibrillator, PCI= Percutaneous Coronary Intervention CABG = Coronary Artery Bypass Grafting, OHCA = Out of Hospital Cardiac Arrest, COPD = Chronic Obstructive Pulmonary Disease, OSAS = Obstructive Sleep Apnoea Syndrome, TIA = Temporary Ischemic Accident, TSK = Tampa Scale for Kinesiophobia, CAQ = Cardiac Anxiety Questionnaire, HADS = Hospital Anxiety and Depression Questionnaire.

Internal consistency

Cronbach's α for the whole scale was 0.84. The corrected inter-item correlation of item 4, 8, 12 and 16 were below <0.25 and were removed from the analysis. After removal of these items with low inter item correlation, Cronbach's alpha increased to 0.88. All values are presented in **table 2**.

Test-retest reliability

Excellent reliability was found for the sum score of the TSK-NL Heart: ICC: 0.82 (95% CI: 0.75 – 0.86). After removal of the items 4, 8, 12 and 16, the ICC sum score was: 0.80 (95% CI: 0.72 – 0.85) which is classified as *substantial*. All ICC values are presented in **table 2**.

Table 2. Internal consistency and Test-retest reliability

Item	Corrected Item-Total Correlation	Cronbachs alpha if item deleted	Intraclass Correlation Coefficient (ICC) (95% CI)
1	.655	.817	0.57 (0.44 – 0.67)
2	.687	.816	0.59 (0.48 – 0.69)
3	.534	.824	0.50 (0.36 – 0.62)
4	.103	.847	0.38 (0.22 – 0.51)
5	.319	.835	0.69 (0.59 – 0.77)
6	.555	.822	0.55 (0.42- 0.66)
7	.438	.829	0.50 (0.37 – 0.62)
8	.107	.845	0.44 (0.29 – 0.57)
9	.660	.816	0.55 (0.42 – 0.66)
10	.663	.817	0.69 (0.59 – 0.77)
11	.605	.819	0.55 (0.42 – 0.66)
12	.223	.840	0.35 (0.20 – 0.49)
13	.264	.838	0.31 (0.15 – 0.46)
14	.593	.821	0.45 (0.30 – 0.57)
15	.605	.820	0.49 (0.35 – 0.61)
16	.099	.845	0.30 (0.13 – 0.44)
17	.356	.833	0.31 (0.15 – 0.45)
Sumscore 17 items			**0.82 (0.75 – 0.86)**
Sumscore 13 items			**0.80 (0.72 – 0.85)**

Construct validity

Relationship TSK-NL Heart and external measures. Since the data were not normally distributed, we used the spearman correlation coefficient (r_s). A strong positive correlation was found between the TSK-NL Heart sum score (13-items) and the CAQ: r_s = 0.61 (95% CI 0.51 – 0.71). A strong positive correlation was found between the TSK-NL Heart (13-items) and HADS-A: r_s = 0.60 (95% CI: 0.48 – 0.70).

Exploratory Factor Analysis. After the removal of 4 items (4, 8, 12 and 16) we performed an analysis on the 13 remaining items. The KMO was 0.89 indicating good sample adequacy. Bartlett's test of sphericity was significant (Approximate Chi-Square: 762.845, P = 0.0001) thereby rejecting the hypothesis that our matrix is an identity matrix and thus suitable for PCA. Three components were identified using Kaiser's criterion (eigenvalue >1). The explained variance of the three components together was 59,5%. **Table 3** shows three components after rotation. After assessment three factors were defined: `Fear of injury', `Avoidance of physical activity' and `Perception of risk'.

Table 3. Pattern Matrix

	Fear of injury	Perception of risk	Avoidance of physical activity
TSK 9	**.854**	.091	-.085
TSK 1	**.852**	.139	-.052
TSK 2	**.781**	.069	.072
TSK 3	**.674**	-.328	-.061
TSK 11	**.627**	.183	.167
TSK 6	**.602**	-.229	.108
TSK 15	**.593**	.180	.234
TSK 7	**.514**	-.455	-.021
TSK 13	.284	**0.647**	.190
TSK 5	.041	**-0.520**	.516
TSK 17	-.125	.139	**0.861**
TSK 14	.252	-.038	**0.665**
TSK 10	.428	-.029	**0.496**
R^2 Factors, %	41.88	9.7%	7.9
R^2 Total ,%			**59.48**

Extraction Method: Principal Component Analysis, Rotation Method: Oblimin with Kaiser Normalization,
Rotation converged in 18 iterations, R^2= explained variance, Highest factors loading for each factor are presented in bold

Prevalence of kinesiophobia

The distribution of kinesiophobia scores across the sample are determined by the 13-item TSK-NL Heart. The new cut-off score of the TSK-NL Heart with 13 items was calculated as $37 * \frac{13}{17} = 28$. Patients who score > 28 points are considered to have kinesiophobia. The median score of the total sample was 27.0 points. In this sample, 45.4% of patients scored above the cut-off score. Highest kinesiophobic scores were found in patients treated with medication only, 59.4% scored above the cut-off value vs 45.1% in patients treated with an interventional procedure and 34.2% of patients treated surgically. In acute patients, 46.8% scored above the cut-off value vs 43.8% in elective patients. All scores are shown in **Fig. 1**.

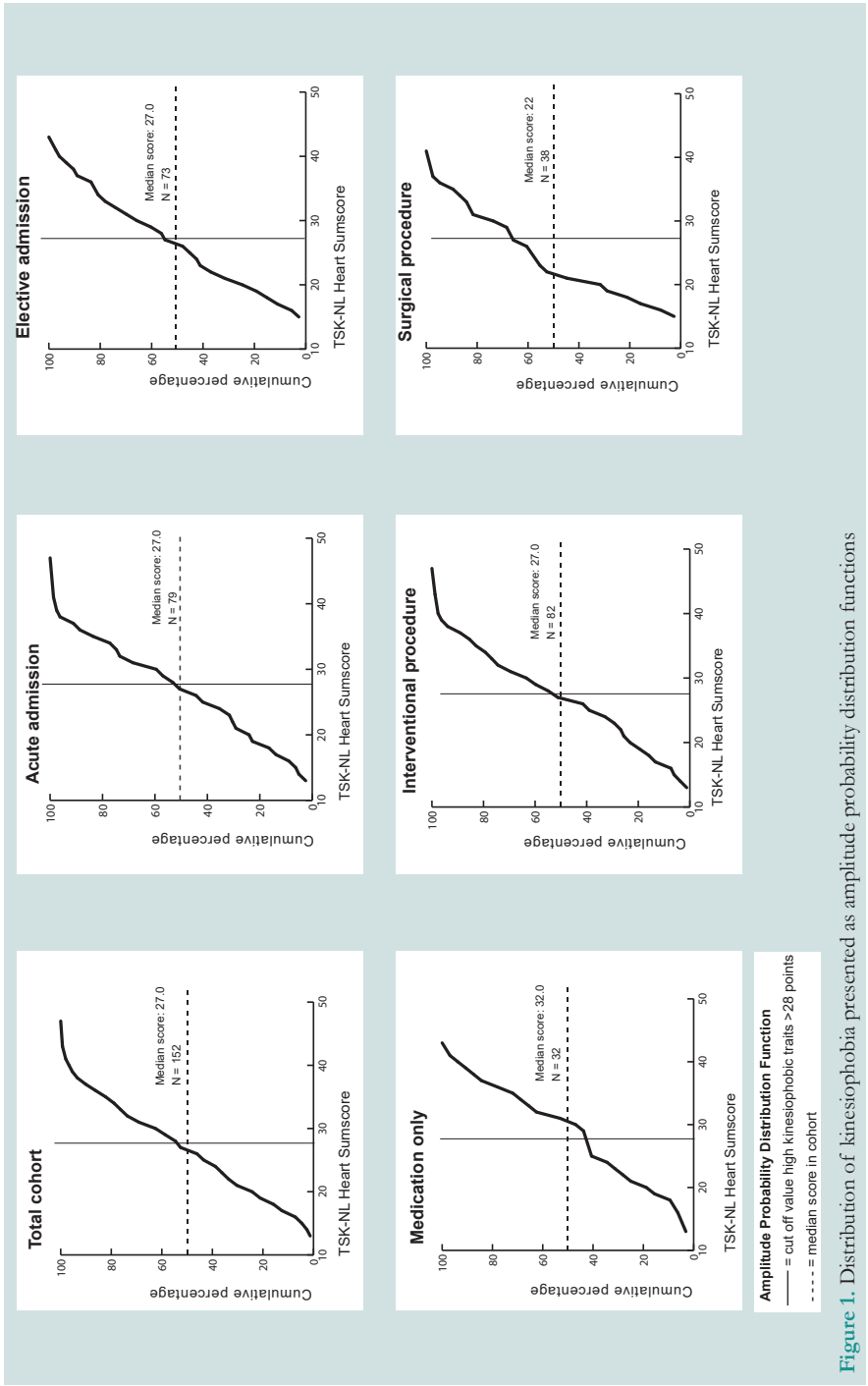

Figure 1. Distribution of kinesiophobia presented as amplitude probability distribution functions

DISCUSSION

This study shows that the TSK-NL Heart is a reliable and valid tool to measure kinesiophobia in patients referred to CR with a variety of cardiovascular diseases. In addition, this study showed that kinesiophobia is present in a substantial proportion of participants referred for CR, especially in those treated with medication only and with interventional procedures. After removal of ambiguous items (4, 8, 12 and 16)the internal consistency of the questionnaire improved. We therefore suggest using the 13-item version of the TSK-NL Heart to measure kinesiophobia in CR participants. Similar results have been reported by other studies (8, 17). The high test-retest reliability reported in this study shows that the TSK-NL Heart is a reliable instrument and indicates that kinesiophobia was stable over the chosen time period of one week. Although the individual items showed only "fair" to "moderate" test-retest reliability, the sum score of the TSK-NL Heart in this study is substantial. This indicates that the TSK-NL Heart is a reliable instrument and gives an indication that kinesiophobia was stable over the chosen time period of one week. Nevertheless, scores on individual items should be interpreted with caution. Similar results, with regard to internal consistency and test-retest reliability, have been reported in previous studies with a similar population (7, 8). A strong correlation was found between the TSK-NL Heart and the HADS-A. This finding is in line with a previous study of Bäck et al. that showed that anxiety, measured on the HADS, increased the odds of having kinesiophobia with 19,2% (5). Theoretically this makes sense since anxiety is the primary affective component tin phobias (18). In our study, 27% of the patients were classified with an anxiety disorder (possible anxiety disorder: 11,2%, likely anxiety disorder: 15,8%) on the HADS-A, while 45,4% had high kinesiophobic scores measured on the TSK-NL Heart. The HADS-Ais commonly used to assess the level of general anxiety in patients in CR (19) however, it does not measure specific anxiety symptoms related to (avoidance of) physical activity (19), such as kinesiophobia. The correlation between the TSK-NL Heart and the CAQ was also classified as strong. As opposed to the HADS-A, the correlation between the TSK-NL Heart and the CAQ was classified as strong and improved after removal of the ambiguous items. This high correlation was expected, since the factor structure of the external measurement tool(CAQ) was similar to the TSK-NL Heart. The CAQ measures behaviour and anxiety-related symptoms (10), where the TSK-NL Heart's primary focus is measuring patient beliefs about their physical state. Secondly, the TSK-NL Heart measures "fear of injury", which is an important aspect of fear avoidance behaviour in patients with cardiovascular disease (20). Itis worth investigating the added value of the TSK-NL Heart in a study in which actual movement behaviour is measured, together with both TSK-NL Heart and CAQ, to determine whether the TSK-NL Heart is more specific than the CAQ. Bäck et al. (7) reported, after performing a confirmatory factor analysis, that the original framework of the TSK with 17 items according to the framework of Kori

et al. was the best fit for their data. Since the current study investigated a different patient population and adapted the questionnaire, we performed a new factor analysis. After removal of 4 items, our PCA revealed3 components that explain the construct of kinesiophobia. Similar levels of explained variance were found by Acar et al. (8) who proposed an 11- item model with 4components. Differences in factor structure might be explained by differences in study population. Bäck et al. included only those patients with CAD, and Acar et al. studied patients with heart failure and pulmonary hypertension. Our study population consisted of amore heterogeneous group of cardiac patients, since we wanted to generalize the findings to a broad group of CR patients. High kinesiophobic scores (> 28) were found inpatients referred to CR. In particular, high kinesiophobic scores were found in patients treated with medication only (59.4% scored above 28) and after an interventional procedure (45.1%) compared with those who received surgical treatment (34.2%). An explanation for these high kinesiophobic scores might be that patients are discharged shortly after their intervention and thus receive less information or guidance from a physiotherapist or registered nurse, which, in turn, might lead to psychological distress (21). Patients treated with medication alone did not receive an intervention that "repaired" their heart, and might feel less confident about their body and the risk of a secondary cardiac event. Patients who were treated surgically had a longer hospital stay, which might have led to lower levels of kinesiophobia, since these patients received more support from a healthcare professional than those treated with an interventional procedure. This study also shows that the difference between acute and elective admissions, in terms of kinesiophobic scores, was small, indicating that patients treated electively should also be assessed for kinesiophobia. The high scores for kinesiophobia seen in this study emphasize the need for more attention for kinesiophobia during CR. The outcomes suggest that the TSK-NL is a reliable tool to measure kinesiophobia. We recommend the use of this questionnaire in future studies, to further investigate the presence of kinesiophobia in CR and to evaluate intervention effects, since reducing kinesiophobia is an important objective of CR (22). Furthermore, early screening for kinesiophobia might result in better CR outcomes in patients with kinesiophobia. The TSK-NL Heart could be used for screening patients in whom there is an indication of possible kinesiophobia. Future research is needed into other psychometric properties of the TSK-NL Heart, such as responsiveness to change, in order to investigate whether this tool is suitable to evaluate outcomes of CR interventions targeting kinesiophobia.

Study limitations

This study has several limitations. Firstly, we chose to include patients who were already referred to CR. Research shows that only 39% of the eligible patients participate in CR (23). Kinesiophobia could result in unwillingness to participate in CR (24). This might have led to selection bias and resulted in a sample with relatively low kinesiophobic scores. Secondly, in line with previous studies (7), the current study used a cut-off score of >28 to define "high kinesiophobic scores",

since, unfortunately, there is no gold standard for kinesiophobia. Nevertheless, a large variety of scores was found in our sample with a substantial number of scores above the cut-off point. Even when a more conservative cut-off point is used, high kinesiophobic traits are present in a substantial proportion of patients. We therefore consider it likely that high kinesiophobic scores exist in CR patients. In a recent study, with a different population, in which a 13-item TSK-pain was used, the clinically meaningful severity levels of the TSK-pain were assessed in a sample of patients with musculoskeletal pain and divided as follows: subclinical: 13–22; mild:23–32; moderate: 33–42; and severe: 43–52 (29). It is not known whether these cut-off scores can be generalized to our population. However, it might be useful to define several categories, since the presence of kinesiophobia is not dichotomous and might be of better use for the clinician (30). More research is needed, in studies with bigger sample sizes, to define clinically meaningful severity scores for the TSK-NL Heart. Thirdly, the current study shows a 3-factor model to be the most suitable for the TSK-NL Heart. This version of the TSK-NL Heart excludes 4 questions due to low inter-item correlations. It should be investigated whether rephrasing these items is necessary to gain better construct validity, instead of removal. Lastly, the current study assessed the prevalence of kinesiophobia. There were high levels of kinesiophobia in this relatively small sample. These findings should be validated in future studies with larger sample sizes.

CONCLUSION

This study shows that the TSK-NL heart has good psychometric properties. We recommend using the13-item TSK-NL Heart to measure kinesiophobia in CR patients. This study indicates that high kinesiophobia scores are present, and also in a substantial proportion of patients referred to CR, emphasizing the need for more attention for kinesiophobia during these rehabilitation programmes.

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Chapter 3

Assessing Changes in Fear of Movement in Patients attending Cardiac Rehabilitation: Responsiveness of the TSK-NL Heart Questionnaire

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ABSTRACT

Objectives: Our primary objective was to determine the responsiveness of the TSK-NL Heart. Secondary objective was to assess kinesiophobia changes during cardiac rehabilitation (CR).

Methods: We measured kinesiophobia pre- and post-CR using the TSK-NL Heart questionnaire in 109 cardiac patients (61 years; 76% men). The effect size of kinesiophobia score changes was calculated for the full population. A measure that is responsive to change should produce higher effects sizes in patients that improve kinesiophobia. Therefore, effect sizes were also calculated for patients that did or did not improve on selected external measures. For this step, the Cardiac Anxiety Questionnaire (CAQ) and the Hospital Anxiety and Depression Scale (HADS) were filled out as external measures in a subsample of 58 patients.

Results: Effect size of the TSK-NL Heart for the full study population was small (0.29). In line with our hypothesis the effect size was higher (moderate) for patients with improved CAQ (0.52) and HADS scores (0.54). Prevalence of high kinesiophobia levels decreased from 40% pre-CR to 26% post-CR ($p=0.004$).

Conclusions: The TSK-NL Heart has moderate responsiveness and can be used to measure kinesiophobia changes. Improvements in kinesiophobia were observed during CR. Nevertheless, high kinesiophobia levels were still highly prevalent post-CR.

INTRODUCTION

Physical activity (PA) is one of the cornerstones of prevention of cardiovascular disease (CVD) (1). Fear of movement, also known as kinesiophobia, might be associated with inadequate levels of PA.(2) Kinesiophobia is present in 45% of patients after a recent CVD hospitalization (2) and in 20% of patients 3 to 10 months after hospital discharge (3). In addition to low levels of PA, high levels of kinesiophobia are also related to decreased muscle endurance and decreased quality of life (2).

Participation in cardiac rehabilitation (CR), including exercise and psychological interventions, has been shown to improve psychological factors such as general anxiety and depression (4, 5, 6). Therefore, CR might also be a suitable setting for interventions targeting patients with lasting kinesiophobia. Nevertheless, before interventions can be designed, the impact of current CR should be studied to determine the prevalence of high levels of kinesiophobia post-CR. Furthermore, it is unknown which clinical and demographic variables are predictive of lasting kinesiophobia and which beliefs about PA contribute to high levels of kinesiophobia post-CR. Insight in these aspects is important for the design of interventions.

The lack of data on kinesiophobia pre- and post-CR is partly due to the absence of well-validated instruments. Kinesiophobia is measured with the Tampa Scale for Kinesiophobia (TSK) (7). The TSK was originally developed for patients with musculoskeletal pain and has been shown to have good reliability and validity, and to be responsive to change in this population (7, 8). The TSK questionnaire was adapted by Back et al for use in cardiac patients and renamed TSK-Heart (9). Although the TSK-Heart was validated (3, 9, 10, 11), it is still unknown if the TSK-Heart is responsive to change.

The primary objective of this study was to determine the responsiveness of the Dutch version of the TSK-Heart questionnaire in a CR population. In case reasonable responsiveness was found, our secondary aims were to assess changes in kinesiophobia during CR and to explore candidate predictors (demographic and clinical variables and belief about PA) of high levels of kinesiophobia post-CR.

MATERIALS AND METHODS

Study design and participants

For participation in this longitudinal prospective cohort study, we invited patients with a variety of cardiac diagnoses referred to CR at Capri Cardiac Rehabilitation (Rotterdam, the Netherlands) or Cardiovitaal Cardiac Rehabilitation (Amsterdam, the Netherlands) between July 2018 and February 2019. The majority of patient is referred to CR within 1-3 months after a cardiac event. Inclusion criteria were: age

>18, proficiency in Dutch and access to email. A waiver of approval was granted by the Medical Ethics Committee of the Erasmus University Medical Centre, Rotterdam, the Netherlands (MEC-2017-1096). All patients provided informed consent. To assure methodological quality the box Responsiveness (construct approach) of the Cosmin checklist was used to design this study (see **Appendix 1**) (12). We aimed to include a minimum of 150 participants to determine both validity (see previous publication (3) and responsiveness. According to the Cosmin Checklist, a minimum of 50 patients is considered adequate and a minimum of 100 patients is seen as good to determine responsiveness using a construct approach (12).

Cardiac rehabilitation program

All patients were enrolled in a multidisciplinary CR program that is based on European and Dutch guidelines (13, 14). The program comprised two training sessions per week (aerobic and strength exercises) for a duration of 6-12 weeks. Educational sessions were offered on cardiovascular risk factors, healthy lifestyles and emotional coping. All sessions lasted for about one hour. Based on individual goals, patients could participate in individual or group counselling sessions focused on healthy diet, smoking cessation and stress management. If needed, patients were referred to a psychologist for additional psychological support. CR was ended when individual goals were met or after consultation between patient and the multidisciplinary CR team.

Data collection

Kinesiophobia

Kinesiophobia was measured with the Dutch version of the 13-item Tampa Scale for Kinesiophobia for cardiac patients (TSK-NL Heart) (3). The outcome is a continuous score between 13-52. A cut-off score of 29 or higher was used to define high levels of kinesiophobia (3). In addition to the total score, a sum score was calculated for each of the three subscales of the TSK-NL Heart: 1) fear of injury (sum score between 8-32 of items 1,2,3,5,6,7,9,12); 2) perception of risk (sum score between 2-8 of items 4 and 10); 3) avoidance of PA (sum score between 3-12 of items 8,11,13).

External measures

Since a gold standard for determining kinesiophobia is lacking, we used a construct approach (12) with an external criterion. As external criteria we used two measurement tools which are often used to determine anxiety in CR: 1) The Cardiac Anxiety Questionnaire (CAQ) (15) and 2) the Hospital Anxiety and Depression Scale (HADS) (16). In our previously conducted cross-sectional study, we found the TSK-NL Heart to be strongly correlated with the CAQ and HADS (3). The CAQ measures cardiac anxiety, which can be defined as "anxiety symptoms that are triggered by specific cardiac-related stimuli and symptoms" (15). The outcome is a continuous score between 0-72. The HADS consists of

two subscales to measure generic anxiety (HADS-A) and general depression (HADS-D) (16). For the purposes of this study, only the HADS-A was used. The outcome is a continuous score between 0-21.

Procedure

Data on age, sex, cardiac diagnoses, type of intervention, history of cardiac disease and comorbidities were obtained from medical charts. Patients were asked to complete the TSK-NL Heart, CAQ and HADS-A online, at home, a week before the start of CR (pre-CR). At 3 months follow up (post-CR), patients were asked to complete the TSK-NL Heart again. To determine external responsiveness, only a subsample of the patients (only patients receiving CR at the location in Rotterdam) received the CAQ and HADS for a second time.

Statistical methods

Patient selection and characteristics

Patient characteristics are presented as mean and standard deviation (SD) for normally distributed data and as median and interquartile range (IQR) for non-normally distributed data. Normality was checked using a Kolmogorov-Smirnov test. Categorical data are presented as percentages. To evaluate potential bias, differences in baseline characteristics between patients included and excluded from analysis were evaluated using an independent samples t-test, Mann-Whitney U test or Chi square test, as appropriate. In case of missing items within a questionnaire, a maximum of 2 items were imputed with the median score on the other items of the same patient (17).

Responsiveness

Internal responsiveness was estimated by calculating the effect size (ES, (change score/ SD of pre-CR score)) and standardized response mean (SRM; (change score/ SD of change score)) of the change in the total score in the full study population. For both the ES and SRM, a score ≤0.49 was considered small, 0.50-0.79 as moderate and ≥0.80 as large (18). Since ES and SRM are based on parametric distributions, the TSK-scores pre-CR and post-CR will be assessed using Paired samples t-test (parametric distribution) and Wilcoxon signed rank test (non-parametric distribution). If similar results are yielded from both tests, the ES and SRM can be safely interpreted. Since substantial improvements in TSK-NL Heart scores are only expected in a subsample of patients entering CR with high kinesiophobia scores (3) and since specific kinesiophobia interventions are lacking during CR, no large treatment effect was anticipated. Therefore, we anticipated to find small to moderate ES and SRM values for the full study population. A measure that is responsive to change should be able to distinguish between subgroups of patients that do or do not show changes. Higher ES and SRM values are therefore expected in a subsample of patients that shows improvements on the external measures (CAQ and HADS-A). Therefore, external responsiveness was determined by calculating ES and SRM values for subsamples of patients

that showed improvements (change score >0) on the external measures and for patients whose scores did not improve (change score ≤0). We defined the responsiveness of TSK-NL Heart to be reasonable in case the ES and SRM values were at least moderate for the subsample that improved on the external measures and small for the group that did not improve.

External responsiveness was further explored using Spearman's correlation coefficients between change scores on the TSK-NL Heart and change scores on the external measures (CAQ and HADS-A). A correlation coefficient ≤0.29 was considered a poor correlation; 0.30-0.49 a moderate correlation, ≥0.5 a strong correlation (19). Since all three questionnaires measure anxiety, we anticipated a correlation between the change scores (3). Nevertheless, since the TSK-NL Heart measures a specific anxiety (movement-related), we did not expect to find a strong correlation.

Changes in kinesiophobia and predictor finding analysis

The non-normally distributed TSK-NL Heart, HADS-A and CAQ mean score changes, between pre-CR and post-CR, were tested with a Wilcoxon signed rank test. Pre-CR scores and post-CR scores were presented with amplitude probability distribution function (APDF) plots (3). For the original TSK, one study reports a change of 5.5 points, on a 13-item scale, as clinically relevant while another study reports a change of 4.5, on a 17-item scale, as clinically relevant (8, 20). For the purpose of this study, we calculated the number of patients showing an improvement of at least 5 points on the TSK-NL Heart.

For the predictor finding analysis (21) an univariate logistic regression analysis was performed with the dichotomized TSK-NL Heart score (scores ≥29 vs score <29) as dependent variable and baseline characteristics (age, sex, diagnosis and type of intervention) and pre-CR scores on the TSK-NL Heart (total score and scores on subscales), CAQ and HADS- A as predictor variables.

For all tests we used SPSS version 26 (IBM Crop, Amonk, USA). A p-value <0.05 was considered significant.

RESULTS

Methodological quality

All 10 items of the COSMIN criteria checklist were completed (see **Appendix 1**). Nine items were scored as `very good' and one was scored `adequate'.

Participants

A total of 171 patients participated in this study. Of these, 109 patients (61 years old, 76.1% male) completed the TSK-NL Heart both pre-CR and post-CR and were included for the analysis (**Figure 1**, **Table 1**). The majority of patients were referred to CR after an acute event (52.3%) such as a myocardial infarction. Details regarding cardiac diagnosis can be found in table 1. A history of cardiac disease

was present in 23.9% of patients. Included patients were more often men (76.1% vs 61.3%; p=0.04), had lower levels of kinesiophobia (median TSK-NL Heart score (IQR) score of 26 (11) vs 29.5 (14); p=0.03) and had less generic anxiety (median HADS-A score (IQR) score of 5 (5.5) vs 6.0 (7.0); p=0.02) as compared with patients excluded due to incomplete TSK-NL Heart questionnaires.

The external measures (HADS-A and CAQ) were only completed post-CR in one of the participating centers. Therefore, external responsiveness could only be determined within this subsample consisting of 58 patients. There were no baseline differences observed between the sample included for the internal responsiveness (n=109) and external responsiveness (n=58).

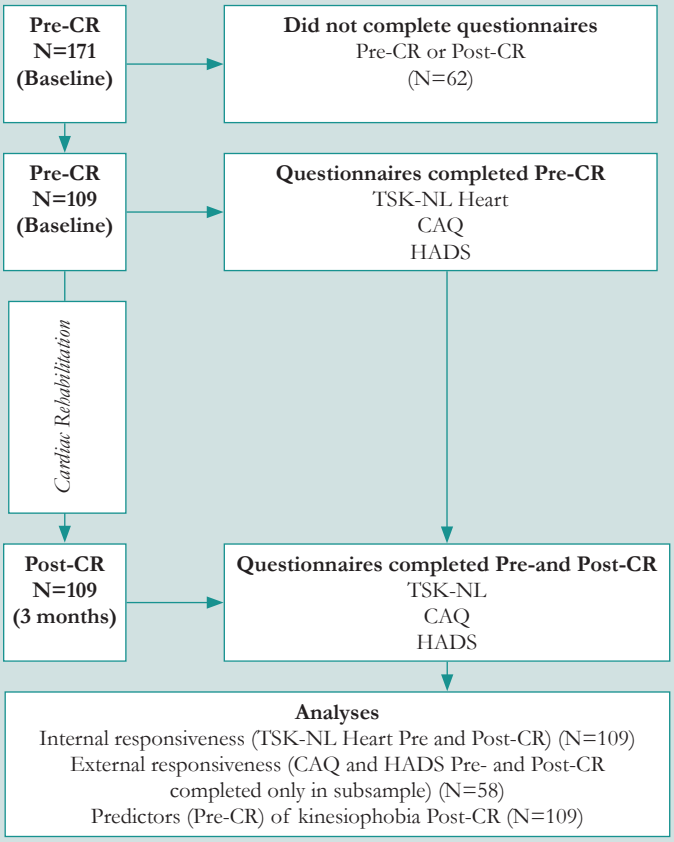

Figure 1. Flowchart of study

Table 1. Baseline Characteristics of patients included for analysis (n=109)

Characteristics	Included
Male, n (%)	83 (76.1%)
Age, years, mean (SD)	61.1 (11.6)
Referral admission, n (%)	
Acute	57 (52.3%)
STEMI	22 (20.2%)
NSTEMI	21 (19.3%)
Unstable AP	1 (0.9%)
Ventricular tachycardia with ICD	2 (1.8%)
Ventricular tachycardia without ICD	2 (1.8%)
Supraventricular tachycardia AF	5 (4.6%)
Supraventricular tachycardia atrial flutter	1 (0.9%)
Aspecific thoracic pain	3 (2.8%)
Elective	52 (47.7%)
Stable AP	21 (19.3%)
Congenital heart disease	2 (1.8%)
Heart failure	9 (8.3%)
Valvular disease	18 (16.5%)
Aneurysm	2 (1.8%)
Referral procedure, n (%)	
medication only	19 (17.6%)
interventional	53 (49.1%)
surgical	36 (33.3%)
Cardiac history, n (%)	26 (23.9%)
Comorbidities	
Stroke	2 (1.8%)
TIA	4 (3.7%)
COPD	9 (8.3%)
OSAS	7 (6.4%)
Rheumatic disease	6 (5.5 %)
Musculoskeletal disorder	6 (5.5%)
Oncological disease	6 (5.5%)
Renal failure	3 (2.8%)
TSK-NL Heart score, median (IQR)	26 (11)
CAQ score, median (IQR)	23.5 (16.8)
HADS-A score, median (IQR)	5 (5.5)

STEMI= ST-Elevation Myocardial Infarction; NSTEMI= Non-ST-Elevation Myocardial Infarction; AP= Angina Pectoris; ICD= Internal Cardiac Defibrillator, AF= Atrial Fibrillation; TIA= Temporary Ischaemic Accident; COPD= Chronic Obstructive Pulmonary Disease; OSAS= Obstructive Sleep Apnoea Syndrome; TSK= Tampa Scale for Kinesiophobia; CAQ= Cardiac Anxiety Questionnaire; HADS-A= Hospital and Anxiety Questionnaire- Anxiety Scale

Responsiveness

The parametric and non-parametric distributions of the TSK-NL Heart were assessed prior to investigating the ES and SRM. Both the Paired samples t-test and Wilcoxon signed rank test yielded similar results (Paired samples t-test: mean (SD) TSK NL Heart: pre-CR: 26.11 (7.20) and post-CR: 24.03 (7.41) p <0.001) (Wilcoxon signed rank test: Median (IQR) TSK NL Heart pre-CR: 26.0 (11) and post-CR: 23.0 (11) p<0.001), indicating that the assessment of ES and SRM is justified. Both the ES of the change score (0.29) and the SRM of the change score (0.37) were small. There was a moderate and significant correlation between change scores on the TSK-NL Heart and the CAQ (Rs=0.30, p=0.02). There was a poor and non-significant correlation between change scores on the TSK-NL Heart and the HADS-A (Rs=0.21, p=0.11). Based on the CAQ, 44 patients were classified as improved, while 13 patients did not improve (see **Table 2**). Both the ES and the SRM of the TSK-NL Heart change score were moderate for patients with an improved CAQ score (ES=0.52; SRM=0.57) and small for patients with no improvement (ES=0; SRM=0). Based on the HADS-A, 29 patients were classified as improved, while 29 patients did not improve (see **Table 2**). In line with the CAQ, both the SRM and the ES of TSK-NL Heart change score were moderate for patients with an improved HADS-A score (ES=0.54; SRM=0.60) and small for patients that did not improve (ES=0.26; SRM=0.36).

Changes in kinesiophobia and predictors for high levels of kinesiophobia post-CR

Since moderate ES and SRM values were found in the subsample that improved on the external measures, we determined the responsiveness of the TSK-NL Heart to be reasonable and we proceeded with our secondary aims. Total score on the TSK-NL Heart improved from a median score (IQR) of 26.0 (11.0) pre-CR to 23.0 (11.0) post-CR (p< 0.001) (**Figure 2**, **Table 2**). A total of 31.2% of patients showed an improvement of at least 5 points on the TSK-NL Heart. Prevalence of a high level of kinesiophobia (TSK-NL Heart score ≥29) was seen in 40.4% pre-CR and improved to 25.7% post-CR (p=0.004).

Patients with a high level of kinesiophobia pre-CR were more likely to have high levels of kinesiophobia post-CR (OR= 9.83, 95% CI=3.52-27.46). Additional univariate regression analyses revealed that the odds of having high kinesiophobia levels post-CR were also higher when having a higher baseline score on the CAQ (OR=1.12, 95% CI=1.06-1.19) and HADS-A (OR=1.26, 95% CI=1.11-1.42). Furthermore, high scores pre-CR on all TSK subscales (reflecting beliefs that contribute to kinesiophobia) were related to high levels of kinesiophobia post-CR, especially pre-CR score on the subscale `Avoidance of PA' (OR = 1.95, 95% CI = 1.44 – 2.65). See **Table 3**.

Table 2. Responsiveness: effect size and standardized response mean (n=109)

Group of patients	Pre-CR TSK score median (IQR)	Post-CR TSK score median (IQR)	ΔTSK score median (IQR)	P-value*	Effect Size (ES)	Standardized response mean (SRM)
Internal responsiveness						
Total sample (n=109)	26.0 (11.0)	23.0 (11.0)	-2.0 (8.0)	<0.001	0.29	0.37
External responsiveness						
Total sample that completed CAQ (n=57)	25.0 (10.5)	23.0 (10.5)	-2.0 (7.0)	0.002	0.37	0.46
Improved on CAQ (n=44)	25.0 (10.0)	23.0 (10.5)	-4.0 (7.0)	0.001	0.52	0.57
Not improved on CAQ (n=13)	21.0 (15.0)	22.0 (16.0)	0.0 (4.0)	0.88	0	0
Total sample that completed HADS-A (n=58)	25.0 (10.5)	23.0 (10.3)	-2.5 (7.0)	0.001	0.39	0.48
Improved on HADS-A (n=29)	25.0 (10.0)	22.0 (9.5)	-4.0 (8.5)	0.005	0.54	0.60
Not improved on HADS-A (n=29)	22.0 (12.5)	24.0 (10.5)	-2.0 (6.5)	0.08	0.26	0.36

IQR=Interquartile Range; TSK= Tampa Scale for Kinesiophobia; CAQ= Cardiac Anxiety Questionnaire; HADS-A= Hospital and Anxiety Questionnaire-Anxiety Scale

*Wilcoxon signed rank test to compare pre-CR and post-CR TSK scores

Table 3. Univariate logistic regression analysis with high TSK-NL score post-CR as dependent variable (n=109).

Predictor	Low TSK score (<29), n=81	High TSK score (≥29), n=28	OR high TSK score post-CR	95% CI	P-value
sex, n (%)					
male	61 (75.3%)	22 (78.6%)	*ref*		
female	20 (24.7%)	6 (21.4%)	0.83	0.30-2.35	0.73
Age, mean (SD)	61.7 (11.6)	59.3 (11.6)	0.98	0.95-1.02	0.35
Admission, n (%)					
elective	38 (46.9%)	14 (50%)	*ref*		
acute	43 (53.1%)	14 (50%)	0.88	0.37-2.09	0.78
Procedure, n (%)					
medication	13 (16.1%)	6 (22.2%)	*ref*		
surgical	29 (35.8%)	7 (25.9%)	0.52	0.15-1.87	0.32
interventional	39 (48.1%)	14 (51.9%)	0.78	0.25-2.44	0.67
High TSK score pre-CR, n (%)					
low	59 (72.8%)	6 (21.4%)	*ref*		
high	22 (27.2%)	22 (78.6%)	9.83	3.52-27.46	<0.001
TSK total score Pre-CR, median (IQR)	23.0 (10.0)	32.0 (7.7)	1.24	1.13-1.36	<0.001
TSK Fear of injury Pre-CR, median (IQR)	15.0 (8.0)	21.5 (5.0)	1.28	1.14-1.44	<0.001
TSK Perception of risk-Pre CR, median (IQR)	4.0 (2.0)	5.0 (2.0)	1.82	1.23-2.70	0.003
TSK Avoidance of PA-Pre-CR, median (IQR)	5.0 (3.0)	6.5 (2.0)	1.95	1.44-2.65	<0.001
CAQ score pre-CR, median (IQR)[1]	21.0 (16.0)	32.5 (15.5)	1.12	1.06-1.19	<0.001
HADS-A score pre-CR, median (IQR)[2]	3.0 (3.0)	7.5 (4.5)	1.26	1.11-1.42	<0.001

1Data missing for n=13; 2Data missing for n=12
SD=Standard Deviation; IQR=Interquartile Range; TSK= Tampa Scale for Kinesiophobia; PA = physical activity, CAQ= Cardiac Anxiety Questionnaire; HADS= Hospital and Anxiety Scale

Histogram High levels of kinesiophobia (TSK-NL Heart) Pre-CR and Post-CR (Chi square test).

Amplitude Probility Distribution Function (APDF) of HADS-A, TSK-NL Heart and CAQ sumscores Pre-CR and Post-CR (Wilcoxon signed rank test).

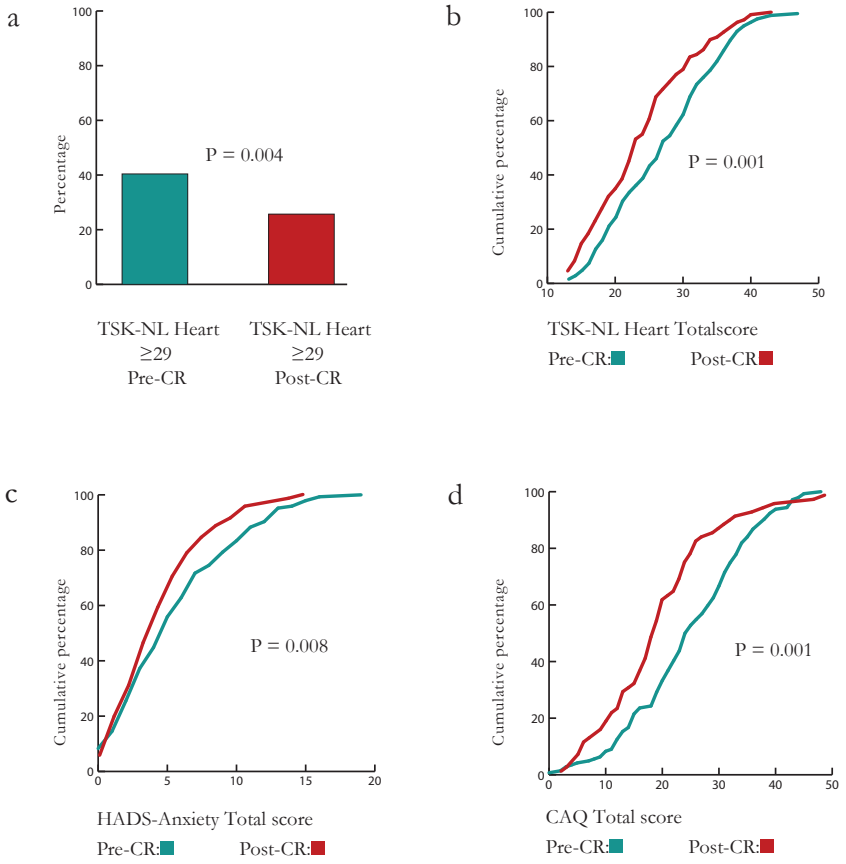

Figure 2. Total scores TSK-NL Heart, HADS-A and CAQ.

DISCUSSION

In line with our hypothesis, small ES and SRM values were found for the TSK-NL Heart change scores in our full study population and higher (moderate) ES and SRM values in a subsample of patients that showed improvements on the external measures. These results suggest that the TSK-NL Heart has reasonable responsiveness in patients completing CR. Our outcomes reveal that at the start of CR, 40% of patients had high levels of kinesiophobia, which decreased to 26% post-CR.

The original TSK was developed for patients with low back pain (8, 20, 22, 23, 24). Internal responsiveness in our full study population (ES: 0.29; SRM :0.37) was low when compared to that in patients with chronic low back pain participating in a rehabilitation program (ES 1.36; SRM 1.49) (8). Values of the ES and SRM depend on the expected magnitude of the treatment effect. Despite the fact that targeting kinesiophobia is an objective of CR, no specific treatment strategies for kinesiophobia are currently used in CR. In addition, only a subsample of patients that enter CR have high levels of kinesiophobia (3). Therefore, substantial reductions in TSK-NL Heart scores are not expected for the whole population. Consequently, low ES and SRM were anticipated. By including this heterogeneous population, we were able to determine whether the TSK-NL heart is able to distinguish between subgroups of patients that do or do not show changes in kinesiophobia. We did indeed find that ES and SRM values improved from small to moderate for patients that improved on the CAQ and for patients that improved on the HADS-A as compared to patients that did not improve on these external measures. Furthermore, a moderate significant correlation was found between the change scores on the TSK-NL Heart and CAQ while the correlation between the change scores on the TSK-NL Heart and the HADS-A was non-significant. An explanation for this finding might be that the TSK-NL Heart and CAQ both measure specific cardiac related fear while the HADS-A measures generic anxiety.

Overall, our outcomes indicate that the TSK-NL Heart has moderate responsiveness. We recommend further research into the responsiveness of the TSK-NL Heart in larger sample sizes using anchor-based methods to confirm our results. Using anchor-based methods also allows for research into the minimal clinical important change (MCIC). The MCIC cannot be determined with a construct approach as used in our study. Therefore, it can be debated whether the improvement of 2 points we found on the TSK-NL Heart score is clinically relevant. Nevertheless, 31% of patients showed an improvement of at least 5 points on the TSK-NL Heart, which was previously suggested to be a clinically relevant change in other patient populations (8, 20). Furthermore, an improvement was seen in percentage of patients scoring above the threshold for high kinesiophobia scores from 40% till 26%. This together indicates that relevant improvements are made during CR.

Regardless of attendance to CR, a large number of patients (26%) still had

high levels of kinesiophobia on the long term. Before designing interventions, it is of value to understand which patients should be targeted. The results of our univariate logistic regression analysis with a limited number of baseline characteristics suggest that high kinesiophobia scores post-CR are independent of sex, age, diagnosis (acute vs elective) and type of intervention, but may be predicted by high kinesiophobia and generic anxiety scores at start of CR. In line with our findings, a high level of generic anxiety (HADS-A) has been shown to be a predictor for kinesiophobia in a previous study with patients with CVD(2), while sex and medical background did not predict kinesiophobia (25, 26). In addition, our results also show that high scores on the sub-scales of the TSK-NL Heart were all predictive of high levels of kinesiophobia post-CR. Especially high scores on the subscale `avoidance of PA' increased the risk for high levels of kinesiophobia post-CR. A recent qualitative study shows that avoidance of PA is often the result of negative beliefs and attitudes towards PA (27).

Outcomes of our study can assist clinicians in determining who could potentially benefit from additional interventions and can also help in designing these interventions. Nevertheless, before these interventions are developed, future studies should first investigate how kinesiophobia relates to PA in cardiac patients. Furthermore, future studies should investigate a larger set of potential predictors (e.g. time since cardiac event and specific diagnosis categories) in a larger study population.

Limitations

To our knowledge this is the first study evaluating the responsiveness of the TSK for cardiac patients. Nevertheless, some aspects of our study warrant consideration. First, patients who were excluded from the current analysis (patients that did not complete the TSK-NL Heart post-CR) had lower TSK-NL Heart scores, which might limit generalizability. Although we could no investigate reasons for not completing the questionnaire, we hypothesize that this was mainly due to not completing the CR program. This suggests that patients with higher kinesiophobia levels might quit CR prematurely more often than patients with lower levels. Second, univariate logistic regression analyses were used to assess a limited number of demographic and clinical variables as predictors of kinesiophobia post-CR. The results of this analysis should be interpreted with caution as our sample size was restricted. Nevertheless, both the external anxiety measures and the kinesiophobia score at start of CR all significantly predict high levels of kinesiophobia post CR at the level of $p<0.001$. Finally, we did not include a control group of patients not participating in CR. Therefore, caution is required when attributing the improvements that we found in kinesiophobia to CR.

CONCLUSION

Our outcomes indicate that, in patients attending CR, the TSK-NL Heart has moderate responsiveness and can be seen as a candidate measurement tool to evaluate changes in kinesiophobia. In addition, outcomes demonstrate improvements in kinesiophobia levels after completion of CR. Nevertheless, a considerable proportion of patients (26%) retain high levels of kinesiophobia after completion of CR, warranting further investigations and the development of treatment strategies.

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APPENDIX 1: COSMIN CRITERIA RESPONSIVENESS BOX B

Design requirements	Very good	Adequate	Doubtful	Inadequate
1. Formulate hypotheses about expected relationships between the change scores on the PROM under study and (change scores on) other outcome measurement	**Hypotheses will be formulated including the expected direction and magnitude of the correlations stated**		Hypotheses vague or will not be formulated but possible to deduce what was expected	Unclear what is expected
2. Provide a clear description of the construct(s) measured by the comparator instrument(s)	**Constructs measured by the comparator instrument(s) is/are clearly described**		Constructs measured by the comparator instrument(s) is/ are not clearly described	
3. Provide information that the measurement properties of the comparator instrument(s) are sufficient	**Sufficient measurement properties of the comparator instrument(s) in a population similar to the study population**	Sufficient measurement properties of the comparator instrument(s) but not sure if these apply to the study population	Some information on measurement properties (or a reference to a study on measurement properties) of the comparator instrument(s) in any study population	No information on the measurement properties of the comparator instrument(s), or evidence of insufficient measurement properties of the comparator
4. Use an appropriate time schedule for assessments of PROM of interest and comparison instruments	**PROM and comparison instrument will be administered at the same time at all occasions**	PROM and comparison instrument not administered at the same time, but assumable that patient will not change in the interim period at all occasions	PROM and comparison instrument will not be administered at the same time, but unclear if patients will changed	PROM and comparison instrument will not be administered at the same time, and patients are expected to change
5. Use an appropriate time interval between first and second measurements	**Time interval appropriate**			Time interval NOT appropriate

Design requirements	Very good	Adequate	Doubtful	Inadequate
6. Describe anything likely to occur in the interim period (e.g. intervention, other relevant events)	**Anything likely to occur during the interim period (e.g. treatment) is adequately described**		Unclear or NOT described what will likely to occur during the interim period	
7. Ensure that a proportion of the patients is likely to change (i.e. improvement or deterioration) on the construct to be measured	**Part of the patients is likely to change (evidence provided)**	NO evidence provided, but assumable that part of the patients will change	Unclear if part of the patients will change	Patients will likely NOT change
8. Perform the analysis in a sample with an appropriate number of patients (taking into account expected number of missing values)	**≥100 patients**	**50-99 patients**	30-49 patients	<30 patients
Statistical methods	**Very good**	**Adequate**	**Doubtful**	**Inadequate**
9. Ensure that the statistical methods are adequate for the hypotheses to be tested	**Statistical methods are appropriate**	Assumable that statistical methods are appropriate	Statistical methods are not optimal	Statistical methods are NOT appropriate
10. Provide a clear description of how missing items will be handled	**The way missing items will be handled is clearly described**		The way missing items will be handled is not clearly described	

Results of this study presented in bold.

PART 2

The course of kinesiophobia in patients with cardiovascular disease

Chapter 4

Factors related to fear of movement after acute cardiac hospitalization

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ABSTRACT

Background: Fear of movement (kinesiophobia) after an acute cardiac hospitalization (ACH) is associated with reduced physical activity (PA) and non-adherence to cardiac rehabilitation (CR). Purpose: To investigate which factors are related to kinesiophobia after an ACH, and to investigate the support needs of patients in relation to PA and the uptake of CR.

Methods: Patients were included two to three weeks after hospital discharge for ACH. The level of kinesiophobia was assessed with the Tampa Scale for Kinesiophobia (TSK-NL Heart). A score of >28 points is defined as `high levels of kinesiophobia' (HighKin) and ≤28 as `low levels of kinesiophobia' (LowKin). Patients were invited to participate in a semi-structured interview with the fear avoidance model (FAM) as theoretical framework. Interviews continued until data-saturation was reached. All interviews were analyzed with an inductive content analysis.

Results: Data-saturation was reached after 16 participants (median age 65) were included in this study after an ACH. HighKin were diagnosed in seven patients. HighKin were related to: 1) disrupted healthcare process, 2) negative beliefs and attitudes concerning PA. LowKin were related to: 1) understanding the necessity of PA, 2) experiencing social support. Patients formulated `tailored information and support from a health care provider' as most important need after hospital discharge.

Conclusion: This study adds to the knowledge of factors related to kinesiophobia and its influence on PA and the uptake of CR. These findings should be further validated in future studies and can be used to develop early interventions to prevent or treat kinesiophobia and stimulate the uptake of CR.

BACKGROUND

Anxiety after an acute cardiac hospitalization (ACH) is common. A recent study shows that 43% of patients suffer from anxiety at the time of ACH and 28% directly after ACH (1). Accumulating evidence suggests that anxiety is an important risk factor for fatal and non-fatal cardiac events (2-4).

Cardiac rehabilitation (CR) is the cornerstone of secondary prevention aimed at improving physical, psychological and social functioning (5). CR consists of multifactorial interventions such as physical activity counseling, exercise training, diet/nutritional counseling, risk factor control, patient education, psychosocial management and vocational advice (5).

Exercise training is a key element of CR and is defined as: '*a subset of physical activity that is planned, structured, and repetitive and has as a final or an intermediate objective the improvement or maintenance of physical fitness*' (6). Recent studies show that exercise based CR reduce cardiovascular mortality and hospital admissions and moreover improve quality of life and psychological wellbeing (7, 8). In addition, participation in exercise based CR increases daily physical activity in patients that suffered myocardial infarction (9). Physical activity is defined as '*any bodily movement produced by skeletal muscles that results in energy expenditure*' (6). During physical activity counseling, patients are encouraged to accumulate 30 to 60 minutes of moderate-intensity physical activity per day on at least 5 days of the week (9).

Despite its well know benefits, only 17% of patients perform the recommended amount of PA (10). A potential explanation for these low PA levels, among other factors, might be anxiety experienced by patients after ACH (11). Specifically, fear of movement (kinesiophobia) might be an important barrier to achieve adequate PA levels (12).

Kinesiophobia is described as an irrational, debilitating fear of movement and is explained by the fear avoidance model (FAM) (13). The FAM is a biobehavioral model that describes how individuals develop chronic musculoskeletal pain (CMP) as a result of avoidance behavior based on pain related fear (13). A recent systematic review reports that high levels of kinesiophobia (HighKin) in patients with CMP are associated with greater levels of pain intensity, disability and low quality of life (14). In patients with coronary artery disease (CAD) HighKin are reported in 20% of the patients and are associated with decreased health-related quality of life, decreased muscle strength and reduced levels of PA (15). In addition, patients with HighKin participate to a lesser extend in CR programs than those with low levels of kinesiophobia (LowKin) (16). Avoidance of PA is an important predictor of major adverse cardiac events and should thus be targeted (4).

Exposure based rehabilitation programs, in which patients are gradually exposed to PA, are effective in patients with CMP (17, 18). The setting of CR might potentially also reduce or prevent kinesiophobia after ACH by gradually exposing patients to PA (19, 20). Participation in CR is therefore strongly recommended

after ACH, especially for those with HighKin or high levels of anxiety (20, 21). However, patients are often discharged within a short time frame which leaves little time for psychological support and patient education on the importance of CR (22).

It is unclear which factors are related to kinesiophobia, which in turn might lead to non-adherence to CR. In addition, little is known about the support needs of patients and their informal caregiver, with regards to PA and the uptake of CR. Insight in these factors might result in the development of early interventions to target or prevent kinesiophobia and to stimulate PA and the uptake of CR.

The aims of this study were therefore to explore 1) which factors are related to kinesiophobia after an ACH 2) the support needs of patients and their informal caregivers with regard to PA and the uptake of CR after ACH.

METHODS

Design

In this qualitative study we performed semi-structured interviews with patients that were discharged after an acute cardiac event. For this study we used the COREQ checklist to assure methodological quality (23). Recruitment of participants ended when data-saturation was reached. The Medical Ethics Committee of the Amsterdam University Medical Center approved the study protocol (protocol number: NL65218.018.18).

Participants

Patients were enrolled in this study at hospital discharge at the Amsterdam University Medical Centre between January 2019 and July 2019. To obtain a wide variety of viewpoints, patients were included via a purposeful sampling strategy (24). Patients were excluded if they: (a) had cognitive problems (MMSE <24), (b) were unable to speak Dutch or, (c) were transferred to a nursing home.

Materials

The interview guide was developed for this study and is based on the FAM which is the theoretical model for kinesiophobia (13). The interview guide was tested in a panel, in two rounds, that individually read the interview guide and gave feedback on the first version. Afterwards the final version of the interview guide was created. The panel consisted of a patient, a physical therapist, a cardiac nurse, a psychologist and a cardiologist. The interview guide can be found in **appendix 1**.

Procedures

Patients were asked to fill in an informed consent form at hospital discharge. Patients that agreed to participate in this study were contacted by telephone two to three weeks after hospital discharge to arrange an interview at home or at

the outpatient clinic. Prior to the start of the interview, the participant's level of kinesiophobia was assessed with the Tampa Scale for Kinesiophobia (TSK-NL Heart). The TSK-NL Heart consists of 13 questions with a four-point answer scale with a minimum score of 13 and maximum score of 52 points. A score of >28 is an indication of high levels of kinesiophobia (25). This cut off score was used to divide the patients into two groups, a `low level of kinesiophobia' group (LowKin) and a `high level of kinesiophobia' group (HighKin). The TSK is validated in various groups of patients (26). After the TSK-NL Heart was completed by the participant, the patient's informal caregiver was invited to participate in the interview and to share their perspective. Each interview was recorded with a digital voice recorder. Four interviewers conducted the interviews in pairs, the first author (PK), a researcher (IvD), and two assistant researchers (AvP and DR), all trained by a researcher with extensive experience in conducting semi-structured interviews (CL).

Data analysis

For this study an inductive content analysis was used since little information about the phenomenon exists (27). Each interview was transcribed by one of the interviewers. All interviews were assessed by PK and IvD. On the basis of this preliminary analysis the researchers independently assessed if new information was obtained or data saturation was reached. The transcripts were analyzed with software for qualitative data analysis (MAXQDA). A sequential coding strategy was used to analyze the transcripts. Three types of coding were used consecutively: open, axial and selective coding (27). Initial codes were created by studying the segmented information. Afterwards, the codes were abstracted into categories and subcategories. The underlying meaning of these categories were linked together to create overall themes. All data were independently coded for categories, subcategories and themes by two researchers (PK, IvD). A third researcher (CL) reviewed all codes and decided, together with PK and IvD, which themes were the most appropriate.

RESULTS

Data-saturation was achieved after a total of 16 patients were included in this study (**table 1**), of which seven patients had high levels of kinesiophobia (**figure 1**). In six cases an informal caregiver (five spouses, one sibling) was present during the interview.

Table 1. Baseline characteristics

	Sex	Age range (years)	Cardiovascular diagnosis	Intervention	Cardiac disease history	Co-morbidity
Baseline Characteristics (n=16)						
1	Male	60-69	NSTEMI	PCI	Stroke, hypertension	HIV
2	Female	60-69	AF	ECV	Hypertension	Lynch syndrome Colon carcinoma
3	Female	70-79	STEMI	PCI	Hypertension Hypercholesterolemia	Hypothyroid
4	Male	80-89	NSTEMI	PCI	AF	-
5	Male	70-79	AF	ECV	Stroke	-
6	Male	70-79	NSTEMI	PCI	Hypertension Hypercholesterolemia	Urothelial Carcinoma
7	Male	50-59	STEMI	PCI	Hypertension Hypercholesterolemia	
8	Male	40-49	AF	ECV	Morbus Epstein	-
9	Male	60-69	STEMI	PCI	-	-
10	Female	70-79	AF	ECV	Stroke	Hypothyroid Cholelithiasis
11	Female	50-59	STEMI	PCI	-	-
12	Male	60-69	NSTEMI	PCI	Diabetes Mellitus Hypertension OSAS	Respiratory infection
13	Female	50-59	STEMI	PCI	Hypertension Hyperglycemia	
14	Female	70-79	AHF/AF	ECV	AF Mitral insufficiency	Depression Alcohol abuse
15	Male	60-69	AHF/AF	ECV	Myocardial infarction Hypercholesterolemia Diabetes mellitus	Arthritis Lung carcinoma COPD

Table 1. *Continued*

	Sex	Age range (years)	Cardiovascular diagnosis	Intervention	Cardiac disease history	Co-morbidity
16	Male	40-49	AF	ECV	Myocardial infarction Hypercholesterolemia	
TSK-NL Heart (13-52)						
TSK-NL Heart, median (min-max)	26 (20-45)					

Abbreviations: STEMI (ST-Elevation Myocardial Infarction), NSTEMI (Non-ST-Elevation Myocardial Infarction), PCI (Percutaneous Coronary Intervention), AF (Atrial Fibrillation), Acute Heart Failure (AHF), ECV (Electro Cardioversion),OSAS (Obstructive Sleep Apnea Syndrome), HIV (Human Immunodeficiency Virus), COPD (Chronic Obstructive Pulmonary Disease).

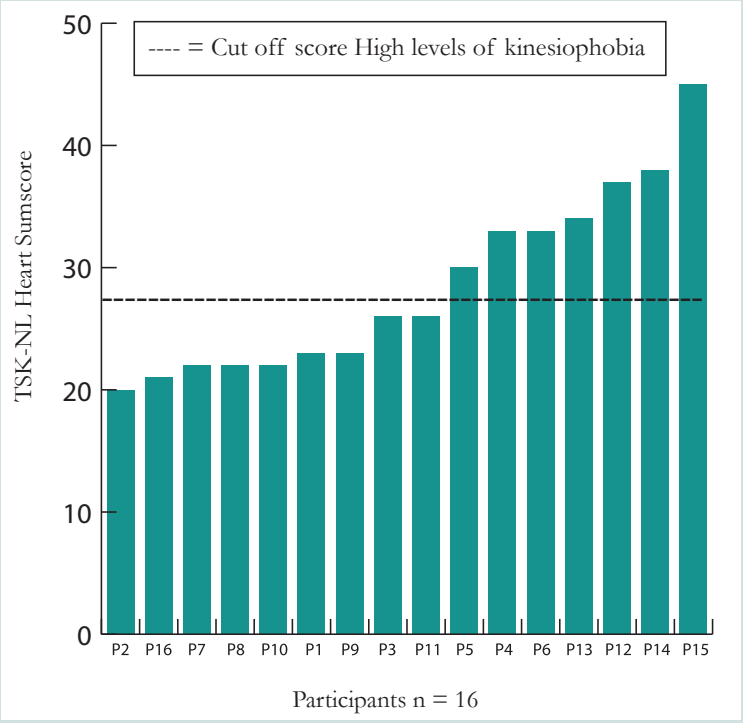

Figure 1. Baseline kinesiophobia scores

Data were analyzed after the groups were divided into patients with HighKin and LowKin. Two themes were extracted that were related to HighKin: 1. Disrupted health care process and 2. Negative beliefs and attitude concerning physical activity. Two subsequent themes were related to LowKin: 1. Understanding necessity of physical activity after ACH, 2. Experiencing social support. One overall theme was related to support needs of patients and was defined as: Tailored information and support from health care professional. All themes and subcategories are presented in **table 2**.

Table 2. Identification of themes

Themes	Categories	Sub-categories
Factors related to kinesiophobia		
Disrupted health care process	Negative experience health care system	Reluctancy hospital
		Losing faith in the hospital
		Feeling isolated during stay
		Long waiting time for cardiac rehabilitation
		Referral problems cardiac rehabilitation
	Inconsistent information at hospital discharge	Building up Physical activity
		Cardiac event/intervention
		Side effects medication
		Impact words physician
Negative beliefs and attitudes concerning physical activity	Body signals during physical activity	Chest pain/dyspnea
		Prior experience/hypervigilance
		Side effects medication
		Serious vs innocent
		Fear of injury
		Distrusting the body
	Passive coping style	Avoidance of PA
		Preventing physical activity patient
		Hypervigilance (informal caregiver)
Factors related to low or no kinesiophobia		
Understanding necessity of physical activity after ACH	Previous experience serious illness	Appreciation of the value of physical activity
		Controlling co-morbidity with physical activity
		Illness spouse
	Receiving and understanding information	Health literacy
		Correct attribution body signals
	Positive experience with exercise and physical activity	Feeling healthy
Experiencing support	Social support network	Sharing stories with fellow cardiac patients
		Graded exposure to PA with informal caregiver

Table 2. *Continued*

Support needs		
Tailored information and support	**Themes**	**Categories**
	Consistent information	Physical activity
		Cardiac event/intervention
		Side effects medication
	Guidance health care professional	Reassurance / trusting health care professional
		Developing an active lifestyle.
		Building up physical activity
		Stimulating self-efficacy

Based on our findings we adjusted the `fear avoidance model' for patients that suffered an ACH (see **Figure 2**).

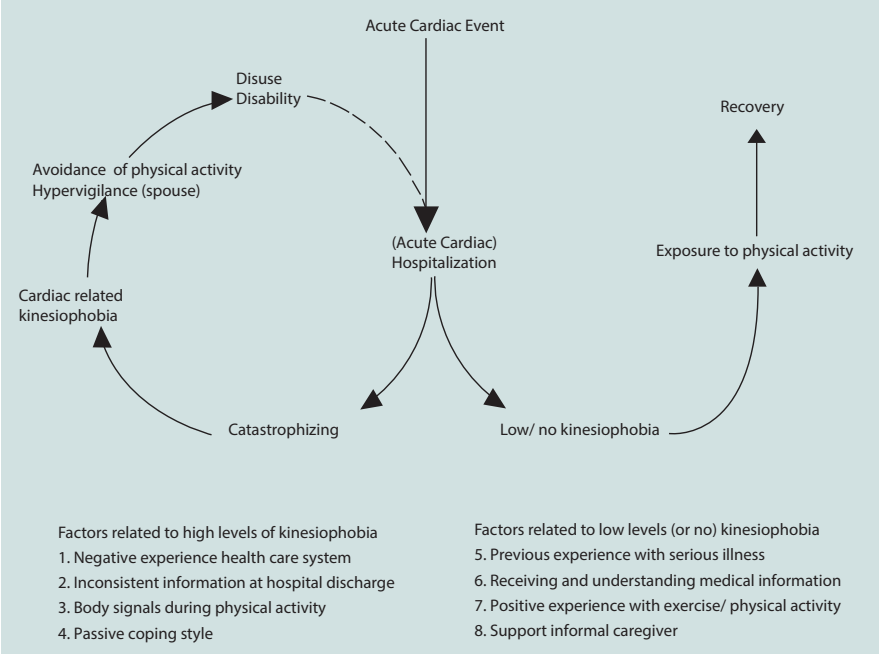

Figure 2. Fear avoidance model for Acute Cardiac Hospitalization

Factors related to high levels of kinesiophobia after an ACH

Theme 1: Disrupted health care process

Negative experience health care system

Patients with HighKin reported more negative experiences with the health care system than those LowKin. Several patients that were admitted to the cardiology ward experienced a lack of attention from the medical staff while still feeling vulnerable and anxious after their cardiac event.

> *'I was left alone in a bed and did not see anyone during my stay at the nursing ward. There was no one that came to me to ask me how I was doing and if I was afraid. Just some human contact would make it so much better' (P13).*

In the weeks after hospital discharge, patients stated they missed information about their health condition, building up PA, and wanted to be in contact with a health care professional to be reassured. Several patients reported that the interval between hospital discharge and cardiac rehabilitation was too long which resulted in insecurity about their condition.

> *'Four weeks is quite long while waiting for cardiac rehabilitation' (P13).*

In addition, the referral process from the hospital to CR was often unclear for patients.

> *'The referral to CR went completely wrong. It took ages before it was clear where I needed to go and what was expected. Thinking about this makes me short of breath again' (P6).*

Inconsistent information at hospital discharge

Not receiving any, or inconsistent, information made patients feel insecure about performing and building up PA in daily life. Health care providers were often unclear in communicating about the amount of PA that the patient could do after hospital discharge.

> *'They did not gave me any information about what I could and could not do, looking back I find this very bad' (P6).*

In addition, patients described that they lacked knowledge on how the body and the heart worked and what type of intervention was given to them. A lack of knowledge about building up PA and the type of intervention made patients feel insecure about performing PA as they were afraid it might lead to injury.

> *'Someone told me that a stent can shift within the artery, if I'm not feeling well, I think about this' (P13).*

Furthermore, little information about side effects of medication was provided. Severe bodily reactions, caused by side effects of medication, made patients cautious about PA and in some cases led to avoidance of PA.

> *'At hospital discharge the physician gave me a whole list with medication and then said I*

could go home, that's all he said, this made me insecure' (P13.)

In addition to clear and consistent information, patients also wanted to be reassured by their physician before leaving the hospital.

'I really missed talking to my physician about what had happened to my heart before I left the hospital' (P14).

Physician's words were found to influence patients' beliefs about their physical state and thereby also the amount of PA they could perform in daily life.

'The doctor told me to keep calm, keep calm, keep calm, this just goes through my head the whole time' (P12).

Theme 2: Negative beliefs and attitude concerning physical activity

Distressing body signals during physical activity

Body signals such as: chest pain, dyspnea, pain in the jaw and extreme fatigue, were often experienced as distressing and made patients fearful about PA.

In some cases, these body signals were caused by side effects of medication.

'I felt a weird pressure on my chest, like my heart skipped a beat. I panicked, so I went back to the emergency room where they examined me. Afterwards they told me it was a side effect of metropolol' (P13).

Experiencing severe bodily signals made patients alert and in some cases hypervigilant.

'If my heart skips a beat, I don't do anything, I'm really anxious to become short of breath' (P15).

It was difficult for patients to discriminate between serious and innocent body signals. Patients described that they often felt like they were experiencing a new cardiac event and did not know how to interpret their body signals.

'I don't have to do anything, if I just breath in a certain way it feels like it can go wrong again' (P14).

'Sometimes I feel a slight sting in my chest and I don't know what to do' (P13).

Participants stated that they were afraid that PA could harm their body. As a consequence, these participants often distrusted their body and performed little PA.

'I don't know if my heart is damaged and what I can and cannot do' (P6).

Passive coping style

Due to the impact of the event, several patients developed a passive coping style and avoided PA.

> *'I did not do anything for six weeks, I'm just staying in bed and on the couch, I can't do much more' (P12).*

P14 stated that she did want to do any PA, even when her partner asked her to join him.

> *'Daily, my husband asks me if I will join him for a walk, every day I decline, I know physical activity is healthy, but I just don't do it, I was never a sporty type' (P14).*

In addition, P14 stated that participating in CR did not work for her.

> *'Talking about developing an active lifestyle, three years ago i participated in CR and I talked to a psychologist, but these tricks do not work for me' (P14).*

Several informal caregivers became hypervigilant which resulted in withholding patients from any household tasks or other forms of PA.

> *'If I do too much and I get complaints, my husband becomes angry and tells me to sit down.' (P13).*

> *'My husband does all the groceries and cooking and tells me to relax' (P14).*

Patients with HighKin often avoided PA and developed a passive coping style. In several cases, this maladaptive coping style was facilitated by the informal caregiver as a result of hypervigilance.

ADDITIONAL RESULTS

Although, two patients, P3 and P11 respectfully, were classified as patients with LowKin their quotes expressed signs of HighKin.

Negative experience health care system

P11 reported that the hospital was reluctant with admitting her to the emergency room as it was suspected that her complaints were non-specific. After the general practitioner insisted an immediate admission to the cardiac care unit, she was diagnosed with a NSTEMI.

> *'The interventional cardiologist said afterwards that it was good I listened to my body' (P11).*

Due to this incident, the patient stated she lost trust in her body and eventually became hypervigilant about body signals.

Inconsistent information at hospital discharge

In addition P11 reported to miss information which made her insecure about suffering another cardiac event.

'They didn't tell me anything at the hospital and it passed by so quick. Who says I won't suffer another myocardial infarction?' (P11).

P11 also reported that she suffered from side effects of the statins which impacted her ability to move.

'I missed information about medication and side effects'. At first, I felt better than after my myocardial infarction, until the statins began to work. I sat on the couch like a dead bird, muscle ache everywhere and unable to move' (P11).

P3 reported that she did not know if physical activity would injure her body.

'I don't know what I can and cannot do and if I injure my body if I do any physical activity' (P3).

'What is my heart able to handle? Not knowing this, is very annoying' (P3).

P3 also reported that the information about PA, provided at the hospital, was unclear.

'What does it mean to take it easy? The doctor told me I could do the same amount of physical activity as before the event, but it's still unclear how much I can do, I should have asked (P3).

Distressing body signals during physical activity
P11 stated that experiencing body signals made her anxious.

'And when I am sitting on the couch, or walking around, I feel every sting. That frightens me' (P11).

In addition, P11 also stated that it was difficult to discriminate between body signals.

'How can I determine the severity of my body signals?' (P3).

'I don't know what I can do and cannot do and if I injure my body if I do any physical activity, my heart suffered a big blow and even though I do not feel this every second, I do know it, you never know what may happen next'. (P3).

Factors related to low levels of kinesiophobia after an ACH.
Theme 1: Understanding necessity of physical activity after ACH
Previous experience with recurrent (serious) illness
Patients with LowKin often stated that they were not afraid to move due to previous hospital admissions or co-morbidity.

'I'm not afraid to move, I just can't keep my balance when I'm walking due to the stroke I have suffered. Before my stroke I was very active, but now I'm just so tired' (P10).

'I've had more than twenty cardioversions already, I know how it works, I won't let it rule my life' (P8).

Some patients reported to have comorbidities that required physical activity to control it.

'I have to do exercise in order to control my diabetes'. (P9).

Prior experience with being admitted to the hospital was related to LowKin. In addition, having a co-morbidity that required exercise, motivated patients to be physically active or perform exercise, which in turn might have prevented the occurrence of kinesiophobia.

Receiving and understanding medical information

Patients with LowKin reported that they received consistent information from their physician and felt that the physician took the time to answer their questions which made them feel reassured.

'I was really relieved that he said there was no acute danger and that I could do whatever I wanted, he really asked me a lot of things and I felt he really listened to me' (P2).

Side effects of medication often caused unpleasant body signals. Patients with LowKin were more inclined to attribute unpleasant body signals to side effects of medication than to a new cardiac event.

'The prescription said that these pills could cause pain under the sternum, so whenever I feel a pain in my chest, I say it's due to a side effect of my medication' (P2).

Giving time to patients to ask questions and providing clear and consistent information made patients feel more confident about performing PA. Besides talking to a physician, these patients also felt reassured by reading information about side effects of their medication. Being able to read and understand medical information and correctly interpreting body signals related to side effects might lead to LowKin.

Positive experience with exercise

Most patients with LowKin had a positive experience with exercise and were thus more inclined to do exercise despite their ACH.

'I always feel better when I return home after doing exercise' (P2).

'When I am playing volleyball I completely forget everything else' (P8).

Some patients already participated in CR and were looking forward to participating again since CR was a positive experience for them.

'After my previous cardiac event I immediately wanted to start training just to feel better, I can't wait for it' (P7).

Theme 2: Experiencing support

Social support

Patients with LowKin felt supported by talking to people that went through comparable experiences.

> *'It's not just about the rehabilitation but it's also about drinking coffee together and sharing experiences, that also helps me' (P9).*

These patients also felt supported by their informal caregiver that helped them building up PA levels.

> *'Last weekend I went for a walk with my neighbor. I was a bit anxious so we walked for a short while and that felt good. She really helped me through' (P2).*

Support needs in patients and spouses with regards to kinesiophobia and participation in CR

Patients, both with HighKin and LowKin, and spouses were asked what they needed in order to increase PA levels and participate in CR after an ACH.

Theme: Tailored information and support from health care professional

Receiving consistent information

Patients stated that they wanted more detailed information about PA during hospital discharge.

> *'I just want some simple information about what I can and cannot do, can I walk the stairs? Can I drive my car?' (P11).*

Patients also wanted to learn more about the side effects of certain types of medication since this caused distressing body signals which in turn led to avoidance of PA.

> *'I would like to know why I have to take those pills, I had lots of side effects'. (P12).*

Furthermore, patients wanted more background information about their cardiac event and the intervention they received.

> *'It's not a small thing, having a heart attack. In the hospital you don't know what's going on and when you leave you still don't know' (P11).*

For several patients it was unclear what to expect from CR. They had many questions about the aim of CR and did not know what to expect.

> *What is there to rehabilitate about the heart?' (P3).*

Guidance health care professional

Patients wanted to be reassured by a physician, before they started increasing their PA levels, as they often felt insecure about their heart. Some patients said they would be more confident if they would be monitored continuously.

> *'It would be great if there would be someone next to you all the time to make an ECG and tell you nothing is wrong (P3)'.*

In addition, patients said they wanted to be reassured about their physical state by talking to their physician.

> *'Certain things I would like to have re-confirmed' (P14)*

Trust in health care professionals was noted as an important prerequisite to perform more PA.

> *'Trusting caregivers, cardiologist, nurse practitioners, physiotherapists is really important' (P3).*

Patients stated that they want to be confident enough to perform daily PA.

> *'I want be confident again that I don't injure myself, by walking stairs or walking for miles' (P3).*

It was also reported by patients that they wanted to be able to gain confidence and do exercise by themselves.

> *'I want to participate in CR to gain confidence so that afterwards I can start exercising alone' (P7).*

In the period before cardiac rehabilitation, patients stated that they felt anxious about doing PA without the guidance from a physical therapist.

> *'I would feel anxious if I started exercising without guidance. It's about confidence. I can do it, but it would not feel right' (P7).*

Patients reported that they hoped cardiac rehabilitation would help them build up a more active lifestyle.

> *'I hope that I will benefit from cardiac rehabilitation and that afterwards I will be able to take the bike instead of the car to do my groceries' (P6).*

One patients chose to build up PA by herself and stated that she wanted more information about the type of exercises that were recommended.

> *'Should I do interval training or focus more on strength training' (P2).*

DISCUSSION

This study shows that HighKin are related to a disrupted health care process and negative beliefs and attitude concerning physical activity. LowKin after an ACH are related to understanding the necessity of physical activity and experiencing support. Patients in both groups (HighKin and LowKin) stated that they needed tailored information and support from a health care provider after hospital discharge.

Some patients and informal caregivers reported a negative experience with the health care system after their hospital admission was denied due to hospital crowding. In some cases, this resulted in significant stress in patients and informal caregivers. Previous studies have found that hospital crowding is related to lower patient satisfaction (28), patients not receiving the appropriate care (29) and complications during the hospital stay (30) which in turn can lead to HighKin (15). This finding emphasizes the need for greater attention to the negative psychological effects of hospital crowding on patients and informal caregivers. Other aspects related to HighKin are a long waiting time until CR or problems with referral to CR. Although current guidelines state that CR should start 28 days after the referral (42 days for CABG) (20), patients reported that time until the start of CR was too long which made them feel insecure about being physically active. Feeling anxious after a cardiac event is associated with delays in seeking medical help and the adoption of an unhealthy lifestyle (31) and might thus lead to delayed participation in CR which negatively impacts fitness outcomes of patients (32). A recent study shows that an active lifestyle (self-reported) at the hospital ward, after an ACS, is associated with reduced risk of new cardiac events. An early intervention (e.g. before discharge from hospital) that stimulates PA might potentially prevent kinesiophobia and the recurrence of cardiac events (33).

Experiencing a lack of consistent information at hospital discharge contributed HighKin since patients lacked knowledge about building up PA levels after an ACH. Not receiving information, especially about the safety of PA, is a well-known barrier for PA in patients with cardiovascular disease (34). When information is provided, it might lack clarity due to vague or inconsistent language. An example of vague information with respect to PA is the advice to `take it easy' or to `just do the same amount of PA as before the event'. This is an important finding since research shows that health care providers' orientations towards illness predicts perceived harmfulness of PA in patients (35). Therefore, health care providers must be as clear and consistent as possible when providing information on PA.

Patients often had difficulties in discriminating between `harmful' and `harmless' body signals, which were often caused by stress or side effects of medication. Before hospital discharge, patients should be educated on how to discriminate between body signals. Not being able to do this, might result in avoidance of PA and unnecessary hospital visits. Many patients in this study believed that PA could result in injury to their heart. In our previous study, we

validated the TSK-NL Heart questionnaire, and showed that `fear of injury' is the main factor in the construct `kinesiophobia' (25). Fear of injury after an acute cardiac event is normal and understandable. However, excessive fear of injury results in ineffective coping strategies, such as avoidance of PA, which might lead to further disability and possible secondary cardiac events (24). Patients with little understanding of pain mechanisms tend to perceive their body signals as more threatening or dangerous due to fear of injury, eventually leading to more catastrophic thoughts and less adaptive coping strategies (36). Insight in the origin of body signals and learning effective coping strategies might prevent avoidance behavior in patients after an ACH.

In several cases, informal caregivers performed all physical tasks (household, groceries) as a result of hypervigilance. Research suggest that hypervigilance in spouses after a cardiac event, although well intended, may undermine the patient's health and recovery (37) and should thus be targeted.

Several patients reported to have LowKin due to prior experience with (severe) illness. This finding is line with the study of Bäck et al. (2013), which suggested that suppression of previous experience of heart failure was related to LowKin (15). In this study, some patients had experience with controlling their comorbidity (e.g. diabetes) by doing exercise and were therefore motivated to be physically active, or perform exercise, which in turn might have led to lower levels of kinesiophobia. Patients with LowKin stated, in contrast to those with HighKin, that they received consistent information and also felt they were given the opportunity to ask questions before leaving the hospital. Moreover, these patients attributed their body signals to side effects of medication and felt reassured by carefully reading the medication prescription instead of attributing their body signals to a new cardiac event. A previously conducted systematic review found that poor ability to obtain and understand medical information (health literacy) is consistently associated with anxiety, readmissions and lower social support (38). This finding might also apply to patients with HighKin and emphasizes the need for accessible and understandable information for (all) patients after an ACH.

Patients that had experience with exercise, or already participated in CR, were more positive about PA and exercise and were looking forward to starting CR. Previous experience with exercise has been reported by Bäck et al. (2017) as an important facilitator of participation in CR (39). Furthermore, these patients felt supported by patients that went through the same experience during CR. Talking about their experiences relieved their anxiety and kinesiophobia. These patients also felt more support from their informal caregivers who gradually exposed them to greater levels of PA. Graded exposure to PA is an effective method to overcome kinesiophobia in patients with low back pain (15) and might also be suitable for patients with cardiovascular disease.

Patients stated that they wanted consistent information about their cardiac event and cardiac intervention, body signals, side effects of medication and health benefits of CR before hospital discharge. Aside from consistent information, patients wanted to be reassured by a health care professional when building

up PA in their daily lives. Being well informed and reassured, in the early phase after an ACH, is vital since 1 in 5 patients drop out of CR as a result of feeling anxious (40). Targeting anxiety and kinesiophobia in the early phase after an ACH before the start of (physical) CR might alter participation rates in CR (39).

Strengths and limitations

This study has several strengths. To our knowledge this is the first study that explores kinesiophobia after an ACH with an inductive content analysis. A variety of patients with different ages, gender, diagnoses and co-morbidities were included in this study. We consider this a strength since we wanted to explore viewpoints from a variety of participants that were eligible for CR.

This study also has limitations. Firstly, we used semi-structured interviews to obtain our data. During semi-structured interviews, the interviewer actively participates which in turn might lead to bias due to personal prejudices about the topic. Secondly, content analysis is subject to error especially due to interpretation of the data. To minimize the chance of misinterpretation and to increase the trustworthiness of the results, triangulation was used. Thirdly, we aimed to explore the concept of kinesiophobia in a heterogeneous cohort using a purposeful sampling strategy which in turn impacts the generalizability of the results. Nevertheless, due to the qualitative research design, meaningful, in-depth data was obtained concerning experiences, beliefs and barriers in patients with varying backgrounds. Lastly, we used the TSK-NL Heart to define the level of kinesiophobia in cardiac patients were the cut-off score of >28 points is used to define high levels of kinesiophobia (9). A single cut-off point might be suitable for practical reasons like admission to an intervention but the concept of fear in itself is not dichotomous. Our data suggest that the cut-off point of 28 might be too high. Two patients (P11, P3) in our study scored slightly under the cutoff with a score of 26 points. Based on their interviews they seemed to be misclassified since they reported several signs of kinesiophobia. A recent study suggests using categories to classify the severity of kinesiophobia as follows: subclinical: 13–22; mild: 23–32; moderate: 33–42; and severe: 43–52 (22). According to this classification, several patients in our study population would have been identified with mild kinesiophobia. It's unknown if the above mentioned categories are applicable for patients with cardiovascular disease. More research is needed to assess the validity of these cut off points for the TSK-NL Heart.

This study reveals factors related to kinesiophobia after an ACH and the support needs of patients and informal caregivers. These findings need be further investigated in studies with a quantitative research design and can be used to develop early interventions to target or prevent kinesiophobia after an ACH.

CONCLUSION

The findings of this exploratory study suggest that `a disrupted health care process' and `negative beliefs and attitudes concerning physical activity' are related to high levels of kinesiophobia after an ACH. On the other hand, understanding the necessity of PA and experiencing social support after ACH, are related to low levels of kinesiophobia. Patients reported `tailored information and support from a health care professional' as most important needs after ACH. These findings can be used to make health care professionals more aware of patients' needs after ACH and thereby taking into account the possible role of kinesiophobia in the health care process. The results of this study need to be further investigated in studies with a quantitative study design and can be used to develop early intervention strategies to prevent kinesiophobia, stimulate physical activity and the uptake of CR.

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APPENDIX 1. INTERVIEW GUIDE

Main topics	Example of follow-up questions
Patient's and informal caregivers experiences during cardiac event	- Can you tell us about what happened during your cardiac event?
Experiences during hospitalization	- What was your experience at the hospital? - How was it to do physical activity at the hospital after the event? - Did you receive any help or instructions from a health care professional (cardiologist/registered nurse/ physiotherapist)? - Can you tell us about the discharge process?
Experiences after hospital discharge	- What are your experiences after hospital discharge - How was it to do daily physical activities directly after hospital discharge? - Did you receive support or do you receive support now? - Where there any barriers for physical activity after hospital discharge and are there any barriers now? - What are your beliefs about physical activity? - Do you avoid certain types of physical activity? - If you look back at your experience, what would you have liked to see different? (information/guidance/ treatment).
Cardiac rehabilitation	- Are you planning to participate in cardiac rehabilitation?

Chapter 5

Impact of kinesiophobia on initiation of cardiac rehabilitation: a prospective cohort path analysis

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ABSTRACT

Objectives: To identify factors associated with kinesiophobia (fear of movement) after cardiac hospitalization and to assess the impact of kinesiophobia on CR-initiation.

Methods: We performed a prospective cohort study in cardiac patients recruited at hospital discharge. We assessed kinesiophobia with the Tampa Scale for Kinesiophobia (TSK). For this study the total score was used (range 13-52). We assessed baseline factors (demographics, cardiac disease history, questionnaire data on anxiety, biopsychosocial complexity and self-efficacy) associated with kinesiophobia using linear regression (β) with backward elimination. Prospectively, the impact of kinesiophobia on probability of CR-initiation in the first 3 months after hospital discharge (subsample referred for CR) was assessed using logistic regression.

Results: In total, 149 patients (78.5% male) with a median (IQR) age of 65 (14) were included, of which 82 (59%) were referred for CR. Moderate and severe levels of kinesiophobia were found in 22.8%. In the total sample, kinesiophobia was associated with cardiac anxiety (β=0.33 95%CI: 0.19 to 0.48), social complexity (β=0.23 95%CI: 0.06 to 0.39) and higher education (β=-0.18 95%CI:-0.34 to -0.02). In those referred for CR, kinesiophobia was negatively associated with self-efficacy (β = -0.29 95% CI: -0.47 to -0.12) and positively with cardiac anxiety (β= 0.43 95%CI: 0.24 to 0.62). Kinesiophobia decreased the probability of CR-initiation (OR $^{\text{Range13-52 points}}$ = 0.92 95%CI: 0.84 to 0.99).

Conclusion: In patients hospitalised for cardiovascular disease, kinesiophobia is associated with cardiac anxiety, social complexity, educational level and self-efficacy. Kinesiophobia decreased the likelihood of CR-initiation with 8% per point on the TSK.

INTRODUCTION

Fear of movement (kinesiophobia) is present in 45% of patients with cardiovascular disease (CVD) at the start of cardiac rehabilitation (CR) and remains present in 20% of patients after 3-10 months after hospital discharge. Kinesiophobia is associated with decreased quality of life and low PA-levels (1-3). Moreover, kinesiophobia negatively impacts the uptake of cardiac rehabilitation (CR), despite CR's proven benefits such as reduced morbidity and mortality, and better psychological wellbeing (4-6).

The effect of kinesiophobia at hospital discharge on the uptake of CR has not been prospectively investigated. Previous qualitative research has shown that patients attribute high levels of kinesiophobia to a lack of support and information at hospital discharge from a health care provider (3). Insight in factors associated with kinesiophobia at hospital discharge, and how kinesiophobia impacts CR-initiation, could help to identify potential determinants of kinesiophobia, which in turn could potentially impact CR-initiation, and help to adequately support and refer those with kinesiophobia.

Therefore, the aims of this study were to explore (1) factors associated with kinesiophobia at hospital discharge and (2) the impact of kinesiophobia on initiation of cardiac rehabilitation.

METHODS

Study design

We performed a prospective cohort study from in patients hospitalised with cardiovascular disease from hospital discharge up to 3 months follow-up. To explore factors associated with kinesiophobia and the effect of kinesiophobia on CR-initiation, a hypothetical path-model was developed (explained in detail below) (**Figure 1**). Patients were included at hospital discharge (or shortly after) from the Amsterdam University Medical Centre at the department of Cardiology.

Ethics consideration

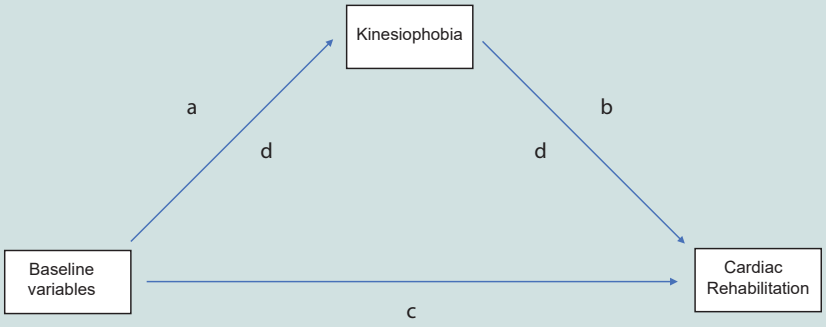
The Medical Ethics Committee of the Amsterdam University Medical Centre approved the study (protocol number: NL65218.018.18).

Patient population

Eligible patients had been hospitalized for acute coronary syndrome (ACS), stable angina pectoris (AP), acute heart failure (AHF) or atrial fibrillation (AF). Exclusion criteria were: referral to a nursing home; inability to complete questionnaires, e.g. due to language problems.

Patient and public involvement

Patients or the public were not involved in the design, conduct, reporting or dissemination plans of our research.



Analyses
a. Direct effect of baseline variables on kinesiophobia.
b. Direct effect of kinesiophobia on CR-initiation.
c. Direct effect of baseline variables on CR-initiation.
d. Indirect effect of baseline variables on CR-initiation, with kinesiophobia as mediator.

Figure 1. Hypothetical path model

Sample size considerations

Based on previous research we expected to include 10 variables in our final path-model (2). We therefore aimed to include 15 times the number of parameters in our study, resulting in a final sample size of 150 patients (7).

Data collection and measurements

Patients were identified between August 2019 and May 2021 through the electronic health records system of the Amsterdam University Medical Center. During hospitalisation, eligible patients were approached by study personnel of the Amsterdam University of Applied Sciences and, if they consented, enrolled in this study. The following data were collected from the electronic health record: age, sex, educational level, marital status, cardiac diagnosis and disease history. Patients were asked by email to complete questionnaires about their biopsychosocial complexity, the level of self-efficacy, anxiety and depression at discharge.

Outcomes

The primary outcomes were kinesiophobia at hospital discharge and CR-initiation (yes/no) 3 months after discharge. At hospital discharge, patients completed the Tampa Scale for Kinesiophobia (TSK-NL Heart). The TSK-NL Heart consists of 13 questions with a four-point scale ranging from 1 to 4, with a minimum score of 13 and maximum score of 52 points. Scores on the TSK-NL Heart are categorized as follows: subclinical: 13–22; mild: 23–32; moderate: 33–42; and severe: 43–52 (1). After 3 months patients were asked, by telephone, if they 1) were referred for CR, 2) initiated CR 3) were readmitted to the hospital for an unplanned procedure.

Self-reported measurements
All self-reported measurements were completed during, or shortly after, hospital discharge (maximum 2 days).

Biopsychosocial complexity
Patients' biopsychosocial complexity was assessed with the Intermed Self-Assessment (IMSA). The IMSA has four domains: biological complexity (chronicity and severity of symptoms, complications and life threat), psychological complexity (restrictions in coping, resistance to treatment, mental health threat, psychiatric dysfunction) and social complexity (social dysfunction, residential instability). Scores >19 indicate high complexity. In this study, the biological, psychological and social domains were analysed separately (8).

Generic anxiety and depression
Anxiety and depression were assessed with the Hospital Anxiety and Depression Scale (HADS). A sum score of 8-10 is defined as `possible anxiety/depressive disorder', a sum score of 11-21 is defined as `likely anxiety/depression disorder' (9).

Cardiac anxiety
The cardiac anxiety questionnaire (CAQ) is an 18-item, self-report questionnaire, designed to measure cardiac anxiety (fear, attention, avoidance of physical exercise and safety-seeking behaviour), rated on a 5-point Likert scale ranging from 0 (never) to 4 (always) (10).

Self-efficacy
Self-efficacy was assessed with the General Self-Efficacy Scale (GSES). The GSES is a 10 item questionnaire with a four-point Likert scale ranging from 0 (completely disagree) to 4 (completely agree). A higher sum score indicates better self-efficacy (11).

Statistical analysis
Descriptive statistics
Patient characteristics are presented as median and interquartile range (IQR) or numbers (%). We analysed baseline kinesiophobia and differences between patients based on CR- referral and CR- initiation. In addition, we assessed which patients were readmitted to the hospital for acute coronary syndrome, revascularization or electro-cardioversion within the period of this study (3 months).

Path analysis
We explored direct effects (relations between independent and dependent variables) and indirect effects (the effect of an independent variable on a dependent variable through one or more intervening or mediating variables) (12) (**Figure 1**). Since little is known about kinesiophobia in patients with CVD, a comprehensive approach

was used to explore the association between baseline variables, kinesiophobia and the initiation of CR. We studied the association between demographic variables (age, sex, educational level), medical variables (diagnosis, cardiac disease history, risk factors), psychological variables (biopsychosocial complexity, generic anxiety, cardiac anxiety, self-efficacy) and kinesiophobia. Categorical variables were recoded into dummy variables (educational level, diagnosis, cardiac disease history, risk factors). All other variables (age, BMI, kinesiophobia, psychological variables). were analysed as continuous. In addition, we studied the longitudinal association between kinesiohobia, the abovementioned demographic, medical, psychological variables and CR-initiation. An overview of all analyses is found in **appendix 1**.

First, univariable linear regression was used to select variables associated with kinesiophobia (TSK-NL Heart total score). Univariable logistic regression was used to select variables associated with CR-initiation in a subsample that was referred for CR (cut-off for variable retainment in both analyses: $P<0.10$) (13). Second, a path analysis was conducted. Backward elimination was used to select significant ($P<0.05$) variables associated with kinesiophobia. The initiation of CR (yes/no) was regressed on kinesiophobia to study the direct effect of kinesiophobia on CR-initiation and possible indirect effects of baseline variables on CR-initiation, with kinesiophobia as mediator. Path analyses were conducted for the total sample and in a subsample that was referred for CR.

All effects on kinesiophobia (continuous TSK-NL Heart score) are presented as standardized beta estimates (β). Effect size of (β) was interpreted as small (<0.29), moderate (0.30 - 0.49), large (> 0.50) (14). Effects on the uptake of CR are presented as odds ratios. In the final model, the effect of kinesiophobia on CR-initiation was corrected for age and gender. The Satorra-Bentler scaled chi square test (X2) was used to assess model fit. Patterns of missing data were analysed with Little's test to assess the pattern of missing data. A full conditional specification Multiple Imputation (FCS MI) (15). Data-imputation was conducted in SPSS V28. An overview of all missing data is found in **Appendix 1**. All descriptive and univariable analyses were performed in SPSS V28. The path models were analysed using Mplus V8.0.

RESULTS

Demographic and clinical characteristics

In total, 188 patients were assessed for eligibility. After inclusion, 39 patients (20.7%) did not complete any questionnaires, and 2 died. At hospital discharge, 82 (55%) patients were referred for CR, of which 61 (40.9%) initiated CR in 3 months follow up (**figure 2**).

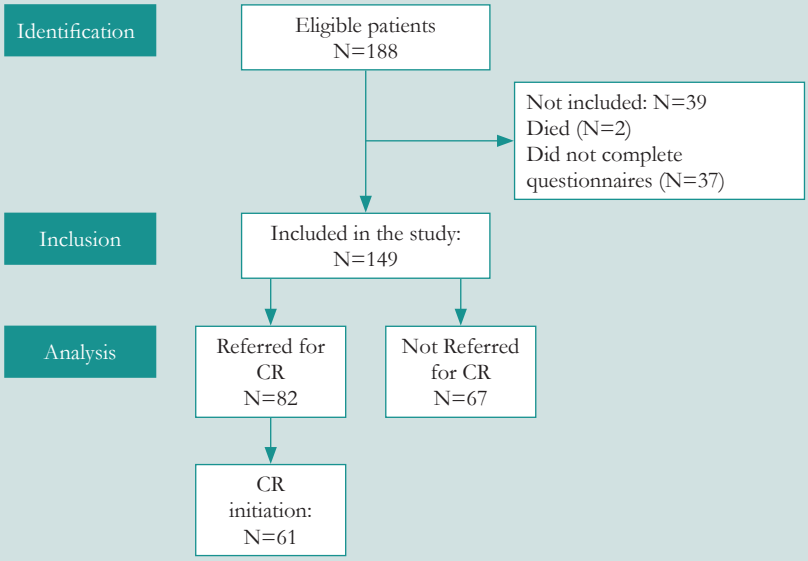


Figure 2. Flowchart study

Finally, 149 patients were included in the analyses with a median age of 65 years (range 32-86). The majority of patients were male (78.5%) and lived with a partner (77.9%). Most patients had been admitted for an elective intervention (55.7%), of which 78.5% underwent a PCI. A history of hypertension was present in 40.9%, dyslipidaemia in 26.2% and diabetes mellitus in 17.4. Prior myocardial infarction was present in 23.4% and prior PCI in 37.6% (**table 1**). The distribution of kinesiophobia levels were: subclinical (24.2%), mild (53.0%), moderate (22.1%) and severe (0.7%) (**figure 3**).

At baseline, TSK-scores were, on average, 3 points higher in patients who were referred but and did not initiate CR, than in those who did initiate CR (30.39 ± SD 6.76 vs 27.37 ± SD 5.98). Within 3 months follow up, 15 patients (10%) were readmitted to the hospital: 6 patients for ECV, 6 patients for PCI, 2 patients for ACS and 1 patient for acute heart failure.

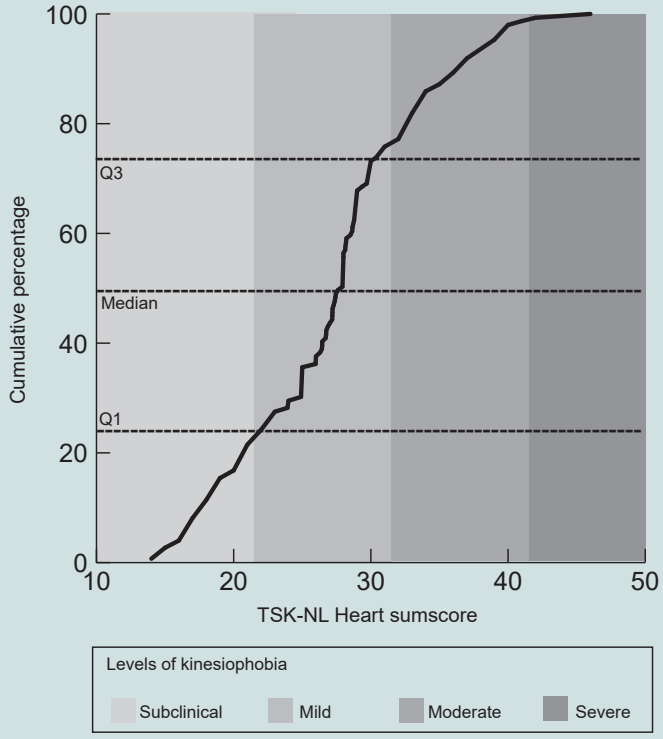


Figure 3. kinesiophobia scores at hospital discharge

Table 1. Baseline characteristics

(N=149)	
Demographics	
Age, years, mean (SD)	65.5 (14)
Male (%)	117 (78.5)
Higher education (%)	39 (26.2)
Lives with partner (%)	116 (77.9)
Index event (%)	
Acute Coronary Syndrome	
STEMI	32 (21.5)
NSTEMI	22(14.8)
UAP	9 (6.0)
Stable Angina revascularization	58 (38.9)
Acute Heart Failure	3 (2.0)
Atrial Fibrillation	25 (16.7)
Admission type (%)	
Acute admission	66 (44.3)
Elective admission	83 (55.7)
Treatment for index event (%)	
PCI	117 (78.5)
ECV	24 (16.1)
Medication only	8 (5.4)
Cardiac disease history (%)	
Myocardial infarction	35 (23.4)
PCI	56 (37.6)
CABG	5 (3.4)
Stroke	14 (9.4)
Peripheral artery disease	10 (6.7)
Cardiovascular disease risk factors (%)	
Diabetes Mellitus type 2	26 (17.4)
History of hypertension	61 (40.9)
History of dyslipidaemia	39 (26.2)
BMI category (kg/m2)	
18- 25	16 (10.8)
25-30	120 (80.5)
>30	13 (8.7)

Values presented as median (IQR) and counts (%)
STEMI: ST-Elevation Myocardial Infarction, NSTEMI: Non ST-Elevation Myocardial Infarction, UAP: Unstable Angina Pectoris, PCI: Percutaneous Coronary Intervention, ECV: Electro Cardio Version, CABG: Coronary Artery Bypass Grafting, BMI: Body Mass Index.

Univariable analyses

An overview of all our univariable linear regression analyses is presented in **table 2**. We found small associations between kinesiophobia and female sex (β= 0.19 95% CI: 0.03 to 0.35) , Age ≤ 50 (β = 0.22 95% CI: 0.38 to 2.49), (HADS anxiety (β = 0.27 95% CI: 0.11 to 0.42). Higher education (β=-0.24 95% CI: -0.40 to -0.08) and GSES self-efficacy (β=-0.18 95% CI: -0.34 to -0.02) were negatively associated with kinesiophobia. Moderate associations were found between kinesiophobia and HADS Depression (β=0.32 95% CI:0.16 to 0.47), IMSA psychological complexity (β = 0.32 95% CI: 0.17 to 0.48), IMSA social complexity (β=0.33 95% CI: 0.17 to 0.48) and CAQ cardiac anxiety (β=0.42 95% CI: 0.27 to 0.57).

In patients referred for CR (N=82), 9 candidate predictors of CR-initiation were found. TSK Kinesiophobia (OR: 0.92 95% CI: 0.85 to 1.00), treatment with ECV (OR:0.21 95% CI: 0.07 to 0.69), atrial fibrillation (OR: 0.21 95% CI: 0.07 to 0.69), HADS anxiety (OR: 0.89 95% CI: 0.79 to 1.00), HADS depression (OR:0.93 95%CI: 0.81 to 1.06), and IMSA psychological complexity (OR: 0.82 95% CI: 0.66 to 1.00) decreased the odds of CR initiation. Treatment with PCI (OR: 3.56 95% CI: 1.15 to 11:00), acute admission (OR: 2.58 95% CI: 0.89 to 7.54) and GSES Self-efficacy (OR: 1.18 95% CI: 1.03 to 1.36) increased the odds for CR initiation (**table 3**). In those referred for CR, 7 patients were readmitted to the hospital for an unplanned procedure, of which 6 initiated CR (OR: 2.18 95%CI: 0.32 to 2.85). An overview of all candidate predictors of CR in the total sample (N=149) is found in **Appendix 2**.

Table 2. Univariable Linear regression with TSK-NL Heart as dependent variable (N=149)

Variable	Standardized Beta (95% CI)	Adjusted R-square	P-value
Demographics			
Age (continuous)	-0.13 (-0.29 to 0.04)	0.001	0.13
Age ≤ 50	0.22 (0.38 to 2.49)	0.05	0.008
Female Sex	0.19 (0.03 to 0.35)	0.03	0.02
Higher Education	-0.24 (-0.40 to -0.08)	0.05	0.003
Index event			
Acute coronary syndrome	0.08 (-0.08 to 0.25)	0.001	0.31
Stable angina revascularization	-0.04 (-0.21 to 0.12)	-0.001	0.61
Atrial Fibrillation	-0.04 (-0.21 to 0.12)	-0.001	0.59
Admission			
Acute admission	0.07 (-0.09 to 0.24)	0.001	0.37
Treatment index event			
PCI	0.02 (-0.14 to 0.19)	-0.01	0.79
ECV	-0.02 (-0.19 to 0.14)	-0.01	0.99
Medication only	-0.01 (-0.16 to 0.16)	-0.01	0.99
Cardiac disease history			
Acute coronary syndrome	-0.08 (-0.25 to 0.08)	0.001	0.32
PCI	0.001 (-0.16 to 0.16)	-0.001	0.49
CABG	0.06 (-0.10 to 0.22)	-0.001	0.46
Stroke	-0.11 (-0.28 to 0.49)	0.001	0.17
Peripheral artery disease	0.03 (-0.13 to 0.20)	-0.001	0.40
CVD risk factors			
Diabetes mellitus	-0.02 (-0.18 to 0.15)	-0.001	0.83
History of hypertension	0.03 (-0.13 to 0.20)	-0.01	0.69
History of dyslipidaemia	0.08 (-0.09 to 0.24)	-0.001	0.35
BMI	0.14 (-0.19 to 0.30)	0.01	0.08
Psychological risk factors			
GSES General Self-Efficacy scale	-0.18 (-0.34 to -0.02)	0.03	0.03
HADS Anxiety	0.27 (0.11 to 0.42)	0.06	0.001
HADS Depression	0.32 (0.16 to 0.47)	0.09	0.001
IMSA Biological complexity	0.21 (0.06 to 0.37)	0.04	0.009
IMSA Psychological complexity	0.32 (0.17 to 0.48)	0.10	0.001
IMSA Social complexity	0.33 (0.17 to 0.48)	0.10	0.001
CAQ Cardiac anxiety	0.42 (0.27 to 0.57)	0.17	0.001

GSES = General Self Efficacy Scale, HADS = Hospital Anxiety and Depression Scale, IMSA = InterMed Self-Assessment, CAQ = Cardiac Anxiety Questionnaire

Table 3. Univariable logistic regression with CR initiation as dependent variable in a subsample referred for CR (N=82)

Variable	CR-initiation No (N=21)	CR-initiation Yes (N=61)	OR (95% CI)	P-value
Demographics				
Age	63 (11.0)	63 (19.0)	0.98 (0.94 to 1.03)	0.49
Age ≤ 50	1 (1.2)	12 (14.6)	4.90 (0.60 to 40.21)	0.14
Age >50	20 (24.4)	49 (59.8)	0.20 (0.03 to 1.68)	0.14
Female sex (%)	7 (33.3)	11 (18.0)	0.44 (0.14 to 1.35)	0.14
Higher education (%)	16 (23.9)	19 (31.1)	1.92 (0.57 to 6.49)	0.29
Index event				
Acute coronary syndrome (%)	6 (28.6)	30 (49.2)	2.42 (0.83 to 7.07)	0.11
Stable angina revascularization (%)	7 (33.3)	23 (37.7)	1.21 (0.43 to 3.44)	0.72
Atrial fibrillation (%)	8 (38.1)	7 (11.5)	0.21 (0.07 to 0.69)	0.01
Admission type				
Acute admission index event	6 (4.0)	31 (20.8)	2.58 (0.89 to 7.54)	0.08
Unplanned admission during study (%)	1 (4.8)	6 (9.8)	2.18 (0.25 to 19.26)	0.48
Treatment index event				
PCI	13 (61.9)	52 (85.2)	3.56 (1.49 to 11.00)	0.03
ECV	8 (38.1)	7 (11.5)	0.21 (0.07 to 0.69)	0.10
Medication only	-	2 (3.3)	-	-
Cardiac disease history				
Acute coronary syndrome	3 (14.3)	15 (24.6)	1.96 (0.51 to 7.58)	0.33
PCI	9 (42.9)	22 (36.1)	0.75 (0.27 to 2.07)	0.58
CABG	-	4 (6.6)	-	-

Stroke	2 (9.5)	2 (3.3)	0.33 (0.42 to 2.45)	0.27
Peripheral artery disease	1 (4.8)	2 (3.3)	0.68 (0.06 to 7.88)	0.76
CVD risk factors				
Diabetes Mellitus (%)	4 (19.0)	11 (18.0)	0.94 (0.26 to 3.33)	0.92
Hypertension (%)	8 (38.1)	23 (37.7)	0.98 (0.35 to 2.73)	0.98
Dyslipidemia (%)	5 (23.8)	19 (31.1)	1.45 (0.46 to 4.53)	0.53
Median BMI, kg/m2 (IQR)	27.07 (1.16)	27.02 (1.20)	0.96 (0.78 to 1.18)	0.69
Psychological risk factors				
Median TSK Kinesiophobia (IQR)	29.00 (10.78)	27.93 (7.00)	0.92 (0.85 to 1.00)	0.06
Median GSES Self-Efficacy (IQR)	32.67 (5.50)	33.49(7.00)	1.18 (1.03 to1.36)	0.02
Median HADS Anxiety (IQR)	7.00 (4.00)	5.39(4.99)	0.89 (0.79 to1.00)	0.06
Median HADS Depression (IQR)	5.00 (5.21)	4.00(5.70)	0.93 (0.81 to1.06)	0.06
Median IMSA Biological complexity	14 (2.63)	15 (4.00)	1.02 (0.88 to 1.18)	0.84
Median IMSA Psychological complexity	6.64(4.0)	5.42(2.81)	0.82 (0.66 to1.00)	0.06
Median IMSA Social complexity (IQR)	7.89 (3.50)	8.64 (3.00)	1.02 (0.83 to 1.27)	0.84
Median CAQ Cardiac Anxiety	26.45 (7.00)	27.00 (11.00)	0.97 (0.92 to 1.03)	0.36

Path analysis

Analysis 1: Total sample

In the total sample we identified three variables that were associated with kinesiophobia (**table 4**). CAQ cardiac anxiety (β = 0.33 95% CI: 0.19 to 0.48) was moderately associated with kinesiophobia. A small association was found between kinesiophobia and IMSA social complexity (β = 0.23 95% CI: 0.06 to 0.39) and higher education (β = -0.18 95% CI: -0.34 to -0.02). We identified two predictors of CR-initiation: age (years) (OR: 0.96 95% CI: 0.93 to 0.99) decreased, while higher levels of GSES self-efficacy (OR: 1.10 95% CI: 1.01 to 1.20) increased the odds for CR-initiation. An overview of all variables associated with kinesiophobia and CR-initiation are presented in a path analysis diagram (**figure 4**). Model fit (X^2= -2.254124, DF: 5, P > 0.9).

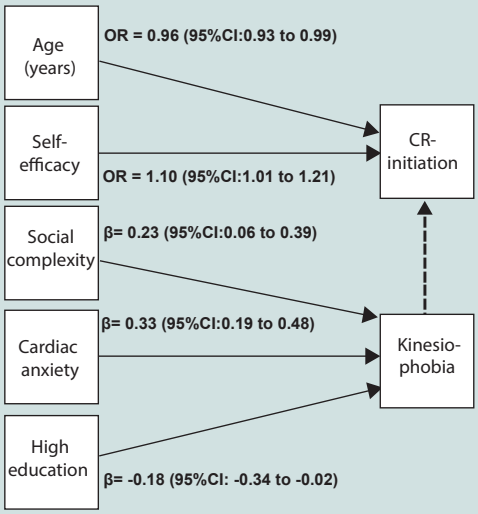


Figure 4. Path-analysis total sample

Table 4. Path analysis with TSK and CR as dependent variables (N=149)

Dependent variable: TSK		
Variable	**Standardized Beta (95% CI)**	**P-value**
CAQ Cardiac anxiety	0.33 (0.19 to 0.48)	0.001
IMSA Social complexity	0.23 (0.06 to 0.39)	0.006
Higher Education	-0.18 (-0.34 to -0.02)	0.03
Dependent variable: CR-initiation		
Variable	**OR (95%CI)**	**P-value**
Age	0.96 (0.93 to 0.99)	0.02
GSES Self-Efficacy	1.10 (1.01 to 1.20)	0.03

Analysis 2: Subsample referred for CR

In the subsample that was referred for CR, we identified two variables that were associated with kinesiophobia (**table 5**). A moderate positive association was found between CAQ cardiac anxiety (β = 0.43 95% CI: 0.24 to 0.62) and kinesiophobia, while GSES self-efficacy (β=-0.29 95% CI: -0.47 to -0.12) was negatively associated with kinesiophobia. Corrected for age, kinesiophobia (OR=0.92 95% CI: 0.84 to 0.99) significantly decreased the odds of CR-initiation. A moderate indirect effect of CAQ cardiac anxiety (OR = 0.98 95% CI: 0.95 to 1.00) on CR-initiation was found with kinesiophobia as a mediator. The subsample analysis is presented in a path analysis diagram (**figure 5**). Model fit (X^2= -0.0062, DF: 4, P > 0.9).

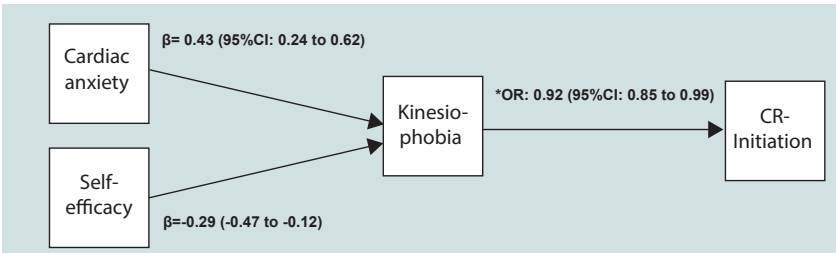


Figure 5. Path analysis subsample referred for CR

Table 5. Path analysis with TSK and CR- initiation as dependent variables, restricted to patients who had been referred to CR (N=82)

Dependent variable: TSK		
Variable	**Standardized Beta (95%CI)**	**P-value**
CAQ Cardiac anxiety	0.43 (0.24 to 0.62)	0.001
GSES Self-Efficacy	-0.29 (-0.47 to -0.12)	0.001
Dependent variable: CR-initiation		
Variable	**OR (95%CI)**	**P-value**
TSK Kinesiophobia		
Model a	0.92 (0.85 to 0.99)	0.05
Model b	0.92 (0.84 to 0.99)	0.04
Model c	0.93 (0.86 to 1.01)	0.08
Model c+d	0.92 (0.85 to 1.01)	0.07
Mediation analysis: indirect effect of cardiac anxiety an self-efficacy on CR-initiation with TSK as mediator		
Variable	**OR (95%CI)**	**P-value**
CAQ Cardiac Anxiety	0.98 (0.95 to 1.00)	0.05
GSES Self-efficacy	1.04 (0.99 to 1.09)	0.11

a = Crude association, b = Corrected for age, c = Corrected for sex, d = Corrected for age + sex

DISCUSSION

We found that mild and moderate levels of kinesiophobia were present at hospital discharge in a substantial group of patients with CVD (53% and 22.1% respectively). Cardiac anxiety, social complexity, and educational level were associated with kinesiophobia at hospital discharge. In patients who were referred for CR, self-efficacy was negatively associated with kinesiophobia. In patients referred for CR, the presence of kinesiophobia was associated with a lower rate of CR initiation. An indirect effect of cardiac anxiety on CR-initiation was found. Our study shows that kinesiophobia decreases the likelihood of CR initiation. Theoretically this makes sense since the construct kinesiophobia comprises `fear of injury', `perception of risk' and `avoidance of physical activity'. Patients with higher levels of kinesiophobia might associate participation in CR as threatening since exercise and physical activity are the cornerstones of CR.

We identified a moderate association between cardiac anxiety and kinesiophobia. In a previous study a similar result was found (1). Moreover, we found that kinesiophobia mediated the relationship between cardiac anxiety and CR-initiation. This finding is in line with previous research which reports that kinesiophobia mediates the relationship between self-rated anxiety and CR-attendance (4). The CAQ measures behaviour and anxiety-related symptoms (e.g. "*I avoid activities that make my heart beat faster*") whereas the TSK-NL Heart measures patients' beliefs about their physical state (e.g. "*If I tried to be physically active my heart problem would increase*"). More research is needed to investigate the impact of specific kinesiophobic beliefs on behaviour and anxiety related symptoms and vice versa.

In line with our findings, Brunetti et al, showed that educational level was negatively associated with kinesiophobia (16). In a previous study, we found that patients with high levels of kinesiophobia often do not understand medical information and misinterpret body signals, which in turn is associated with poor health literacy and low educational level (3, 17). This finding fits well with the call for more tailored and understandable information at hospital discharge, provided by a trained healthcare provider (3).

Patients scoring high on social complexity suffered from higher levels of kinesiophobia. This is in line with our previous study where we found that patients with lower levels of kinesiophobia often experienced greater social support than those with higher levels of kinesiophobia (3). The presence of a partner has been shown to improve lifestyle modification in cardiac patients and increase adherence to CR (18). Moreover, participation of partners in CR-programs improves PA-levels in patients (19, 20). Future studies should evaluate the role of social support on levels of kinesiophobia after cardiac hospitalization.

Self-efficacy was negatively associated with kinesiophobia, in those referred for CR, and predicted CR-initiation in the total sample. Self-efficacy refers to `one's belief in their capacity to execute behaviours necessary to produce

specific performance attainments' (21). The association between self-efficacy and kinesiophobia has been established in patients with musculoskeletal disorders, but not in patients with CVD (22, 23). Zelle et al., reported that the impact of kinesiophobia on physical activity is largely mediated by self-efficacy, and should therefore be evaluated when targeting kinesiophobia (24). Our study showed that self-efficacy increased the likelihood of CR-initiation by 10%. Self-efficacy is linked to CR- initiation, but is often lacking in patients with psychological distress (25). Therefore, self-efficacy-building activities should be considered *before* CR-initiation (26). Currently, behaviour change strategies are offered in CR-programs to improve PA levels, promote smoking cessation and a healthy diet (27). However, these interventions are currently limited to those that initiate CR. An early behavioural intervention, aimed at reducing kinesiophobia and stimulating self-efficacy shorty after hospital discharge might improve CR-initiation.

Strengths and limitations

There are several strengths to our study. First, we studied kinesiophobia and CR-initiation using a prospective design. We were therefore able to study the temporal sequence of kinesiophobia and CR-initiation, and multiple effects that impacted our outcomes. Second, using a path model allows for the specification of multiple, dependent and independent variables simultaneously and thereby gives insight into complex relationships between variables (12). Our comprehensive path analysis gives insight in the factors that are associated with kinesiophobia and predict CR-initiation. These findings aid the development of tailored interventions to target kinesiophobia and improve CR-initiation.

We see the following limitations to this study. First, a substantial number of patients were included after the start of the COVID-19 pandemic. Although CR was offered remotely, this might have impacted kinesiophobia levels and CR-initiation. Second, by using path analysis we were able to explore a network of sequential relations with contributions from all paths (direct and indirect). Conceptually, a mediation model (in contrast to a confounding model) assumes that a series of variables relate via a causal chain of effect and each variable in the model affects variables occurring later in the chain (28). In our model, an indirect effect of cardiac anxiety, through kinesiophobia, was found on CR-initiation. Theoretically, our finding makes sense, since somatic symptoms such as chest pain or palpitations (cardiac anxiety), can lead to negative beliefs about one's physical state (kinesiophobia), which in turn might lead to not initiating CR. Future studies should evaluate the potential mediating role of kinesiophobia in the uptake of CR. Third, although our interest is in causes of kinesiophobia and kinesiophobia as a cause of CR-initiation, our observational study does not permit any claims with regard to causal inference since necessary conditions for causal inference (exchangeability, positivity and consistency) have most likely not been met (29). Nevertheless, this study reports important associations between baseline variables and kinesiophobia. In addition, we showed that kinesiophobia decreased the likelihood of CR-initiation. Future studies, using a causal design can

use these results to investigate determinants of kinesiophobia and the effect of kinesiophobia on CR-initiation.

CONCLUSION

Kinesiophobia is prevalent at hospital discharge. Path analysis revealed that cardiac anxiety and social complexity were positively associated, whereas educational level, and self-efficacy were negatively associated with kinesiophobia at hospital discharge. In addition, patients with (high levels of) kinesiophobia were less likely to initiate cardiac rehabilitation.

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APPENDIX 1. STATISTICAL ANALYSES

Variable	Data type	Missing data (%)	Regressed on outcome: TSK NL- Heart CR initiation
Demographics			
Age	Continuous	-	1+2
Female Sex	Binary	-	1+2
Higher Education	Binary	-	1+2
Index event			
Acute coronary syndrome	Binary	-	1+2
Stable angina revascularization	Binary	-	1+2
Atrial Fibrillation	Binary	-	1+2
Admission			
Acute admission	Binary	-	1+2
Treatment index event			1+2
PCI	Binary	-	1+2
ECV	Binary	-	1+2
Medication only	Binary	-	1+2
Cardiac disease history			
Acute coronary syndrome	Binary	-	1+2
PCI	Binary	-	1+2
CABG	Binary	-	1+2
Stroke	Binary	-	1+2
Peripheral artery disease	Binary	-	1+2
CVD risk factors			
Diabetes mellitus	Binary	-	1+2
History of hypertension	Binary	-	1+2
History of dyslipidaemia	Binary	-	1+2
BMI	Continuous	-	1+2
Psychological risk factors			
GSES General Self-Efficacy scale	Continuous	26 (17.4)	1+2
HADS Anxiety	Continuous	26 (17.4)	1+2
HADS Depression	Continuous	26 (17.4)	1+2
IMSA Biological complexity	Continuous	28 (18.8)	1+2
IMSA Psychological complexity	Continuous	28 (18.8)	1+2
IMSA Social complexity	Continuous	28 (18.8)	1+2
CAQ Cardiac anxiety	Continuous	25 (16.8)	1+2

Variable	Data type	Missing data (%)	Regressed on outcome: TSK NL- Heart CR initiation
Outcomes variables			
Cardiac rehabilitation initiation	Binary	-	-
TSK Tampa Scale for Kinesiophobia	Continuous	34 (22.8)	2

Missing data analyses

This study was part of a large project where data were collected at 4 timepoints (hospital discharge, 3 weeks, 6 weeks and 12 weeks). Patients were included in the analyses if they completed the TSK-Heart NL questionnaire on, at least, one of the abovementioned timepoints. In total, 149 patients were included in the analyses. Missing values of the TSK-NL Heart were: Hospital discharge: 34 (22.8%), 3 weeks 37: (24.8%), 6 weeks: 42 (28.2%), 12 weeks: 54 (36.2%). Little's MCAR test was used to determine patterns of missing data. (Little's MCAR Test Chi Square = 4871,310 DF= 4995, Sig =0.893). A full conditional model (FCS MI) was used to impute data. Convergence was reached after five datasets were imputed. FCS MI is a powerful method to create multiple imputations in datasets with categorical and continuous variables and is well suited for datasets with complex structures (1).

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APPENDIX 2. UNIVARIABLE LOGISTIC REGRESSION WITH CR INITIATION IN THE TOTAL SAMPLE AND SUBSAMPLE REFERRED FOR CR

	Total Sample (N=149)				Referred for CR (N= 82)	
Variable	**CR-initiation No (N=88)**	**CR-initiation Yes (N=61)**	**OR (95%CI)**	**P-value***	**OR (95%CI)**	**P-value***
Demographics						
Median age	66(48.0)	63(19.0)	0.96 (0.93 to 0.99)	0.02	0.98 (0.94 to 1.03)	0.49
Female sex (%)	21 (14.1)	11 (7.4)	0.70 (0.31 to 1.59)	0.40	0.44 (0.14 to 1.35)	0.15
Higher education (%)	68 (45.6)	42 (28.2)	0.65 (0.31 to 1.36)	0.25	0.52 (0.15 to 1.76)	0.29
Index event						
Acute coronary syndrome (%)	33 (22.1)	30 (20.1)	1.61 (0.83 to 3.13)	0.16	2.42 (0.83 to 7.07)	0.11
Stable angina revascularization (%)	35 (23.5)	23 (15.5)	0.92 (0.47 to 1.79)	0.8x	1.21 (0.43 to 3.22)	0.72
Atrial Fibrillation (%)	18 (12.1)	7 (4.7)	0.50 (0.20 to 1.29)	0.15	0.21 (0.07 to 0.69)	0.01
Admission type						
Acute admission (%)	35 (23.5)	31(20.8)	1.56 (0.81 to 3.02)	0.18	2.58 (0.89 to 7.54)	0.08
Unplanned admission during study (%)	9 (6.0)	6 (4.0)	0.96 (0.32 to 2.85)	0.94	2.18 (0.25 to 19.26)	0.48
Treatment index event						
PCI (%)	65 (43.6)	52 (34.9)	2.04 (0.87 to 4.80)	0.10	3.56 (1.15 to 11.0)	0.03
ECV (%)	17 (11.4)	7 (4.7)	0.54 (0.21 to 1.40)	0.21	0.21 (0.07 to 0.69)	0.10
Medication only (%)	6 (4.0)	2 (1.3)	0.46 (0.09 to 2.38)	0.36	-	-
Cardiac disease history						
Acute coronary syndrome (%)	20 (13.5)	15 (10.1)	1.09 (0.51 to 2.35)	0.82	1.96 (0.51 to 7.58)	0.33
PCI (%)	34 (22.8)	22 (14.8)	0.90 (0.46 to 1.76)	0.75	0.75 (0.27 to 2.07)	0.58

	Total Sample (N=149)				Referred for CR (N= 82)	
Variable	**CR-initiation No (N=88)**	**CR-initiation Yes (N=61)**	**OR (95%CI)**	**P-value***	**OR (95%CI)**	**P-value***
CABG (%)	1 (0.7)	4 (2.7)	6.11 (0.67 to 56.02)	0.11	-	-
Stroke (%)	12 (8.1)	2 (1.3)	0.22 (0.05 to 0.99)	0.05	0.32 (0.04 to 2.45)	0.27
Peripheral artery disease (%)	8 (5.4)	2 (1.3)	0.34 (0.07 to 1.66)	0.18	0.68 (0.06 to 7.88)	0.76
CVD risk factors						
Diabetes Mellitus (%)	15 (10.1)	11 (7.4)	1.07 (0.45 to 2.52)	0.88	0.94 (0.26 to 3.33)	0.92
History of hypertension (%)	38 (25.5)	23 (15.4)	0.80 (0.41 to 1.55)	0.50	0.98 (0.35 to 2.73)	0.98
History of dyslipidemia (%)	20 (13.4)	19 (12.8)	1.54 (0.74 to 3.21)	0.25	1.45 (0.46 to 4.53)	0.53
Median BMI, kg/m2 (IQR)	27.28 (1.42)	27.03 (1.20)	1.01 (0.88 to 1.15)	0.91	0.96 (0.78 to 1.18)	0.69
Psychological risk factors						
Median TSK Kinesiophobia (IQR)	27.73 (10.50)	27.93 (93)	0.99 (0.95 to 1.05)	0.93	0.92 (0.85 to 1.00)	0.06
Median GSES Self Efficacy (IQR)	32.86 (4.84)	33.49 (7.00)	1.11 (1.01 to 1.21)	0.02	1.18 (1.03 to1.36)	0.02
Median HADS Anxiety (IQR)	4.29 (4.17)	5.39 (4.99)	0.92 (0.84 to 1.00)	0.06	0.89 (0.79 to 1.00)	0.06
Median HADS Depression	4.65 (4.32)	4.00 (5.70)	0.96 (0.87 to 1.06)	0.44	0.93 (0.81 to 1.06)	0.27
Median IMSA Biological complexity	14.27 (3.00)	15.00 (4.00)	0.99 (0.90 to 1.09)	0.92	1.02 (0.88 to 1.18)	0.84
Median IMSA Psychological complexity	6.00 (3.07)	5.42 (2.81)	0.87 (0.74 to 1.02)	0.09	0.82 (0.66 to 1.00)	0.06
Median IMSA Social complexity	7.79 (3.00)	8.64 (3.00)	1.08 (0.93 to 1.24)	0.32	1.02 (0.83 to 1.27)	0.84
CAQ Cardiac anxiety	26 (10.50)	27 (11.00)	0.99 (0.95 to 1.02)	0.44	0.97 (0.91 to 1.03)	0.36

In the total sample (N = 149) univariable logistic regression analyses revealed 6 candidate predictors of CR-initiation: Age (OR: 0.96 95% CI: 0.93 to 0.99), HADS anxiety (OR: 0.92 95% CI: 0.84 to 1.00) and IMSA psychological vulnerability (OR: 0.87 95% CI: 0.74 to 1.02) decreased the odds of CR-initiation. Treatment with PCI (OR: 2.04 95% CI: 0.87 to 4.80) and GSES Self-efficacy (OR: 1.11 95% CI: 1.01 to 1.21) increased the odds of CR-initiation.

Chapter 6

The longitudinal relationship between fear of movement and physical activity after cardiac hospitalization: a cross lagged panel model

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ABSTRACT

Background: Little is known about the association between fear of movement (kinesiophobia) and objectively measured PA the first 12 weeks after cardiac hospitalization.

Purpose: To assess the longitudinal association between kinesiophobia and objectively physical activity (PA).

Methods: We performed a longitudinal observational study. PA was continuously measured from hospital discharge to 12 weeks using the Personal Activity Monitor. The PAM measures time spent per day in PA-intensity categories: light, moderate and heavy. Kinesiophobia was assessed with the Tampa Scale for Kinesiophobia (TSK) at four time points (hospital discharge, 3, 6 and 12 weeks). The longitudinal association between PA-intensity and kinesiophobia was studied with a random intercept cross lagged panel model (RI-CLPM). A RI-CLPM estimates effects from kinesiophobia on objectively measured PA and vice versa (cross-over effects), and autoregressive effects (e.g. kinesiophobia from one occasion to the next).

Results: On no occasion did we find an effect of kinesiophobia on PA and vice versa. Model fit for the original model was poor (X^2: = 44.646 $P<0.001$). Best model fit was found for a model were kinesiophobia was modelled as a stable between factor (latent variable) and PA as autoregressive components (dynamic process) (X^2 = 27.541 $P<0.12$).

Conclusion: Kinesiophobia and objectively measured PA are not associated in the first 12 weeks after hospital discharge. This study shows that kinesiophobia remained relatively stable 12 weeks after hospital discharge despite fluctuations in light to moderate PA-intensity.

INTRODUCTION

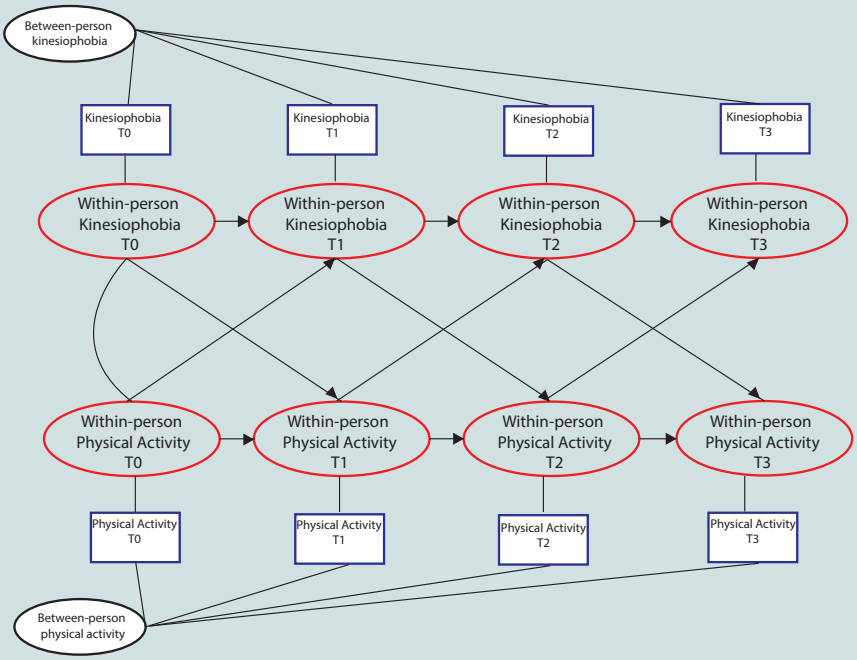
After (acute) cardiac hospitalization, only 17% of patients perform sufficient amounts of daily physical activity (PA) (1). One potential explanation for these low PA-levels might be kinesiophobia (fear of movement). Kinesiophobia is prevalent in 20-45% of cardiac patients and is associated with decreased muscle strength and reduced quality of life (2, 3). In addition, kinesiophobia is associated with low self-efficacy and maladaptive coping strategies, which in turn impede movement behavior (4-6).

Although kinesiophobia is associated with disability, low self-efficacy, and self-reported PA (6-8), the relation between kinesiophobia and objective measures of PA is less clear. The longitudinal association between kinesiophobia and daily PA, measured with an accelerometer has not been prospectively investigated. Using an accelerometer allows for objective measurement of patients daily PA, instead of subjective methods which are prone to recall bias (9). Better understanding of the longitudinal association between kinesiophobia and objectively measured PA is necessary to gain insight in the concept of kinesiophobia and may inform the development of future treatment strategies.

The aim of study was to assess the longitudinal relationship between kinesiophobia and objectively measured physical activity in the first phase (12 weeks) after hospital discharge. A secondary aim was to assess the physical activity levels and kinesiophobia in patients referred for CR.

METHODS

To explore the longitudinal association between kinesiophobia and objectively measured PA, we used a cross-lagged panel model (CLPM). CLPM's are a type of discrete time, structural equation model, used to analyze panel data in which two or more variables are both measured at two or more points in time. CLPM's aim to estimate the effects of one variable on another at different points in time (10)(11). In order to account for stable, trait-like differences between patients, such that the lagged relations pertain exclusively to within patient fluctuations, a random intercept is added to the model (RI-CLPM) at each point time. To fit a RI-CLPM, data is decomposed into within-patient dynamics and stable between patient differences, where the latter, account for unobserved heterogeneity (12). (**Figure 1**).



T0 = week 1 (hospital discharge)
T1 = 3 weeks post hospital discharge
T2 = 6 weeks post hospital discharge
T3 = 12 weeks post hospital discharge

Figure 1. Hypothesized random intercept cross lagged panel model

Ethics consideration

The Medical Ethics Committee of the Amsterdam University Medical Centre approved the study (protocol number: NL65218.018.18).

Sample size consideration

For this study four times points (T=4) were used. A sample size of N=100 was deemed sufficient to reach model convergence (13).

Patient population

Eligible patients had been hospitalized for acute coronary syndrome (ACS), stable angina pectoris (AP), acute heart failure (AHF) or atrial fibrillation (AF) and had undergone a percutaneous coronary intervention (PCI) or electro-cardioversion (ECV). All patients gave written informed consent before participating. Patients were excluded if they were unable to wear an accelerometer or fill in questionnaires (e.g. due to language problems), or transferred to a nursing home.

Data collection and measurements

Patients were identified, between August 2019 and May 2021, through the electronic health records system of the Amsterdam University Medical Centre. In the hospital, eligible patients were approached by researchers of the Amsterdam University of Applied Sciences and enrolled in this study. The following data were collected from the electronic health records: age, sex, education, marital status, cardiac diagnosis and disease history. Patients were asked by email to complete a questionnaire about kinesiophobia at four time points: at hospital discharge (week 1), 3, 6 and 12 weeks post-discharge. In addition, patients were asked to wear an accelerometer (see below) to assess PA-levels for 12 weeks directly after hospital discharge.

Outcomes

Kinesiophobia

Patients completed the Tampa Scale for Kinesiophobia (TSK-NL Heart). The TSK-NL Heart consists of 13 questions, each on a four-point scale ranging from 1 to 4, with total scores ranging between 13 and 52. Scores on the TSK-NL Heart are categorized as follows: subclinical: 13–22; mild: 23–32; moderate: 33–42; and severe: 43–52. The TSK-NL Heart has substantial reliability (ICC: 0.80, 95% CI 0.72 to 0.85) and correlates reasonably well to the Cardiac Anxiety Questionnaire (CAQ) ($R^{spearman}$: 0.61, (95% CI 0.51 to 0.71) and the Hospital Anxiety and Depression Scale (Anxiety) ($R^{spearman}$: 0.60 95% CI: 0.48 to 0.70) (3). In this study the TSK-NL Heart was analyzed as continuous variable.

Objectively measured physical activity

At hospital discharge, patients were asked to wear a PAM-AM300 © Personal Activity Monitor (PAM). The PAM is an uniaxial accelerometer and measures PA intensity by calculating the time spent doing light, medium or heavy PA. Categories of PA are based on metabolic equivalents of tasks (MET's) and are multiplies of the resting metabolism, reflecting the metabolic rate during PA. Light PA comprise activities such as cooking and doing groceries (<3 MET), moderate PA comprise activities such walking or cycling (3-6 MET) and heavy PA comprise activities as aerobics, running or cycle racing (>6 MET) (14). The PAM is a validated tool to assess physical activity intensity in patients with various conditions (15). The PAM has substantial reliability (ICC: 0.80; 95% CI: 0.28 to 0.92) and significantly correlates with the Actigraph accelerometer ($R^{spearman}$: 0.82). Patients were asked to wear the PAM-sensor for 90 days. Scores are presented as minutes of PA per day/ per week, in the categories light, moderate, heavy and total activity.

Data analysis

Descriptive statistics

Descriptive data were presented as frequencies (proportion), mean (SD) or median (IQR). Associations between physical activity and kinesiophobia were analyzed with correlational analysis using the spearman rank correlation

coefficient. Magnitude of the association was interpreted as small (0.00 to 0.30), medium (>0.30 to 0.50) and large (>0.50) (16). Differences in in kinesiophobia and objectively measured PA between hospital discharge and 12 weeks follow up were assessed with the Wilcoxon signed rank test.

The basic RI-CLPM

For this study, TSK-NL Heart scores and total physical activity scores (average minutes per day/per week) of week 1 (hospital discharge), 3, 6 and 12 after hospital discharge were used. Observed scores (kinesiophobia and PA) were decomposed into grand means, stable *between*-components and fluctuating *within*-components. This model is illustrated in **Figure 1**. In this model, the blue squares represent the observed kinesiophobia and PA scores. The *between*-components (random intercepts) of kinesiophobia and PA capture the persons' deviations from the grand mean and represent stable differences between patients. The random intercepts are specified as a latent variable with the repeated measures as its indicators, fixing all factor loadings to 1. The *within*-components (red ovals) are the differences between a patient's observed and expected score, based on the grand means and its random intercepts. The following structural relations between within components were specified: firstly: *Autoregressive effects* (e.g. from T0-kinesiophobia at T1-kinesiophobia) represent the within carry-over effect from one occasion to the next. If this effect is positive, this implies that an individual who experiences elevated kinesiophobia at time=t, relative to his/her own score, is likely to experience kinesiophobia at time= t+1. Secondly, *The cross-lagged effects* represent the cross-over effects from one domain to the other (e.g. T0-kinesiophobia to T1-PA). A positive effect implies that deviation from an individual's level of kinesiophobia will likely be followed by a positive deviation in PA. Autoregressive and cross-lagged effects are presented as standardized beta effect size estimates (β). Effect sizes were interpreted as small (<0.29), moderate (0.30 - 0.49), large (≥ 0.50) (17). The model was adjusted until model fit was deemed sufficient. Model fit was assessed with the Chi square test for model fit (X^2). A X^2 >0.05 indicates acceptable model fit (18). Missing data were handled using Full Conditional Specification Multiple imputation (FCS-MI) and is further explained in **appendix 1**. Multiple imputation and descriptive statistics were performed in SPSS V28 and the RI-CLPM was performed in Mplus V8.

RESULTS

Demographic and clinical characteristics

In total, 188 patients were assessed for eligibility. After inclusion in this study two patients died and 70 did not complete the TSK-NL Heart questionnaire or did not wear the accelerometer.

Finally, 116 patients were included in the analyses with a median age (IQR) of 65.5 (15) years. The majority of patients were male (83.6%) and lived with a partner

(78.4%). Most patients had been admitted for an elective intervention (53.4%) and had undergone PCI (81%) (**Table 1**). The distribution of kinesiophobia levels at hospital discharge were: subclinical (24.1%), mild (55.2%), moderate (19.8%) and severe (0.9%), at 3 weeks: subclinical (21.6%), mild (59.4%), moderate (17.3%) and severe (1.7%), at 6 weeks: subclinical (32.8%), mild (52.5%), moderate (12.1%) and severe (2.6%) at 12 weeks: subclinical (26.7%), mild (63.0%), moderate (9.4%) and severe (0.9%).

Table 1. Population characteristics

(N=116)	
Demographics	
Age, years, median (IQR)	65.5 (9.88)
Male (%)	97 (83.6)
Ethnicity (%)	
White	107 (92.2)
Black	2 (1.7)
Asian	7 (6.0)
Education (%)	
No education	6 (5.2)
Lower education	16 (13.8)
Middle education	39 (33.6)
Higher education	36 (31.0)
Lives with partner (%)	91 (78.4)
BMI category (kg/m2)	
18- 25	15 (12.9)
25-30	92 (79.3)
>30	9 (7.8)
Index event (%)	
Acute Coronary Syndrome	
STEMI	25 (21.6)
NSTEMI	19 (16.4)
UAP	9 (7.8)
Stable Angina revascularization	44 (37.9)
Acute Heart Failure	1 (0.9)
Atrial Fibrillation	18 (15.5)
Admission type (%)	
Acute	54 (46.6)
Elective	62 (53.4)

Table 1. *Continued*

Treatment for index event (%)				
PCI	94 (81.0)			
ECV	16 (13.8)			
Medication only	6 (5.2)			
Cardiac disease history (%)				
Myocardial infarction	27 (23.3)			
PCI	43 (37.1)			
CABG	4 (3.4)			
Stroke	11 (9.5)			
Kinesiophobia (TSK-NL Heart, 13-52) (%)				
	Subclinical	*Mild*	*Moderate*	*Severe*
Hospital Discharge (T0)	28 (24.1)	64 (55.2)	23 (19.1)	1 (0.9)
3 weeks (T1)	25 (21.6)	69 (59.5)	20 (17.2)	2 (1,7)
6 weeks (T2)	38 (32.8)	61 (52.5)	14 (12.2)	3 (2.6)
12 weeks (T3)	31 (26.7)	73 (62.9)	11 (9.5)	1 (0.9)
Physical activity (PA), Median (IQR), Average PA per day/per week				
	Light PA	*Moderate PA*	*Heavy PA*	*Total PA*
Timepoint				
Hospital Discharge (T0)	54.14(32.04)	24.34 (24.10)	0.43 (1.32)	82.09 (53.98)
3 weeks (T1)	82.86 (48.72)	39.21 (27.43)	0.57 (1.40)	127.50 (60.96)
6 weeks (T2)	84.04 (35.89)	35.50 (28.82)	0.83 (1.71)	127.00 (59.21)
12 weeks (T3)	81.34 (28.36)	40.15 (16.11)	1.15 (2.22)	123.85 (39.57)

Abbreviations: STEMI = ST-Elevation Myocardial Infarction, NSTEMI = Non ST-Elevation Myocardial Infarction, UAP = Unstable Angina Pectoris, PCI = Percutaneous Coronary Intervention, ECV = Electro Cardio Version, CABG = Coronary Artery Bypass Grafting. Lower education = VMBO preparatory middle-level applied education. Middle education = Mid-level education, Higher general continued education, Higher education = preparatory scientific education, University of Applied Sciences and higher.

Median TSK scores (IQR) decreased from week 1: 27.4 (7.28), to 12 weeks: 25 (5.90) (P<0.002). Median light activity (minutes/day/per week) (IQR) improved from week 1: 54.14 (32.04) to 12 weeks: 81.34 (28.36) (P<0.001). Median medium activity (minutes/day/per week) (IQR) improved from week 1: 24.34 (24.10) to 12 weeks: 40.15 (16.11) (P<0.001). Median heavy activity (minutes/day/per week) (IQR) improved from week 1: 0.43 (1.32) to 12 weeks: 1.49 (2.21) (P<0.001) (**Figure 3**).

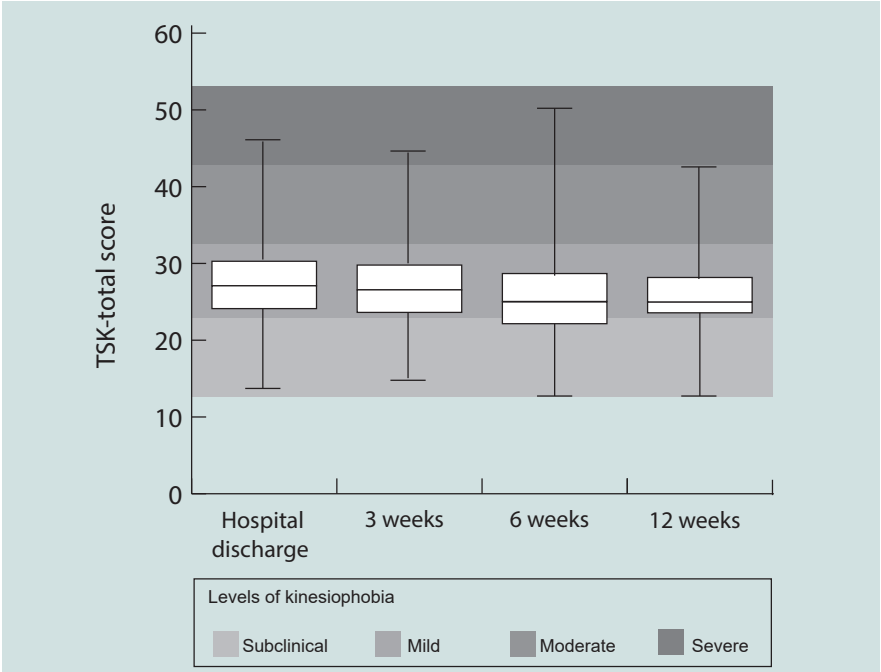


Figure 2. Kinesiophobia at hospital discharge, 3,6 and 12 weeks after hospital discharge (N=116)

Correlation matrix

Table 2 shows all correlations between Kinesiophobia (TSK- scores) and objectively measured PA. Small positive correlations were found between TSK-week 1 and Moderate PA-week12: $R^{spearman}$: 0.21 (95% CI: 0.01 to 0.39), TSK-week 6 and Moderate PA-week 3: $R^{spearman}$: 0.22 (95%CI: 0.03 to 0.40), TSK-week 6 and Heavy PA WK 3: $R^{spearman}$: 0.19 (95% CI: 0.02 to 0.40), and TSK-week 6 and Heavy PA-week 6: $R^{spearman}$: 0.23 (95%CI: 0.04 to 0.40) .

Random Intercept Cross Lagged Panel Model

Large statistically significant autoregressive effects ($\beta > 0.5$) for kinesiophobia and total PA were found at all occasions, indicating the presence of large carry-over effects from one occasion to the next. Patients who had elevated levels of total PA at time=t were also likely to have elevated levels of total PA at time=t+1. Similar carry-over effects were found for total PA. One small cross-over effect was found from Total PA-week1 to TSK-Week3: $\beta = 0.15$ (95%CI: 0.01 to 0.29) indicating that total physical activity at three weeks was associated with increased kinesiophobia at 6 weeks. Model fit for this model was poor (Chi Square = 44.646 P<0.001) (**Table 3**). This model is presented in **Figure 4**.

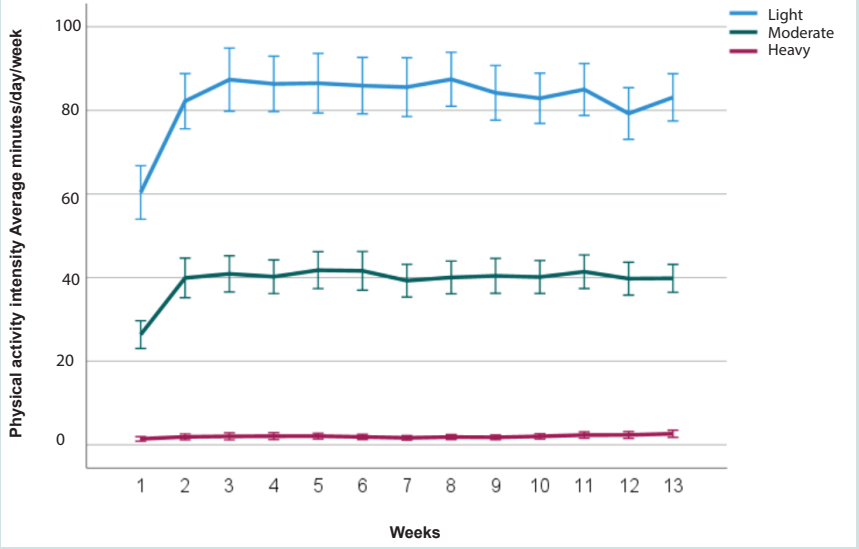


Figure 3. Physical activity scores (per day/per week) measured with the Personal Activity Monitor (PAM) (N=116)

Table 2. Correlational analyses between kinesiophobia (TSK) and Physical activity (PA)

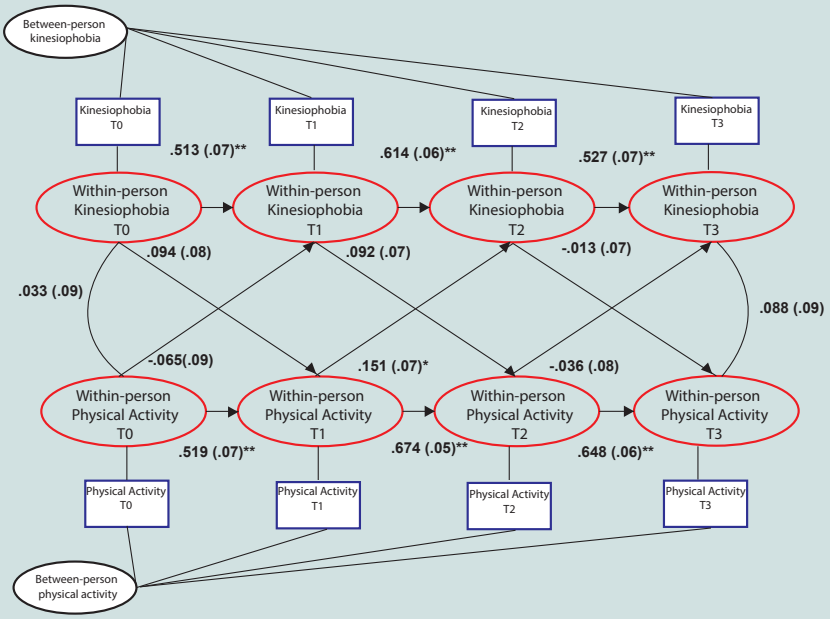
	TSK week 1	TSK week 3	TSK week 6	TSK week 12
Light PA week 1	-,046	,090	,096	-,010
Light PA week 3	,103	-,005	,114	-,051
Light PA week 6	-,003	,066	,077	-,057
Light PA week 12	,022	,036	,049	,037
Moderate PA week 1	,000	,047	,127	-,014
Moderate PA week 3	,135	,034	**,221***	,097
Moderate PA week 6	,114	,112	,173	,096
Moderate PA week 12	**,210***	,034	,061	,078
Heavy PA week 1	-,083	-,028	,098	,025
Heavy PA week 3	,016	-,010	**,191***	,102
Heavy PA week 6	,061	,121	**,233***	,128
Heavy PA week 12	**,189***	,080	,108	**,229***

* Correlation is significant at the level of <0.05 (2-tailed),
PA= Physical activity
TSK = Tampa Scale for Kinesiophobia

Table 3. Random intercept cross lagged panel model

	Standardized Beta (95% CI)	S.E.	EST./S.E.	Two Tailed P-value
Cross lagged and autoregressive effects				
Independent variable	**Dependent variable**			
	TSK week 3			
TSK week 1	0.53 (0.40 to 0.66)	0.067	7.981	0.000
PA week 1	0.12 (-0.03 to 0.27)	0.078	1.521	0.128
	TSK week 6			
TSK week 3	0.61 (0.50 to 0.73)	0.057	10.755	0.000
PA week 3	0.15 (0.01 to 0.29)	0.071	2.120	0.034
	TSK week 12			
TSK week 6	0.53 (0.39 to 0.66)	0.068	7.767	0.000
PA week 6	-0.04 (-0.19 to 0.12)	0.080	-0.449	0.653
	PA week 3			
TSK week 1	0.09 (-0.6 to 0.25)	0.079	1.190	0.234
PA week 1	0.52 (0.39 to 0.65)	0.068	7.663	0.000
	PA week 6			
TSK week 3	0.09 (-0.04 to 0.23)	0.068	1.356	0.175
PA week 3	0.67 (0.58 to 0.77)	0.050	13.348	0.000
	PA week 12			
TSK week 6	-0.01 (-0.15 to 0.13)	0.071	-0.182	0.856
PA week 6	0.65 (0.54 to 0.76)	0.055	11.851	0.000
Model fit				
Chi Square = 44.646 P<0.001 DF = 12				

TSK = Tampa Scale for Kinesiophobia,
PA = total physical activity (light + moderate + heavy) (per day/per week),
DF = degrees of freedom



Chi Square = 44.646 P<0.001
DF = 12
T0 = week 1 (hospital discharge)
T1 = 3 weeks post hospital discharge
T2 = 6 weeks post hospital discharge
T3 = 12 weeks post hospital discharge

Figure 4. Random intercept model kinesiophobia and objectively measured physical activity

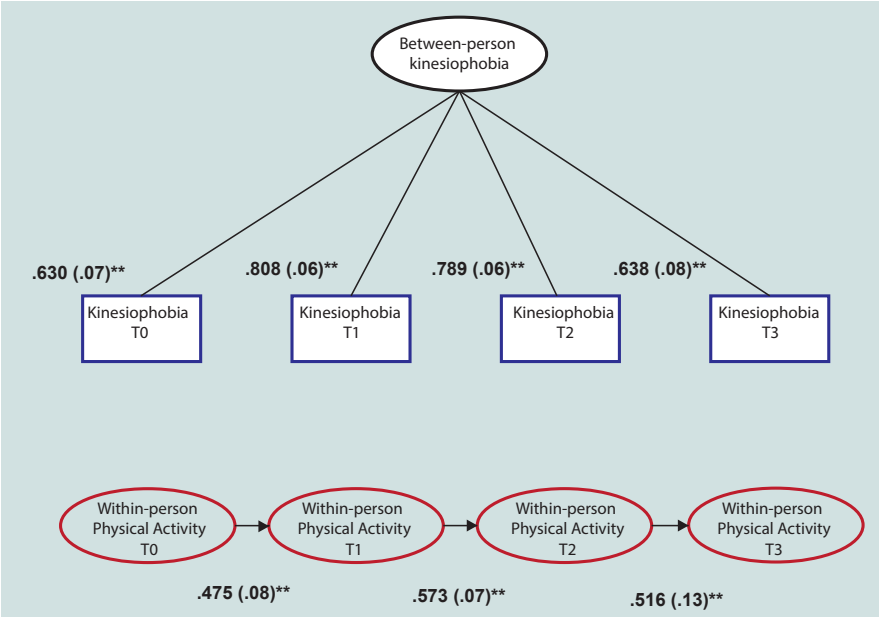
Alternative model: Random Intercept model without cross lagged effects

As described above (see demographics and clinical characteristics) kinesiophobia scores decreased slightly, but significantly. Therefore, after evaluation of the previous model, a new model was proposed by the researchers, where kinesiophobia was modelled as a random intercept (latent variable) and PA as autoregressive variable. This resulted in a model with good model fit (Chi Square = 27.541, P<0.12) (**Table 4**). This model assumes that kinesiophobia is stable over time and is considered a trait-like construct while PA is considered as a dynamic process with PA levels varying over time. No association was found between objectively measured PA and kinesiophobia. This model is presented in **Figure 5**.

Table 4. Random intercept model without cross lagged effects

	Standardized Beta (95% CI)	S.E.	EST./S.E.
Random intercept TSK			
TSK week 1	0.63 (0.49 to 0.78)	0.074	8.511
TSK week 3	0.81 (0.69 to 0.92)	0.059	13.747
TSK week 6	0.79 (0.67 to 0.91)	0.059	13.333
TSK week 12	0.64 (0.49 to 0.78)	0.075	8.539
Autoregressive effects			
PA week 3 by PA week 1	0.48 (0.32 to 0.64)	0.082	5.831
PA week 6 by PA week 3	0.57 (0.43 to 0.71)	0.072	7.959
PA week 12 by PA week 6	0.52 (0.26 to 0.77)	0.129	4.003
Model fit			
Chi Square = 27.541 P<0.12 DF = 20			

TSK = Tampa Scale for Kinesiophobia
PA = total physical activity (light + moderate + heavy) (per day/per week)
DF = Degrees of freedom
All effects P <0.0001



Chi Square = 27.541 P<0.12
DF = 20
T0 = week 1 (hospital discharge)
T1 = 3 weeks post hospital discharge
T2 = 6 weeks post hospital discharge
T3 = 12 weeks post hospital discharge

Figure 5. Random intercept model without cross lagged effects

DISCUSSION

The results of this study show that kinesiophobia and objectively measured PA are not associated with each other in the first 12 weeks after hospital discharge. In addition, we found that kinesiophobia remains stable over time and might be seen as a trait, while light and moderate PA-levels increased over time, especially in the first weeks after hospital discharge.

Concerning the association between kinesiophobia and objectively measured PA, contradictory findings are reported in the literature. A recent study, in patients with low back pain, also shows that kinesiophobia is not associated with objectively measured PA, measured with an accelerometer (7). In addition, other studies did not find an association between physical capacity measures such as walking endurance and maximal oxygen consumption and kinesiophobia (18-20). In contrast, Bäck et al, found that patients with high levels of kinesiophobia took fewer steps than those without kinesiophobia 3 to 10 months after cardiac hospitalization (2). In addition, Bäck et al reported that cardiac patients with high

levels of kinesiophobia avoid high levels of (self-reported) PA (2). In our study, we found that in the first 12 weeks after hospital discharge all patients avoid activities with high intensity. An explanation might be that patients are physically active but only avoid certain activities that cause distressing body signals, which are in turn related to kinesiophobia (4). The results of our study support the absence of an association between kinesiophobia and objectively measured PA in the first 12 weeks after hospital discharge. An explanation for these different findings, might be that all cardiac patients perform less PA in the first weeks after cardiac hospitalization, thereby making discrimination between patients with and without kinesiophobia difficult. Nevertheless, kinesiophobia is consistently associated with disability (8, 21). In our previously conducted path analysis, we found an association between kinesiophobia, anxiety, educational level and self-efficacy, which are in turn associated with disability (22, 23).

In this study, we used a random intercept cross-lagged panel model to account for between-patient unobserved heterogeneity by decomposing the data into *between-person* and *within-person* variation at various time points. Our final model clearly showed that kinesiophobia is best explained as a stable between-factor and PA-intensity as a dynamic process. This is an important finding and suggests that high levels of kinesiophobia might continue to exist in the months after hospital discharge.

Although the results of our study suggest that kinesiophobia does not impact PA, it is important to target kinesiophobia since patients with kinesiophobia have less self-efficacy, higher levels of anxiety and are less likely to initiate cardiac rehabilitation (6, 24). Our previous qualitative study revealed that kinesiophobia is related to negative beliefs about PA ("*By being careful with unnecessary movements I can prevent my heart problems from worsening*" and "*If I tried to be physically active/ exercise my heart problem would increase*"). This study also showed that patients who were exposed to PA, and supported by an informal caregiver during PA in the early phase after hospital discharge, had lower levels of kinesiophobia (4). Gradual exposure to PA after cardiac hospitalization might improve kinesiophobia. Currently, kinesiophobia, in patients with musculoskeletal complaints, is targeted with exposure in vivo (25, 26). Exposure in vivo, in the form of CR, might help to alleviate fear avoidance beliefs in cardiac patients by gradually exposing patients to PA and thereby altering negative beliefs about PA (27). Unfortunately, exposure to PA, under the guidance of an experienced physical therapist, is limited to those that are referred to CR. Therefore, adequate referral to CR of those with high levels of kinesiophobia is important.

Strengths and limitations

This study has several strengths. First, we explored the association between kinesiophobia and PA using a longitudinal design. The longitudinal design allowed us to explore the nature and reciprocity of kinesiophobia and PA after cardiac hospitalization. Second, using the PAM sensor allowed us to measure PA-intensity instead of step-count and thereby giving more detailed insight of PA-patterns

in the first 12 weeks after hospital discharge. Third, the RI-CLPM in which we decomposed our data in a *between* and *within* part, enabled us to capture individual fluctuations and account for unobserved heterogeneity.

Some aspects of this study need consideration. First, in this study we investigated the relation between kinesiophobia measured with the TSK-NL Heart. Although the TSK-NL Heart has been found reliable and valid, it might not capture the whole construct of kinesiophobia (28). The results of our qualitative study suggest that kinesiophobia is related to distressing body signals, inconsistent information and passive coping style (4). Future studies should therefore consider testing the association of PA measures with other fear-related constructs such as: the cardiac anxiety questionnaire (CAQ) or fear avoidance beliefs questionnaire (FABQ). Second, patients were included in this study at hospital discharge. In the first phase after hospital discharge, patients with no kinesiophobia also might have low PA-levels, which makes discrimination between patients difficult. Future studies should assess changes in PA and kinesiophobia scores over a longer times period. Third, a substantial proportion of patients (38.3%) dropped out of this study which might have led to a selection of patients and might have influenced our findings. It's unknown of those that dropped out of this study had higher levels of kinesiophobia. Nevertheless, a variety of TSK-scores and PA-levels were found in our sample and was therefore deemed sufficient to explore the association between kinesiophobia and PA. Future studies should also evaluate the use of graded exposure to improve fear avoidance beliefs in patients with kinesiophobia in studies with a randomized design.

CONCLUSION

Kinesiophobia is not associated with objectively measured physical activity in the first 12 weeks after hospital discharge. Levels of kinesiophobia remained stable during this study. physical activity, on the other hand, is a dynamic process in time. In the first 12 weeks after hospital discharge light and moderate levels of PA fluctuated while high levels of PA were avoided by patients. Future studies should investigate the association between kinesiophobia and PA, using different anxiety measures and over a longer time period.

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APPENDIX 1

Missing data analyses

In this study, data were collected at 4 timepoints (hospital discharge, 3 weeks, 6 weeks and 12 weeks). Patients were included in the analyses if they completed the TSK-Heart NL questionnaire on at least one of the abovementioned timepoints. In total, 188 patients were assessed for eligibility. After inclusion, 149 patients completed the TSK-NL Heart questionnaire on at least one timepoint. Missing values of the TSK-NL Heart were: hospital discharge: 34 (22.8%), 3 weeks 37: (24.8%), 6 weeks: 42 (28.2%), 12 weeks: 54 (36.2%). Of the 149 patients, 33 (22.1%) did not wear the PAM Accelerometer. In total, 116 patients were included in the final sample. In the PAM Accelerometer data, the total amount of missing data was 14.4%. Little's MCAR test was used to determine patterns of missing data and showed that the data were at least missing at random (MAR) (Little's MCAR Test $p > 0.05$). Full conditional specification multiple imputation (FCS-MI) was used to impute missing data in ten datasets. Data were pooled using Rubin's Rules (1).

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PART 3

Bridging the gap from hospital discharge to the start of cardiac rehabilitation

Chapter 7

Design of an early remote coaching program to bridge the gap from hospital discharge to the start of cardiac rehabilitation

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ABSTRACT

Background: Remote coaching might be suited for providing information and support to patients with coronary artery disease (CAD) in the vulnerable phase between hospital discharge and the start of cardiac rehabilitation (CR).

Objective: The goal of the research was to explore and summarize information and support needs of patients with CAD and develop an early remote coaching program providing tailored information and support.

Methods: We used the intervention mapping approach to develop a remote coaching program. Three steps were completed in this study: (1) identification of information and support needs in patients with CAD, using an exploratory literature study and semi structured interviews, (2) definition of program objectives, and (3) selection of theory-based methods and practical intervention strategies.

Results: Our exploratory literature study (n=38) and semi structured interviews (n=17) identified that after hospital discharge, patients with CAD report a need for tailored information and support about CAD itself and the specific treatment procedures, medication and side effects, physical activity, and psychological distress. Based on the preceding steps, we defined the following program objectives: (1) patients gain knowledge on how CAD and revascularization affect their bodies and health, (2) patients gain knowledge about medication and side effects and adhere to their treatment plan, (3) patients know which daily physical activities they can and can't do safely after hospital discharge and are physically active, and (4) patients know the psychosocial consequences of CAD and know how to discriminate between harmful and harmless body signals. Based on the preceding steps, a remote coaching program was developed with the theory of health behavior change as a theoretical framework with behavioral counseling and video modeling as practical strategies for the program.

Conclusions: This study shows that after (acute) cardiac hospitalization, patients are in need of information and support about CAD and revascularization, medication and side effects, physical activity, and psychological distress. In this study, we present the design of an early remote coaching program based on the needs of patients with CAD. The development of this program constitutes a step in the process of bridging the gap from hospital discharge to start of CR.

INTRODUCTION

Cardiac rehabilitation (CR) is a cornerstone of secondary prevention and has been shown to reduce cardiovascular mortality and hospital readmissions and improve psychological well-being (1,2). Although early enrollment in CR is advised, patients with coronary artery disease (CAD) generally wait 4 to 6 weeks after hospital discharge before starting physical CR (3,4). This waiting period constitutes a gap between hospital discharge and the start of CR. Since patients are often discharged within 2 to 4 days, there is little room for patient education while patients are often in need of tailored medical information and support (5). In addition, symptoms of anxiety are present in 28% and depression in 18% of patients entering CR, which negatively impacts adherence to CR (6). While patients are sometimes offered educational support programs after hospitalization and prior to the start of CR that have been shown to increase knowledge and promote health behavior, these interventions are frequently neither initiated nor adhered to (7,8).

A potentially promising strategy for provision of information and support directly after hospital discharge is the use of a remote coaching program. In this study, remote coaching is defined as an online communication system used to provide medical, psychological, and social support to patients at home. Remote coaching programs, as part of a CR program, improve patients' physical capacity, clinical status, and psychosocial health (9). Moreover, remote coaching has the potential of improving self-efficacy, which in turn is associated with improved CR adherence (10-12).

Nevertheless, it is unknown whether remote coaching meets patients' needs in the early phase (ie, gap) after hospital discharge. If the specific information and support needs in the early phase after hospital discharge are known, a remote coaching program to bridge the gap from hospital discharge to the start of CR can be developed.

Therefore, the objective of this study was to explore the information and support needs directly after hospital discharge among patients with CAD and develop an early remote coaching program to provide tailored information and support.

METHODS

Study Design

In this study, we used the intervention mapping (IM) approach, a systematic and comprehensive methodology grounded in theory and developed in collaboration with key stakeholders (health care providers, patients, and informal caregivers) (13, 14). The 6 steps of the IM approach are (1) identification of the problem by performing a needs assessment, (2) identification of outcomes and change objectives, (3) selection of theory-based intervention methods and practical strategies, (4) development of an intervention, (5) generation of an adoption and

implementation plan, and (6) generation of an evaluation plan. In this study, we completed the first 3 steps of the IM protocol.

The development of this remote intervention was performed on the existing platform of Cardiovitaal Cardiac Rehabilitation Amsterdam currently only used by patients who have started outpatient physical rehabilitation. This existing digital platform is used by patients to monitor physical (eg, blood pressure and steps per day) and psychological (symptoms of anxiety and depression) health. In addition, patients and health care providers use this platform to communicate using videocalling or the chat function. The design of the early coaching program was incorporated in the existing digital platform. At the beginning of this study, a multidisciplinary research group of health care providers comprised physical therapists (PK, ICDvD), physical therapist (Ilonka Pol), psychologist (VRJ), cardiologist (RAK), and registered nurse (Christine Dolman). All participants had expertise in the field of CR. The research group met on 3 occasions to discuss each step. The authors (PK and ICDvD) completed each step only after group consensus was reached. During each step the following tasks were completed.

Step 1. Logic Model of the Problem

The overall objective of step 1 was to define a logic model of the problem. The information and support needs of patients with CAD were investigated with an exploratory literature review and semistructured interviews with key stakeholders.

On the basis of these findings, a logic model of the problem was created using the Predisposing, Reinforcing, and Enabling Constructs in Educational Diagnosis and Evaluation (PRECEDE) model, which is used as framework to identify intervention strategies (15). After completion of the model, program objectives and outcomes were formulated by the research group. Based on these findings, outcomes and change objectives were formulated in step 2.

Step 2. Logic Model of Change

The overall objective of step 2 was to define a logic model of change. First, expected outcomes were formulated based on the results of step 1. These outcomes concern behavioral outcomes (outcomes related to the patient level) and environmental outcomes (outcomes related to the social network of the patient and health care setting). Second, based on the outcomes, we formulated program objectives. In the IM approach, these are formulated as performance objectives (outcomes that describe the desired behavior). Performance objectives were formulated at the patient and environmental level. Third, the research group selected determinants to influence during the intervention and created matrices of change objectives. Finally, a logic model of change was created. The logic model of change and matrices of change form the basis of this intervention and were further elaborated on in step 3 where they were matched with theory-based intervention methods and practical strategies.

Step 3. Program Design
The overall objective of step 3 was to select theory-based intervention methods and practical strategies as ingredients for an intervention. As starting point for IM step 4, a preliminary design of an intervention was developed. Consecutive tasks were completed by the research group. First, based on the preceding steps, the overall themes, components, and sequence of the intervention were determined. Second, theory- and evidence-based change methods were selected and matched with the overall themes and components of the intervention. Third, the research group discussed and selected practical applications to deliver the intervention. Last, the design of the intervention was presented.

Study Population
For this study, patients were identified through an electronic patient file search of the Amsterdam University Medical Center and approached by telephone shortly after hospital discharge (2 to 4 days). We aimed to include a heterogenous sample to obtain a wide variety of viewpoints to increase the generalizability of our program.

We included patients with an acute coronary syndrome (ACS), coronary revascularization (percutaneous coronary intervention (PCI) or coronary artery bypass grafting (CABG)), or referral to CR. Patients were excluded if they had cognitive problems (Mini-Mental State Exam <24) or were unable to speak Dutch. Recruitment of patients ended when no new information was discovered in the data analysis (data saturation).

Ethics Approval
The Medical Ethics Committee of the Amsterdam University Medical Center approved the study protocol (NL65218.018.18).

Exploratory Literature Study
An exploratory literature review synthesizes the extant literature and usually identifies the gaps in knowledge that an empirical study addresses (16). The objective of our exploratory literature review was to assess information and support needs after (acute) cardiac hospitalization. A comprehensive search was performed in PubMed to identify relevant studies concerning this topic. For this search, automatic term mapping was used to match the entered terms with Medical Subject Headings to enhance the search strategy. The following terms were used in the search builder: (coronary artery disease) OR (acute coronary syndrome) OR (percutaneous coronary intervention) OR (coronary artery bypass graft) AND (information needs OR support needs). The search strategy included terms occurring in the title and main text with no restrictions for date range but limited to the English language. During the screening process, articles were selected on title, abstract, and full text. The literature search was conducted by ICDvD and continuously discussed with PK and BV.

Semistructured Interviews

Semistructured interviews were conducted to assess patients' information and support needs. An interview guide was developed by the research group, in several rounds, until

consensus was reached about the final version (**Multimedia Appendix 1**). These 30-minute interviews took place at the Amsterdam University Medical Center or at the patient's home. During the COVID-19 pandemic, interviews were continued by telephone. All patients gave informed consent for their personal data being used in this study. Interviews were performed by 2 physical therapists (PK and ICDvD), a physician assistant (Tarik Hoek Spaans), and 2 registered nurses (Bonita Meek and Miranda Balfoort).

All interviews were transcribed and were analyzed with qualitative data analysis software (MAXQDA 2018, VERBI GmbH). Three types of coding were used consecutively: open, axial, and selective. Initial codes were created by studying the segmented information. The codes were then abstracted into categories and subcategories. The underlying meanings of these categories were linked together to create overall themes. All data were independently coded for themes by 2 researchers (PK, ICDvD). A third researcher (BV) reviewed all codes and decided appropriate themes together with PK and ICDvD.

RESULTS

Step 1. Logic Model of the Problem

The initial exploratory literature search identified 4606 electronic database papers. After removal of duplicates and non-English articles, the remaining papers were screened by title and abstract. After the screening procedure (see Figure 1 for flowchart), 38 articles were studied to identify the information and support needs of cardiac patients (see **Multimedia Appendix 2** for an extraction table of our literature search). Patients report a lack of (consistent) information after hospital discharge and that information needs were not always correctly perceived by health care providers (17-19). The highest priority of information needs comprised information about medication and side effects, wound care, postoperative pain, physical activity, and dealing with emotions (20-28). The greatest needs of information were found in young and middle-aged patients with a higher education (20,21). No differences in type of information needs were found between men and women; however, women preferred to receive information before revascularization while men preferred it afterward (29,30). Patients who were hospitalized after an acute coronary event were in greater need of information and emotional support than those treated electively (31). High levels of anxiety were reported in the weeks after hospital discharge, especially in female patients and those with a lower education (32,33). Patients reported distressing body signals, difficulties with sleeping, and insecurity about engaging in physical activity and returning to work (20,32,34-36). Spouses reported high levels

of psychological distress linked to anxiety, financial worry, and loneliness (37-39), highlighting a need to include spouses and informal caregivers in decision making and support programs (40-42).

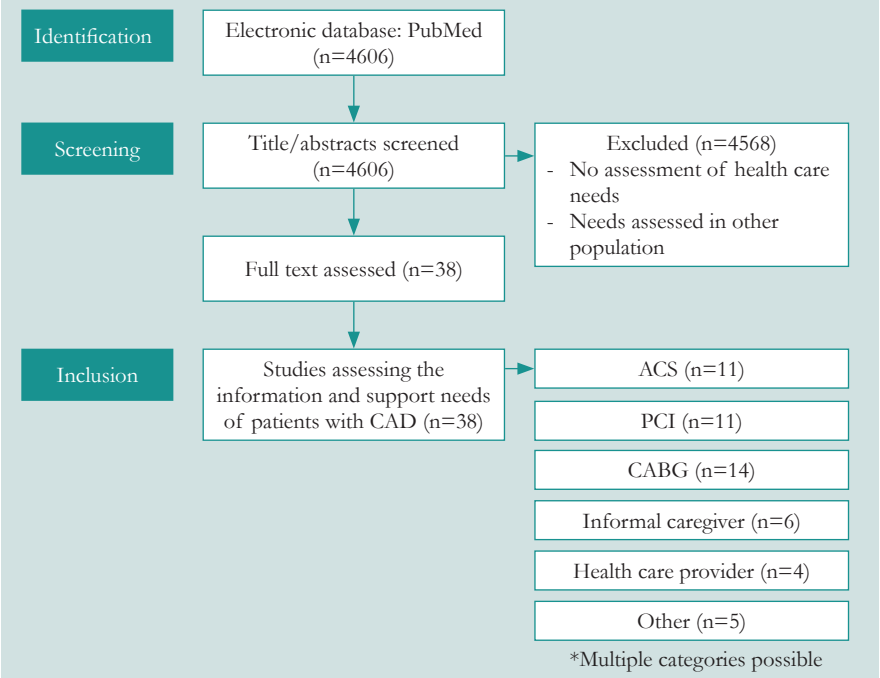

Figure 1. Flowchart of study. ACS: acute coronary syndrome; CABG: coronary artery bypass grafting; CAD: coronary artery disease; PCI: percutaneous coronary intervention.

In general, patient knowledge about risk factors and management of heart disease was limited, and patients often attributed the cause of their disease to nonmodifiable risk factors (ie, age, heredity) instead of lifestyle factors such as smoking, lack of physical activity, and unhealthy food choices (43-46). However, reduction of mortality risk was rated as most important by patients with ACS (47). In addition to having difficulties with understanding medical information, patients experienced problems with the referral process from hospital discharge to CR, which in turn led to a discontinuity in the health care process (48). Those with a lower socioeconomic status felt especially excluded from CR while also having high information needs (49). Moreover, these patients tended to have health beliefs that were not based on medical evidence, a predictor of nonadherence to CR (50,51). Patients described advanced communication skills and pedagogical competences as important skills for health care providers (52). Furthermore, the ability to build trust and tailor information to the individual were described by patients as important skills for health care providers (53,54).

Interviews

Data saturation was achieved after 17 eligible patients were included. Ten patients participated in an interview at the hospital or at home, and 7 patients took part in telephone interviews. Our total study population comprised 17 patients (9 females) with a median age of 64 years. Ten patients were diagnosed with ACS and 7 patients with angina pectoris. An overview of baseline characteristics is presented in **Table 1**. Our data revealed 6 main themes: psychological distress, distressing body signals, lack of information at hospital discharge, passive coping style, disrupted health care process after hospital discharge, and social support. Qualitative findings with reference to individual patients can be found in **Table 1**.

Table 1. Baseline characteristics

Patient	Sex	Age range (years)	Diagnosis/ intervention	Cardiac disease history	Comorbidity
1	Male	60-69	NSTEMI[a]/PCI[b]	Stroke, hypertension	HIV
2	Female	70-79	STEMI[c]/PCI	Hypertension, hypercholesterolemia	Hypothyroid
3	Male	80-89	NSTEMI/PCI	AF[d]	—[e]
4	Male	70-79	NSTEMI/PCI	Hypertension, hypercholesterolemia	Urothelial carcinoma
5	Male	50-59	STEMI/PCI	Hypertension, hypercholesterolemia	—
6	Male	60-69	STEMI/PCI	—	—
7	Female	70-79	AP[f]/PCI	Stroke	Hypothyroid, cholelithiasis
8	Female	50-59	STEMI/PCI	—	—
9	Male	60-69	NSTEMI/PCI	Diabetes mellitus, hypertension, OSASg	Respiratory infection
10	Female	50-59	STEMI/PCI	Hypertension, hyperglycemia	—
11	Male	60-69	AP/CABG[h]	Stroke, hypertension	Rheumatic disease
12	Male	60-69	AP/CABG	—	—
13	Female	50-59	NSTEMI/PCI	Hypertension, hypercholesterolemia	Asthma, lumbar radicular syndrome
14	Female	50-59	AP/CABG	Stroke	Obesity
15	Female	60-69	AP/CABG	Complications during PCI, AF	—
16	Male	50-59	STEMI/PCI	—	Diabetes
17	Female	50-59	STEMI/PCI	—	Mixed connective tissue disease

[a]NSTEMI: non–ST-elevation myocardial infarction. [b]PCI: percutaneous coronary intervention. [c]STEMI: ST-elevation myocardial infarction. [d]AF: atrial fibrillation. [e]Not applicable. [f]AP: angina pectoris. [g]OSAS: obstructive sleep apnea syndrome. [h]CABG: coronary artery bypass grafting.

Psychological Distress and Distressing Body Signals

After hospital discharge, patients reported having symptoms of anxiety and depression. In addition, patients reported needing information and support on dealing with body signals such as fatigue, palpitations, and wound pain after thoracotomy or PCI. These body signals often made patients afraid to engage in physical activity, which in some cases led to fear of bodily sensations and patients monitoring their heartbeat. See **Multimedia Appendix 3** for the complete list of quotations.

> *I don't want to feel that pain anymore.* (P11, subcategory: wound pain/chest pain)
> *I don't dare to do anything.* (P16, subcategory: hypervigilance)
> *I monitor my heart rate.* (P17, subcategory: fear of bodily sensations)
> *Nothing will be the same again.* (P16, subcategory: depression)

Lack of (Consistent) Information at Hospital Discharge

Patients reported a lack of information at hospital discharge or stated that the information was vague or inconsistent. A major concern for patients was a lack of information about side effects of medication, which in some cases led to misinterpretation of body signals and revisiting the emergency room. Patients also reported that they did not know the amount of physical activity they were allowed to engage in after hospital discharge, resulting in reluctance to engage in any physical activity whatsoever. Patients reported needing to be reassured about the chance of a new cardiac event before hospital discharge. Not being reassured by a treating physician led, in some cases, to false beliefs about the procedure (eg, one patient believed a stent could shift in the artery by doing physical activity).

> *I felt a weird pressure on my chest, like my heart skipped a beat. I panicked, so I went back to the emergency room where they examined me. Afterward they told me it was a side effect of metropolol.* (P10, subcategory: side effects medication)
> *I don't know if I can do any physical activity and if I injure my body if do physical activity.* (P4, subcategory: physical activity)
> *One health care provider tells me this, the other tells me that.* (P1, subcategory: inconsistent information)
> *I really missed talking to my physician about what had happened to my heart before I left the hospital.* (P7, subcategory: cardiac event)

Passive Coping Style

After hospitalization, patients often developed a passive coping style by spending all their time on the couch or in bed. In several cases, the informal caregiver performed all household chores and therefore felt overloaded. This maladaptive coping strategy was attributed to psychological distress and the inability to cope with distressing body signals.

> *I'd rather be in bed all the time.* (P16, subcategory: inactivity)

> *I did not do anything for 6 weeks, I'm just staying in bed and on the couch, I can't do much more.* (P9, subcategory: inactivity)

Disrupted Health Care Process After Hospital Discharge

Patients reported problems with continuity of care, especially about the long interval between hospital discharge and the start of CR. For some patients, the relevance of CR was unclear, which made them reluctant to participate in CR.

I think the time between discharge and CR is too long. (P12, subcategory: time until CR)

> *What is there to rehabilitate about the heart?* (P2, subcategory: relevance of CR)
> *The referral to CR went completely wrong. It took ages before it was clear where I needed to go and what was expected. Thinking about this makes me short of breath again.* (P4, subcategory: negative experience hospital)

Social Support

In the phase after cardiac hospitalization, patients received support from their informal caregivers. In some cases, the caregiver was overprotective and took all physical tasks out of the hands of the patient. Although well intentioned, this has a negative effect, since it is necessary that the patient undertakes activities for optimal recovery. During the interviews, patients expressed their support needs and stated that receiving guidance and support, especially during physical activity or exercise, was paramount in regaining confidence.

> *If I do too much and I have complaints, my husband becomes angry and tells me to sit down.* (P10, subcategory: hypervigilance informal caregiver)
> *My husband does all the groceries and cooking and tells me to relax.* (P7, subcategory: hypervigilance informal caregiver)
> *I want to participate in CR to gain confidence so that afterward I can start exercising alone.* (P5, subcategory: CR)
> *I would feel anxious if I started exercising without guidance. It's about confidence. I can do it, but it would not feel right.* (P16, subcategory: CR)

Findings from the exploratory literature study and interviews were divided into the categories determinants, behavioral factors, health problems, and quality of life and compiled in the PRECEDE-based logic model of the problem by PK and IvD. After the research group discussed the model and proposed several adjustments, the final model was developed. The final model is presented in Figure 2. Based on the logic model of the problem, the overall goal was determined by the research group. The overall goal of this intervention is to bridge the gap from hospital discharge to CR by stimulating self-management behavior and providing tailored illness management information and psychological support to patients and their informal caregivers by means of a remote coaching program.

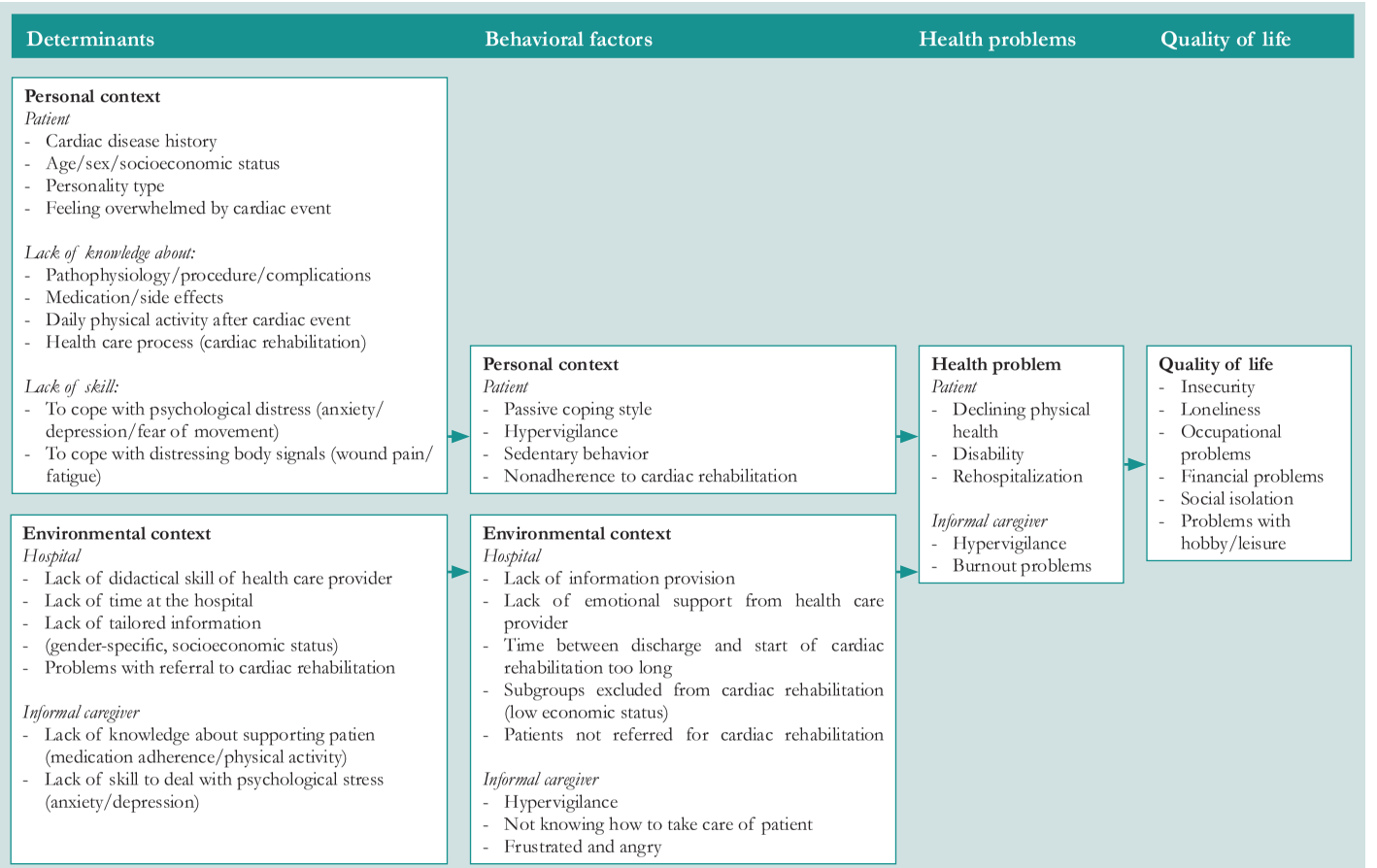

Figure 2. Logic model of the problem.

Step 2. Logic Model of Change

The logic model of change was developed based on the findings in step 1. First, behavioral and environmental outcomes were defined. Second, the influence of these outcomes on the health problem and quality of life was described. Third, performance objectives were formulated for the behavioral and environmental outcomes. Fourth, a theoretical framework and determinants to influence were selected. Last, a determinant matrix was developed that describes how each determinant is related to the performance objectives.

Behavioral Outcomes

Patients and informal caregivers actively prevent physical and psychological problems by adhering to a remote CR program in the first phase after hospital discharge.

Environmental Outcomes

The CR center supports patients and informal caregivers in the first 3 weeks after hospital discharge by providing tailored information and (emotional) support.

Program Objectives

Behavioral and Environmental Outcomes

For the behavioral outcomes, 4 performance objectives were formulated:

- Patients and informal caregivers gain knowledge on how CAD and revascularization affects their bodies and health
- Patients and informal caregivers gain knowledge about medications and side effects and adhere to their treatment plan
- Patients and informal caregivers know which daily physical activities they can and can't do safely after hospital discharge and are physically active
- Patients and informal caregivers can deal with the psychosocial consequences of CAD

For the environmental outcomes, 2 performance objectives were formulated:

- In the 3 weeks after hospital discharge, patients and informal caregivers needs are assessed by the health care professional
- Health care providers give tailored information and coach cardiac patients and their informal caregivers in the first phase after hospital discharge

Theoretical Framework

The research group chose the theory of health behavior change (THBC) and theory of planned behavior (TPB) as the theoretical framework for this intervention. The THBC is presented in Figure 3.

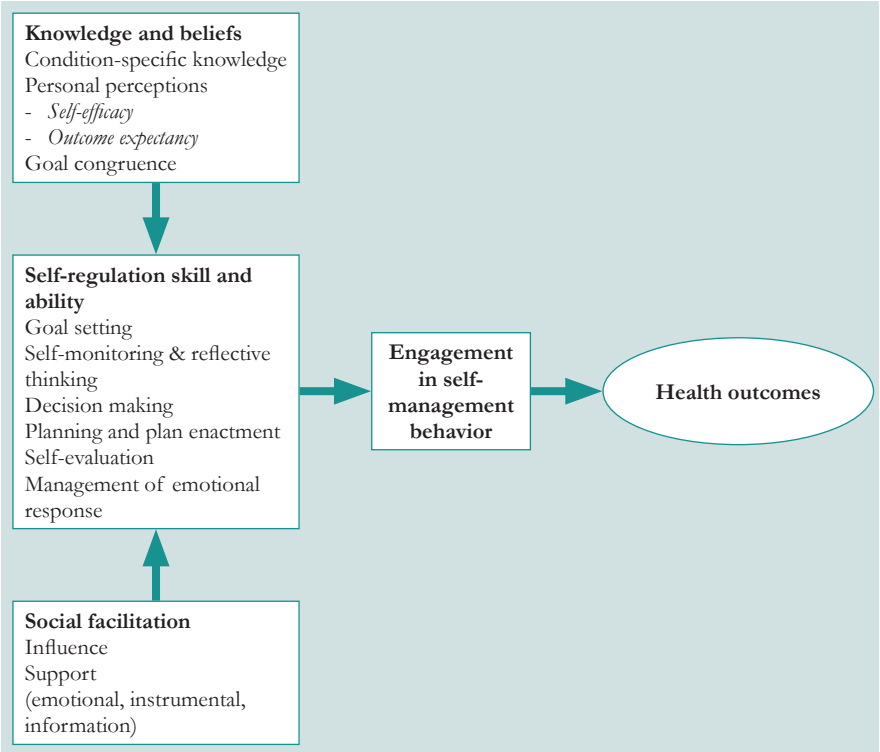

Figure 3. Theory of health behavior change

According to THBC, 3 main determinants influence the adoption of self-management behavior (55). These determinants are knowledge, self-regulatory skills, and abilities and social facilitation (55). The TPB links beliefs to behavior and states that an individual's behavioral intentions are shaped by attitude, subjective norms, and perceived behavioral control (56). According to these theories, knowledge is defined as part of an attitude toward a certain behavior, which in turn is based on personality traits, values, preference, and outcome expectancy. Self-regulatory skills refer to the process of incorporating behavior change in daily life (56). In this study, self-regulatory skills can be described as patients monitoring themselves (eg, body signals, emotions), goal setting (eg, performing daily physical activity), reflective thinking (eg, effects of cardiac event of health and quality of life), planning (eg, medication adherence, appointments with physician), decision making (eg, lifestyle habits), plan enactment (eg, setting feasible goals), self-evaluation, and management of emotions arising as a result of behavior (eg, feeling anxious or depressed). Social facilitation is divided in social influence and social support and refers to the health care provider providing credible information and social support to the patient and informal caregiver. Based on the core components of the THBC and TPB, the research group

chose the following determinants of influence for the remote coaching program: knowledge, skills, attitude, social influence, and self-efficacy. These determinants were used to create a matrix where all performance objectives were described per determinant. A detailed description of all determinants is presented in Multimedia Appendix 4. The last task of step 2 was to create a model of change which represents the relationship between the determinants, performance objectives, and desired outcomes (**Figure 4**).

Step 3. Program Design

The results from step 2 were used to design the program. In this step, the research group matched the 6 determinants and performance objectives with theory-based and practical strategies, in line with the IM taxonomy (57). The selection of theory-based strategies was based on the theoretical framework of Kok et al (57); please see this paper for a detailed explanation of the theory-based strategies.

Selection of Theory-Based and Practical Strategies Before specifically discussing the program objectives in relation to their determinants, the research group freely discussed the program design of this intervention based on the findings in step 1 and 2. The research group agreed that a remote coaching program to bridge the gap between hospital discharge and the start of CR was relevant. The research group defined 2 core elements of the program: behavioral counseling and increasing knowledge by using health video clips.

Behavioral Counseling Health care providers will contact patients and informal caregivers within 2 days after hospital discharge using an eHealth platform. The use of an eHealth platform allows patients and informal caregivers to access information and support from the confines of their own home. During these counseling sessions, which last for about 60 minutes, informal caregivers are invited to join since many of them are in need of information and support. During these sessions, the health care provider assesses the information and support needs of patients and informal caregivers. Many informal caregivers struggle with feelings of psychological distress (37,38). The role of the informal caregiver in these sessions is twofold. During the consultation sessions, the health care provider addresses the psychological stress in patients and informal caregivers. The emphasis is placed on influencing the participant's attitude by looking at negative situations and beliefs from a different perspective using shifting perspective and belief selection as the main behavioral change strategies. In addition, the informal caregiver is invited to stimulate healthy behavior in the patient (such as stimulating physical activity) by using "shifting away from unpopular behavior" as strategy. Self-regulation skills, such as goal setting and monitoring, are trained by using cognitive behavioral techniques and motivation interviewing.

Health Video Clips The research group proposed the use of health video clips in addition to behavioral counseling to increase knowledge. These video clips provide

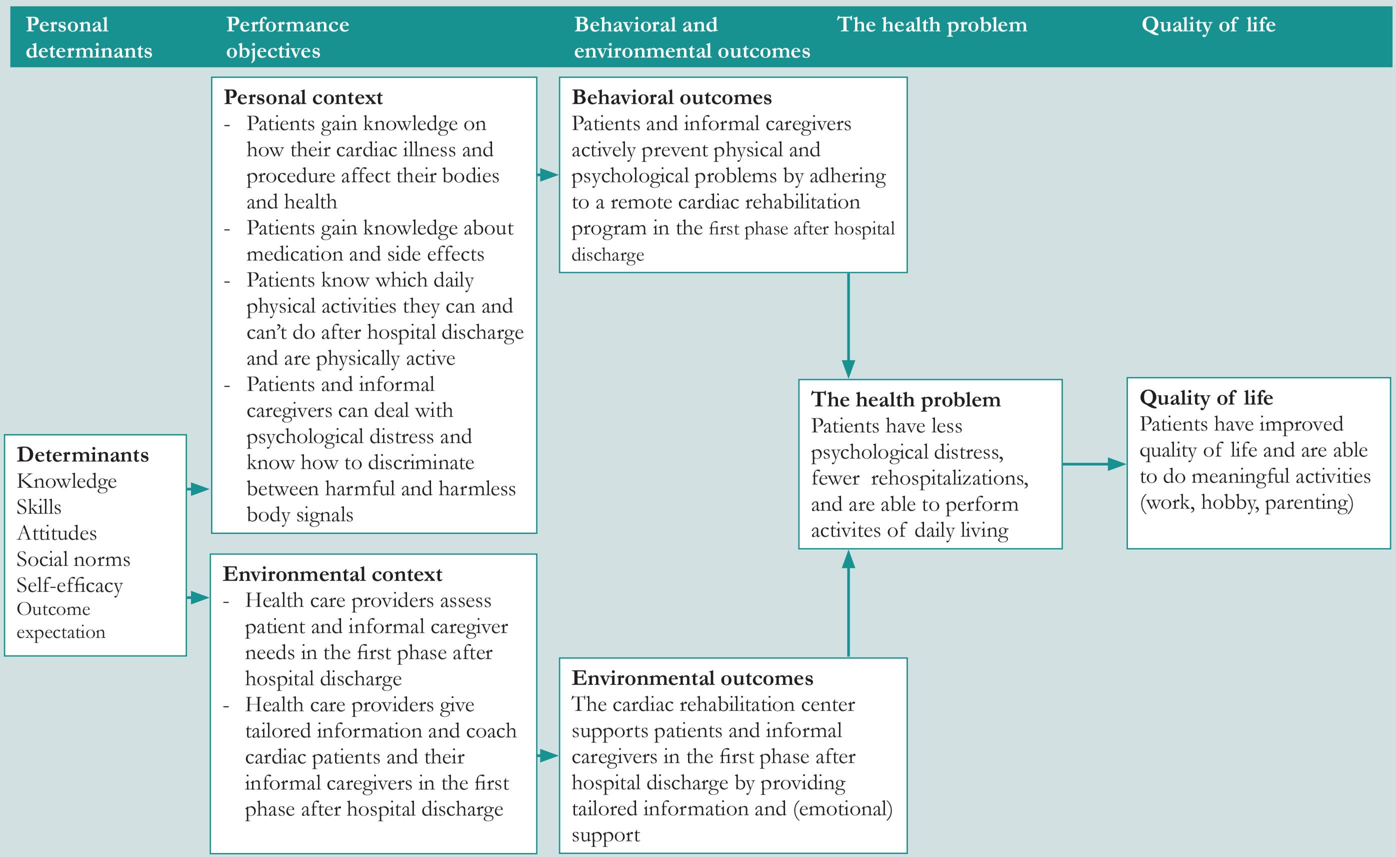

Figure 4. Logic model of change

basic knowledge about a variety of topics collected in step 1 and 2. Together with a cardiologist (RK), we created video clips about CAD and PCI, CAD and CABG, and medication and side effects. The physical therapist (Ilonka Pol) created a video clip about physical activity, and the psychologist (VJ) created a video clip about psychological distress. These video clips are used as a prerequisite to influence self-regulatory skills. All 5 health video clips are accessible for all patients at any time. The health care provider encourages the patient to access these clips before the coaching sessions. The knowledge obtained in the video clips is discussed during the remote coaching sessions and tailored to the specific situation and needs of the patient or caregiver. The theory-based strategies applied in the health video clips are persuasive communication, imagery, and elaboration. Based on the knowledge obtained by patients in these clips, the health care provider can apply the following strategies during consultation: setting goals, reattribution training, self-monitoring behavior, improving physical and emotional states, and setting graded tasks. A comprehensive overview of all strategies is presented in **Multimedia Appendix 5**.

Intervention Plan

Remote Coaching Program

The eHealth platform can be accessed by patients using a personal computer or mobile device (smartphone or iPhone). Important prerequisites to using this eHealth platform are ability to use the camera on their device and some basic knowledge about accessing an internet platform. The research group proposes a 3-step coaching trajectory. In the first phase, the patients' and informal caregivers' needs are assessed, and additional information and support are provided depending on the patients' and informal caregivers' needs. After the first session, the patient can access the health information clips on the eHealth platform to obtain knowledge about a variety of topics (CAD and PCI/CABG, medication and side effects, physical activity, psychological distress, and distressing body signals). During the second session, the health care provider reflects on the obtained knowledge and tailors it to the needs of the patient and informal caregiver if needed. In addition, the health care provider challenges and helps the patient and informal caregiver to formulate short-term goals for the first phase after hospital discharge. In the last session, the health care provider and patient reflect on the patient's progress since hospital discharge and whether short-term goals are reached. During this session, the health care provider helps the patient in formulating long-term goals for after the CR program. If the patient needs more guidance after the third coaching session, more sessions will be planned. The final intervention plan is presented in **Table 2**.

Table 2. Intervention plan

Strategies	Content	Target group
Before the intervention		
1. Assessing patients' needs	Mandatory workshop Objective: Learning to perform a comprehensive assessment to assess the needs of patients and informal caregivers.	Health care provider
2. Changing the behavior of patients	Mandatory workshop Objective: Learning how to coach patients and informal caregivers by using evidence based behavior change techniques (such as motivational interviewing).	Health care provider
During the intervention		
1. Consult health care provider	Coaching session 1 Objectives: Assessing information- and support needs of patients and informal caregiver. Getting acquainted with coach, eHealth portal and CR[a].	Patient & informal caregiver
2. Accessing digital health information	Health videoclips Objectives: Gaining detailed information about coronary CAD[b], medication, physical activity, psychological distress and body signals.	Patient & informal caregiver
3. Consult health care provider	Coaching session 2 Objectives: Health care provider, patient and informal caregiver reflect on health videoclips and formulate short term goals for the period between hospital discharge and starting cardiac rehabilitation.	Patient & informal caregiver
4. Consult Health care provider	Coaching session 3 Objectives: Health care provider, patient and informal caregiver reflect on short term goals and progress. Health care provider and patient formulate long term goals for during and after cardiac rehabilitation.	Patient & informal caregiver

[a] Cardiac Rehabilitation

[b] Coronary Artery Disease

In summary, after hospital discharge, patients are approached by a health care provider and gain access to an eHealth platform. During the first session, the patients' information and support needs are assessed. On the eHealth platform, patients are coached by a health care provider and can access information videos. After the first 4 to 6 weeks, patients continue CR at the CR center or remotely. A flowchart of the intervention is presented in Figure 5.

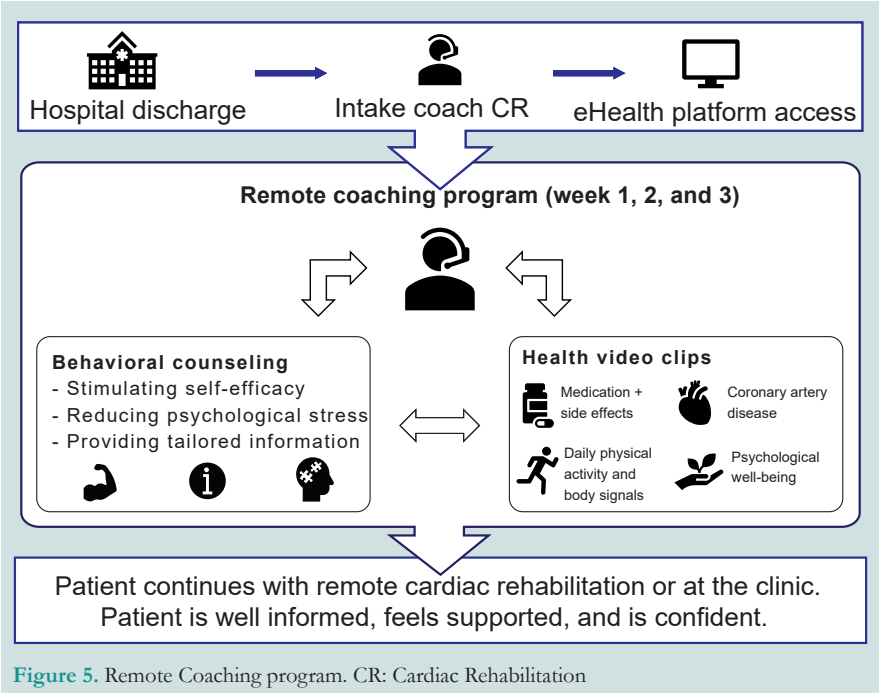

Figure 5. Remote Coaching program. CR: Cardiac Rehabilitation

Design and Implementation of the Intervention

After using the IM protocol to create the content of the program, the final intervention was developed. For this intervention, an existing eHealth app from Cardiovitaal Cardiac Rehabilitation Amsterdam was used. After hospital discharge, patients could access this platform to find information and consult with a health care provider before the start of the outpatient CR program. A screenshot of the eHealth platform is presented in **Multimedia Appendix 6**.

Five health video clips were created together with health care providers who work at the CR center:

- CAD and CABG
- CAD and PCI
- Physical activity after cardiac hospitalization
- Psychological distress after CR
- Medication and side effects

A screenshot of the video clip CAD and PCI is provided in **Multimedia Appendix 7**, and a screenshot of the video clip physical activity after cardiac hospitalization is provided in **Multimedia Appendix 8**.

DISCUSSION

Principal Findings

The results of this study suggest that patients' needs, after hospital discharge, comprise information and support about the following topics: CAD, medication and side effects, daily physical activities, psychological distress, and body signals. In addition, we present a systematic approach to develop an early remote coaching program using the IM protocol. The overall objective of this remote coaching program is to bridge the gap from hospital discharge to the start of center-based CR by stimulating self-management behavior and influencing the following determinants: knowledge, skills, social support, attitudes, and self-efficacy. We selected theory-based techniques that match these determinants, as research indicates the value of theory-based interventions (57,58). Moreover, patients were actively involved in the development of this coaching program. To assure adoption of the intervention, patients have been asked to participate in the future refinement of the final intervention in step 4 of the IM approach.

Comparison With Prior Work

A recent systematic review reports that core components of CR, such as nutrition counseling and psychological and weight management are addressed in one-third of digital CR programs; less than one-third of these programs address management of lipids, diabetes, smoking cessation, and blood pressure (59). Since our CR program aims to bridge the gap between hospital discharge and the start of CR, we chose to assess the needs of patients in the early phase after hospital discharge. Our study shows that in this phase patients value social support, disease specific information, and information about physical activities and psychological distress. Research shows that health care needs change over time. Nevertheless, knowledge about pathology and how to manage psychological distress remain important even after a 2-year follow-up period (60).

Based on our results, we developed a comprehensive coaching program using remote counseling as the main strategy and considered its positive impact on psychosocial health, physical health, and clinical status (9-11). In this study, we chose to complement behavioral counseling sessions with educational video clips. The use of video modeling has potential benefits such as facilitation of knowledge acquisition, improving self-care behaviors, and reducing psychological distress (61). Moreover, video modeling is effective in patients with low health literacy and removes inconsistencies between health care providers (62,63). Informal caregivers were invited to actively participate in this intervention since research shows that many informal caregivers suffer from psychological distress after their partner's hospitalization (37-42). In addition, informal caregivers play an important role in the recovery of the patient; however, hypervigilance in informal caregivers can undermine patients' health and recovery (64). It is therefore important to inform and support informal caregivers in their new role. A recent study shows that

patients and informal caregivers prefer the same content and delivery formats for digital interventions (eg, health video clips, contact with health care provider) (65). It is thus expected that informal caregivers can benefit from this remote coaching program. For this coaching program to be successful, health care providers need to encourage patients to reflect on the obtained knowledge and skills and offer strategies to adopt behavior changes in daily life. Therefore, health care providers should be well trained in applying behavior change techniques and have the ability to build trust in patients.

Strengths and Limitations

First, we consider the use of the IM protocol a strength since digital health behavior interventions often lack theoretical grounding, as expertise from different scientific areas is often lacking in the design phase (66). In line with the IM protocol, the development of this intervention was supported by researchers with expertise in various fields (cardiology, physical therapy, psychology, and nursing science), ensuring a firm theoretical approach. Second, patients' needs and expectations were taken into account in the early phase of the design process, which contributed to the usability and utility of this intervention (67). Results from our literature study and interviews indicated that the interval between hospital discharge and CR was too long and that patients wanted to be in contact with a health care provider to receive support and information. It remains unclear, however, if this remote coaching program is applicable for older adult cardiac patients with comorbidities, as they are often reluctant to use eHealth apps (68). Nevertheless, a recent systematic review shows that older adults (aged 65 years and older) exhibited greater engagement with digital health interventions than younger adults (aged younger than 65 years). Despite the technological barriers, older adults might view digital coaching as social interaction, which is often desired by older adults. In addition, older adults might have more time to engage in digital technologies (69). In this study, 17 patients with various ages, cardiac diagnoses, and comorbidities were included, and the results of the interviews supported the findings from the literature. It is therefore expected that this intervention is suitable for a wide variety of patients referred for CR. To assure adoption of this intervention by older adults, a thorough evaluation of the feasibility of this intervention should be conducted in step 4 of the IM approach. Third, the use of a remote intervention is considered a strength since it can resolve several barriers at the patient level (distance to center, transportation) and health care system level (referral problems, limited facilities) (70). In addition, this study shows that patients are in need of information and support directly after hospital discharge, despite current guidelines, which recommend initiation of CR within 4 to 6 weeks after hospital discharge (4,5). Delayed participation in CR negatively impacts physical and psychological outcomes, while early initiation of CR positively impacts health outcomes (71-73). An early remote coaching program starting directly after hospital discharge might help to overcome logistical issues and delays in CR initiation and is therefore well suited for the period between hospital discharge

and the start of CR. Finally, patients in this study were involved in the first steps of the intervention development. Due to the nature of this study, we used a small sample size to explore patients' needs. However, information obtained from the interviews was supplemented with data from our scoping literature study. We therefore expect that our results are generalizable to the greater cardiac population. Future studies should focus on program refinement (IM step 4) of this remote coaching program and assess its feasibility and effectiveness in studies with larger sample sizes. It would be interesting to assess the effectiveness of this early remote coaching program on symptoms of psychological distress and participation in outpatient CR.

CONCLUSION

This study shows that patients with CAD are in need of tailored information and support after hospital discharge. The main areas of information and support are CAD, medication and side effects, physical activity, psychological distress, and body signals. In addition, this study presents the development of a remote intervention, using the IM protocol, to bridge the gap from hospital discharge to the start of CR.

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MULTIMEDIA APPENDIX 1. INTERVIEW GUIDE.

Themes	Topics
Medication	Type of medication, Effect of medication, Dose of medication, Interactions, Side effects, other
Surroundings	Support, Partner, Sexuality, Support, Other
Disease knowledge	Cardiac illness, type of intervention, prognosis
Daily activities	Return to work, Leisure
Lifestyle	Smoking, Diet, Alcohol, Physical activity
Disease impact	Dealing with stress and worry, Anxiety, Depression, Body signals, Sleep
Future	Course of disease, Chance of recurring cardiac event, Where to find information and who to call

MULTIMEDIA APPENDIX 2. EXTRACTION TABLE.

Reference	Country	Study design	Participants / studies	Data collection	Main finding(s)
Aazami et al. (2016)	Iran	Cross sectional qualitative study	18 PCI patients	Semi structured interviews after hospital discharge	This study showed that there is uncertainty and insecurity in patients who undergo angioplasty. This study emphasizes the need for procedural knowledge, social support.
Akbari et al. (2015)	Iran	Semi-experimental study	100 CABG patients	Intervention: discharge training 6 weeks post discharge with booklet before surgery and 6 weeks after. Control group: usual care: prescribing medication, wound care and checking vital signs.	This study showed that patients in the intervention group experienced fewer problems concerning: Job status (P<0.03) Chronic illness (P<0.03) Respiratory difficulties (P<0.05) Blood pressure (P<0.03) Palpitation (P<0.001) Wound healing (P<0.001)
Alkubati et al (2021)	Jordan	Cross sectional	120 CABG patients	Cardiac Patients Learning Needs Inventory (CPLNI) before hospital discharge	This study showed that CABG patients have high information needs within 24-48 hours before hospital discharge. Patients wanted information about: (1) chest and leg wound care (2) medication information, (3) complications. Male patients needed more information than female patients (p=0.004). Younger (p=0.021) and middle-aged (p=0.032) patients needed more information than older ones. Highly educated (p=0.000) and school-level (p=0.002) patients needed more information than those in the uneducated group. Working patients needed more information than non-working ones (p=0.000).

Reference	Country	Study design	Participants / studies	Data collection	Main finding(s)
Almaskari et al. (2019)	Oman	Cross sectional	90 CABG patients and 90 nurses	Modified Cardiac Patients Learning Need Inventory (MCPLNI)	This study showed that nurses perceived information about chest and leg wound care, medications and complications as patients' most important learning need. Patients perceived a need for post-CABG learning related to chest and leg wound care, complications and medication as most important, while learning related to physical activity received a moderate priority.
Anderson et al. (2014)	United States	Cross sectional	61 patients referred for CR	Participants completed a baseline questionnaire including measures of depression and irrational health beliefs	This study showed that older age ($p < .05$) and higher income ($p < .05$) were associated with better CR adherence, but CR adherence was lower among African Americans than Caucasians ($p < .01$). Depression was not related to adherence ($p = .78$), but irrational health beliefs predicted CR adherence (β=-0.29, $P < 0.5$)
Antonakoudis (2006)	Greece	Non randomized trial	110 ACS Group A participated in cardiac rehabilitation Group B did not participate in cardiac rehabilitation	Velasco-Del Barrio questionnaire for Health Related Quality of Life	This study showed that a significant difference was found between Group A and B regarding the parameters symptoms (17 ± 6.8 vs 22 ± 6.5, $p<0.001$) and social behavior (21 ± 4.2 vs 23 ± 5.5, $p<0.0001$).
Askham et al. (2010)	Denmark and Faroe Islands	Cross sectional	8 female ACS patients	Semi-structured interviews 3-4 weeks after hospital discharge.	This study presents the following themes related to needs. (1) 'Discharged home, now what?': illustrated the difficulties experienced by these women following discharge and (2) risk factor management and lifestyle adjustments: related to perceptions relating to risk, loss, recovery and support.

Bäck et al. (2017) .	Sweden	Cross sectional	16 patients with ACS	Interviews, analyzed with inductive content analysis	This study presents aspects that influence patients' attendance at cardiac rehabilitation. (i) previous experience of exercise, (ii) needs in the acute phase, (iii) important prerequisites for attending exercise-based CR and (iv) future ambitions.
Bonnet et al. (2005)	France	Cross sectional	1612 patient at risk for cardiovascular disease	Assessment of unhealthy lifestyle factors (physical inactivity, smoking and poor diet) and symptoms of anxiety and depression.	This study showed that both anxiety and depression appeared as independent determinant of an unhealthy lifestyle in both sexes, with a stronger influence for depression. Depression and to a lesser extent anxiety are associated with a cluster of unhealthy behaviors in subjects at risk of cardiovascular disease, suggesting the difficulty of modifying lifestyle in patients with anxious-depressive disorders.
Czar et al. (1997)	United States	Longitudinal study	28 patients treated with PCI after or ACS or Stable Angina pectoris.	Learning needs questionnaire at hospital discharge and first visit at the clinic after discharge	This study showed that the most important learning needs were: symptom recognition, cardiac anatomy and physiology, and medications.
de Melo Ghisie al (2014)	Canada	Cross sectional	306 CR patients and 28 CR providers	Information Needs in Cardiac Rehabilitation (INCR) questionnaire	This study showed that low-income CR participants had significantly greater information needs than high-income participants. CR providers were cognizant of patient information needs, except patients did desire more information on diagnosis and treatment than providers perceived
Eshah et al. (2011).	Jordan	Cross sectional	150 patients with acute coronary syndrome	The Patient Learning Needs Scale (PLNS) was collected at the cardiac care unit	This study showed that highest information needs concerned: medication and treatment and activities of daily living. Older patients, and those with low SES, requested less information than others did.

Reference	Country	Study design	Participants / studies	Data collection	Main finding(s)
Forster et al. (2021)	Various	Systematic review	33 studies involving 5255 stroke-survivors and 3134 informal caregivers	2 reviewers independently assessed trial eligibility and risk of bias. Interventions were categorized: active information provision included: active participation with subsequent opportunities for clarification and reinforcement; passive information provision provided no systematic follow-up or reinforcement procedure. Overall certainty of evidence was assessed with GRADE.	This study showed that: active information vs. passive information provision may improve stroke-survivor knowledge and quality of life (SMD) 0.41, 95% confidence interval (CI) 0.17 to 0.65, and may reduce anxiety ((RR) 0.85, 95% CI 0.68 to 1.06; 5 studies, 1132 participants) and depression. (RR 0.83, 95% CI 0.68 to 1.01; 6 studies, 1315 participants)
Gao et al. (2009)	Taiwan	Cross sectional	103 CABG patients	Symptom Distress Inventory and Health Care Needs Inventory within 1 month after discharge	This study showed that the most important predictors for overall health care needs were length of hospital stay after surgery, symptom distress, and gender
Gentz et al. (2000)	USA	Systematic Review	19 studies involving patients learning needs and concern after PCI.	Studies were identified in CINAHL and MEDLINE	This study showed that Informational knowledge, such as risk factor education and survival management, were considered of high importance. The majority of subjects modified their behavior, and the most common modification was in diet. Both learned knowledge and lifestyle changes decreased over time. Self-efficacy expectations and levels of anxiety were predictors of behavior changes and knowledge retention in the early recovery period after the coronary angioplasty procedure.

Halm (2017)	United states	Cross sectional	32 CABG caregivers	Interviews in the first 3 months after hospital discharge	This study showed that age-specific themes related to motivating exercise (<70), applying support hose, and self-reliance (>70). Gender-specific themes related to incision worries and transportation (all females); regulating blood sugars, vital sign anxiety, hurrying back, reinforcing healthy behaviors, and being there (females <70); meal planning, coordinating appointments, and anger over self-care reminders (females >70); caregiver relief, inconsistent information, and doing it all (all males); upsetting scars (males <70), and lost sleep (male >70).
Halm et al. (2016)	United states	Cross sectional	32 Caregivers of patients that underwent CABG	Telephone interviews 3 months post discharge	This study showed that the needs of informal caregivers of patients that underwent CABG comprise information and support about: (1) 'knowing what I'm supposed to be doing' Information about: (2) medication (3)mobility (4) symptom monitoring (5)memory (6) appetite (7) emotional spirits (8) finances
Jickling et al. (1997) .	Canada	Cross sectional	20 men and 20 women with a 1st time Elective CABG	Patient Learning Needs Scale and open-ended question directly after hospital discharge.	This study showed that no differences were found in information needs between men and women. The highest areas of information needs included: treatment and complications, activities, medications, and enhancing quality of life.
Kähkönen et al. (2017) .	Finland	Cross sectional	416 patient with CAD	Social Support of People with Coronary Heart Disease questionnaire after hospital discharge	This study showed that healthcare professionals should pay extra attention to women, single patients, physically inactive patients, those demonstrating a lower level of education, those with a longer duration of CHD, and respondents without previous acute myocardial infarction. Continuum of care and counselling are important to ensure especially among them.

Reference	Country	Study design	Participants / studies	Data collection	Main finding(s)
Kattainen et al (2004)	Finland	Longitudinal study	439 Men and176 women with elective PCI and CABG	The data were collected by structured interview before coronary artery procedures and by mailed questionnaires 6 and 12 months afterwards	This study showed that patients in both groups needed information about recovery and psychosocial functioning before and after the treatments. Women in the PTCA group needed more informational support than men before procedures, while men needed more support afterwards.
Keessen et al. (2020)	Netherlands	Cross sectional	16 patients with acute coronary syndrome, atrial fibrillation or acute heart failure	Semi structured interviews after hospital discharge.	This study showed that after hospital discharge patients are in need of: Tailored information Support health care provider
Kilonzo et al. (2011)	Ireland	Cross sesctional	33 PCI patients 13 nurse	Survey directly after PCI	This study showed that patients preferred information and support about: Disease-specific items, physical action, psychosocial and emotional information. Cardiac nurses perceived physical action as least important and focused more on psychosocial and emotional issues.
Krannich et al (2009)	Germany	Longitudinal study with 2 time points	70 CABG patients	Patients filled in their needs 48 hours after hospital discharge and 10 days after hospital discharge.	This study showed that before CABG, patients rated the need for "preparation for surgery", and after CABG the need for "information about the correct handling of drugs", as the most important. The rating of "information about the correct handling of drugs" showed a significant increase after CABG surgery ($T(69) = -3.46$; $P < 0.001$) and the need for a "letter with the latest scientific information on heart disease" was significantly reduced during this period ($T(69) = 2.07$; $P = 0.04$)

Lie I, et al. (2012)	Norway	Longitudinal study	93 CABG patients	2 and 4 weeks after CABG	This study showed that needs of patients were characterized by a substantial amount of uncertainty and worries related to what to expect and what was normal for postoperative pain, assessment and sensation of surgical site, different experiences with physical activity/exercise, uncertainty about medications, difficulties with sleep pattern, irritability, postoperative complications, uncertainty about return to work, and insufficient information at discharge.
Lukkarinen et al. (2003)	Finland	Cross sectional	146 informal caregivers of patient that underwent PCI or CABG	Open ended questions questionnaire	This study showed that informal caregivers: had to monitor for symptoms, treat symptoms, take care, understand and support. They had to assume responsibility for everyday life. They felt themselves to be alone in that situation. They did not receive support from health care providers. All informants felt uncertainty due to financial problems, poorly planned care and unexpected changes in the course of the disease.
Moore et al. (1994)	United states	Cross sectional	CABG Patients and spouses	Profiles of mood states questionnaire 6 weeks post CABG	This study showed that spouses experienced more psychological distress than patients at 6 weeks after surgery. Younger spouses reported more anger than older spouses.
Mosleh et al (2017)	Jordan	Cross sectional study	365 cardiac patients (PCI and CABG) and 166 cardiac nurses	Patients completed the Patient Learning Needs Scale (PLNS) within 24-48 hours after hospital discharge.	This study showed that the top-priority learning needs according to both patients and cardiac nurses was information on wound care and medication. In contrast, the lowest-priority learning need was physical activity. Nurses perceived information about physical activity as most needed to patients, whereas patients perceived information about medications, postintervention complications and postintervention concerns as mostly needed.

Reference	Country	Study design	Participants / studies	Data collection	Main finding(s)
Mühlbacher et al (2016).	Germany	Cross sectional	623 ACS patients	Analytic Hierarchical Process to evaluate important patient outcomes.	This study showed that patients showed a clear priority for the attribute "reduction of mortality risk" (weight: 0.402). The second most preferred attribute was the "prevention of a new myocardial infarction" (weight: 0.272), followed by "side effect: dyspnea" (weight: 0.165) and "side effect: bleeding" (weight: 0.117). The "frequency of intake" was the least important attribute (weight: 0.044).
Omari et al (2014)	Syria	Cross sectional	135 CABG patients	Modified Cardiac Patients Learning Needs Inventory (MCPLNI)	This study showed that information about chest and leg wound care, complications, medication and physical activity were the most important learning needs. There were significant differences between patients' perceptions of learning needs and their age, chronic illnesses and their working status.
Pedersen et al. (2017)	Denmark	Cross sectional	24 ACS patients and 12 informal caregivers.	Semi structures interviews with 12 patients that completed the full CR program and 12 that did not complete CR.	This study showed that non-participation in CR was explained by the following themes: exclusion by time and place, exclusion by health beliefs, exclusion from counseling, exclusion by alienation, and exclusion of relatives.
Perk et al. (2015)	Sweden	Cross sectional	1,073 PCI patients	Questionnaire after revascularization about: patient's attribution of the cause of the cardiac event, perception of the information provided by physicians and nurses, and a self-assessment of changes in lifestyle post PCI regarding tobacco, physical activity, food habits and stress.	This study showed that non-modifiable risk factors (age, heredity) were attributed a higher rate as the cause of disease compared to modifiable factors (smoking, physical activity, food habits). Most patients (67%) perceived they were cured, and 38% perceived from the given information that there was no need to change their habits. A mere 27% reported that they still had cardiovascular disease and needed behavioral change. After PCI, 16% continued to use tobacco; half of these were offered smoking cessation support. In spite of an 80% referral rate to cardiac rehabilitation, one out of two patients did not enroll. Fewer than half were regularly physically active.

Pier et al. (2008)	Australia	Cross sectional study	14 patients with CAD	Semi-structured interviews	This study showed that the most prominent information needs included identification and management of risk-related physical symptoms, and psychosocial information, most notably to enhance patients' social support. Patients considered this information important for alleviating health anxiety and negative affect.
Polikandrioti et al. (2015)	Greece	Cross sectional study	454 hospitalized patients with ACS	Needs of hospitalized patients with coronary artery disease questionnaire at hospital discharge.	This study showed that the type of ACS was statistically significant correlated with the place of residence ($p=0.002$), management of disease ($p<0.001$) and prior experience of hospitalization ($p=0.003$). All six needs were statistically significantly correlated with the type of ACS, ($p<0.001$ for the need for support and guidance, $p<0.001$ for the need to be informed from the medical and nursing staff, $p<0.001$ for the need for being in contact with other patient groups, and ensuring communication with relatives, $p<0.001$ for the need for individualized treatment and for the patient's personal participation to his/her treatment, $p<0.001$ for the need to meet the emotional needs and physical needs and $p=0.010$ for the need to trust the medical and nursing staff).
Rolley et al. (2011)	Australia	Cross sectional	18 Caregivers of patients that underwent PCI.	Focus group	This study showed that the needs of caregivers comprised: (1) a gendered approach to health, illness and caring; (2) shock, disbelief and the process of adjustment following PCI; (3) challenges and changes of the carer-patient relationship and (4) the needs of the carer for support and information

Reference	Country	Study design	Participants / studies	Data collection	Main finding(s)
Svavarsdóttir et al. (2015)	Iceland and Norway	Cross sectional	17 PCI patients	Interviews with systematic text condensation.	This study showed that patients saw a good educator as one who they feel is trustworthy and who individualizes the education to patients' needs and context and translates general information to their personal situation in lay language. Building trust was dependent on the patients' perceiving the educator to be knowledgeable and good at connecting with the individual patient, so that the patients feel they are being treated as a whole person with equality and respect.
Svavarsdóttir et al. (2016)	Iceland and Norway	Cross sectional	19 health care providers (nurses, physiotherapists and cardiologists)	Interviews, analyzed with systematic text condensation.	This study showed: Knowledge and skills needed for being a good educator defined by health care providers: This includes being able to establish interpersonal relationships with patients, capturing their learning needs, facilitating an effective dialogue and providing individualized patient centered education and lifestyle counselling.
Valaker et al (2017) .	Norway	Cross sectional	22 PCI patients	In depth interviews with patients 6-8 weeks after PCI to explore continuity of care	This study showed that patients were not receiving adequate instruction and information on how to integrate health information. Patients also needed help to facilitate connections to community-based resources and to schedule clear follow-up appointments.
Wachters-Kaufmann et al. (2005)	Netherlands	Longitudinal study	33 stroke survivors and 27 caregivers	Telephone survey at 3 and 12 months after hospital discharge	This study showed that patients and caregivers prefer to receive information within 24h and to be informed about, and be given, relevant written information. The information given by the various professional stroke care-providers could be better coordinated. The role of the GP as an information provider lagged quite a long way behind.

MULTIMEDIA APPENDIX 3. QUOTATIONS.

Categories	Subcategories	Quotes
Distressing body signals	Fatigue	*`I get tired so quickly' (P15)*
	Wound pain / chest pain	*`I don't want to feel that pain anymore' (P11)*
	Hypervigilance	*`I don't dare to do anything' (P16)*
		`If my heart skips a beat, I don't do anything, I'm really anxious to become short of breath' (P10)
	Fear of bodily sensations	*`I monitor my heart rate' (P17)*
		`And when I am sitting on the couch, or walking around, I feel every sting. That frightens me' (P8)
Psychological problems	Anxiety	*`I have many panic attacks' (P12)*
	Depression	*`My whole outlook on life has changed after my event'. (P12)*
		`Nothing will be the same again' (P16)
Lack of information hospital discharge	Medication	*`At hospital discharge the physician gave me a whole list with medication and then said I could go home, that's all he said, this made me insecure.' (P10)*
	Side effects medication	*`I felt a weird pressure on my chest, like my heart skipped a beat. I panicked, so I went back to the emergency room where they examined me. Afterwards they told me it was a side effect of metropolol' (P10)*
		`I would like to know why I have to take those pills, I had lots of side effects' (P9)
		`I missed information about medication and side effects'. At first, I felt better than after my myocardial infarction, until the statins began to work. I sat on the couch like a dead bird, muscle ache everywhere and unable to move' (P8)
	Physical activity	*`I don't know if I can do any physical activity and if I injure my body if do physical activity' (P4)*
		`They did not gave me any information about what I could and could not do, looking back I find this very bad'(P4)
		`What is my heart able to handle? Not knowing this, is very annoying' (P2)

Categories	Subcategories	Quotes
		`I just want some simple information about what I can and cannot do, can I walk the stairs? Can I drive my car?'(P11)
		'I want be confident again that I don't injure myself, by walking stairs or walking for miles' (P2)
	Inconsistent information	*`One health care provider tells me this the other tells me that' (P1)*
		`What does it mean to take it easy?' (P2)
		`It's not a small thing, having a heart attack. In the hospital you don't know what's going on and when you leave you still don't know' (P8)
	Cardiac event	*`They didn't tell me anything at the hospital and it passed by so quick. Who says I won't suffer another myocardial infarction' (P10)*
		`I really missed talking to my physician about what had happened to my heart before I left the hospital' (P7)
	Procedure	*`Someone told me that a stent can shift within the artery, if I'm not feeling well, I think about this' (P8)*
Passive coping style	Inactivity	*`I rather be in bed all the time' (P16)*
		`I did not do anything for six weeks, I'm just staying in bed and on the couch, I can't do much more' (P9)
Healthcare system	Unclear communication Health care provider	*`I did not know I would get a pacemaker' (P14)*
		`One health care provider told me I could cycle again but then the other told me not to' (P14)
	Time until cardiac rehabilitation	*`I think the time between discharge and CR is too long'. (P12)*
		`Four weeks is quite long while waiting for cardiac rehabilitation' (P10)
	Relevance of cardiac rehabilitation	*`What is there to rehabilitate about the heart?' (P2)*
	Negative experience Hospital	*`I didn't feel well for a long time but they did not listen to me'. (P15)*
		`Everyone was so busy, they did not have time for everyone' (P15)
		`I was left alone in a bed and did not see anyone during my stay at the nursing ward. There was no one that came to me to ask me how I was doing and if I was afraid. Just some human contact would make it so much better' (P8)

		`The referral to cardiac rehabilitation went completely wrong. It took ages before it was clear where I needed to go and what was expected. Thinking about this makes me short of breath again' (P4)
	Trusting caregivers	*`Trusting caregivers, cardiologist, nurse practitioners, physiotherapists is really important' (P2)*
Support	Daily activities	*`My children do all the groceries, I don't do anything" (P17)*
	Hypervigilance informal caregiver	*`They tell be to be careful the all the time' (P17)*
		`If I do too much and I get complaints, my husband becomes angry and tells me to sit down.' (P10)
		`My husband does all the groceries and cooking and tells me to relax' (P7)
	Cardiac rehabilitation	*`It would be great if there would be someone next to you all the time to make an ECG and tell you nothing is wrong' (P2)*
		`Certain things I would like to have re-confirmed' (P7)
		`I want to participate in cardiac rehabilitation to gain confidence so that afterwards I can start exercising alone' (P5)
		`I would feel anxious if I started exercising without guidance. It's about confidence. I can do it, but it would not feel right' (P16)
		`I hope that I will benefit from cardiac rehabilitation and that afterwards I will be able to take the bike instead of the car to do my groceries' (P5)

MULTIMEDIA APPENDIX 4. DETERMINANT MATRIX.

Performance objective	Theoretical determinants				
	Knowledge	**Skills**	**Attitudes**	**Social influence**	**Self-efficacy**
Content of eHealth intervention					
Patients gain knowledge on how CAD and revascularization affects their bodies and health.	Understand what happened to their heart and how this affects their body.	Possess the skill to deal with post-operative complaints.	Accept that they had a cardiac procedure and have post-procedural complaints as a consequence.	Informal caregivers support patients in dealing with post-procedural pain.	Patients feel confident that they are capable of dealing with post-procedural complaints.
Patients gain knowledge about medication and side effects.	Understand the function of medication and know about possible side effects and understand the necessity of adhering to their medical treatment plan.	Adhere to medication, recognize possible side effects and consult a health care provider if necessary.	Acknowledge that medication aids the recovery process. Actively monitor medication treatment plan and (side) effects.	Informal caregivers support patients with adhering to their medical treatment plan and help dealing with possible side effects.	Feel confident about adhering to their medical treatment plan.
Patients know which daily physical activities they can and can't do safely after hospital discharge and are physically active.	Understand the necessity of physical activity and understand how their cardiac procedure influences their ability to perform daily physical activities	Gradually build up physical activities and develop alternative strategies to perform daily physical activities.	Having a positive outlook on daily physical activity.	Informal caregivers support patients in building up physical activities and stimulate alternative activities if necessary.	Feeling confident about doing daily physical activities and gradually expanding the repertoire of activities.

Patients can deal with the psychosocial consequences of CAD	Having knowledge about the impact of psychological distress on their body and understanding the difference between harmful and harmless body signals.	Being able to effectively communicate about psychological distress and are able to distinguish harmful and harmless body signals.	Acknowledge that they suffer from psychological distress and have distressing body signals.	Informal caregivers support patients suffering from psychological distress after hospital discharge	Effectively seeking (professional) support if needed.
Health care providers assess patients and informal caregivers needs in the first week after hospital discharge.	Have knowledge about common physical and psychological problems of patients and informal caregivers in various subgroups.	uses assessment skills to assess needs of patients and informal caregivers.	Acknowledges that a broad and thorough assessment of patients and informal caregivers needs is essential.	Effectively assess the social environment of the patient and involve the informal caregivers during the assessment.	Feels confident and capable in performing a comprehensive needs assessment.
Health care providers give tailored information and support to cardiac patients and their informal caregivers	Have comprehensive knowledge about needs of cardiac patients and patients.	Are able to tailor the information to subgroups of patients.	Offers remote supports to patients and informal caregivers in the first phase after hospital discharge.	Coaches patient in mobilizing relevant social support.	Has confidence in coaching patients using an eHealth platform.

* In this table, patients also refers to informal caregivers

MULTIMEDIA APPENDIX 5. PROGRAM STRATEGY.

Theoretical determinants	Theory based methods	Practical strategies
Patient and informal caregiver		
Knowledge - *Understanding* coronary artery disease, procedures (PCI/CABG), function of medication and side effects, necessity of physical activity and influence of coronary artery disease on daily activities, origin of psychological distress and body signals.	Belief selection, Tailoring, individualization. Persuasive communication, Using imagery, Elaboration	*Consult with a health care provider.* - Assessment of beliefs, encouraging positive beliefs, weakening negative beliefs, introducing new beliefs. Information is tailored for subgroups and individualized. - Video clips with consistent information about medication use, coronary artery disease, procedures (PCI/CABG), physical activities and psychological distress. The content of videoclips is evaluated with the health care provider during the next consultation.
Skills - Dealing with postprocedural pain, adhering to medical treatment plans and dealing with side effects. - Gradually building up physical activity. - Dealing with psychological distress and discriminating between harmful and harmless body signals.	Goal setting Reattribution training Self-monitoring of behavior Improving physical and emotional states, Setting graded tasks.	*Consult with a health care provider.* - Patients and health providers formulate concrete goals for the first phase after hospital discharge - Patients study video clips about dealing with post-procedural pain, adhering to medical treatment plan and dealing with side effects, building up physical activity, dealing with psychological distress and body signals. The content of videoclips is evaluated with the health care provider during the next consultation.
Attitude - Accepting current status, actively monitor medication treatment plan, having a positive outlook on daily physical activity. Acceptance of psychological distress.	Shifting perspective, Elaboration, Direct experience, Repeated exposure Motivational interviewing	*Consult with a health care provider.* - During consultation the patient is being coached in looking at their situation from a different perspective (health problems, psychological distress and physical activity). - Patient learns to challenge him- or herself and discover the growing possibilities despite boundaries. - Patient studies video clips to shift perspective, perform exercises and evaluates with health care providers.

Social influence - Informal caregiver supports patient in dealing with post-procedural pain, adhering to treatment plan, building up physical activities, dealing with psychological distress and distressing body signals. - Patients support each other by sharing experiences with each other.	Prompting hiding of the unpopular behavior or shifting attention away from the behavior. Mobilizing social support Providing opportunities for social comparison	*Consult with a health care provider.* - During consults with health care providers the informal caregiver is actively involved and coached by health care providers about supporting patients. - Patients without a partner are coached on how to reach out and find social support through eHealth portal. - Discussion board where patients (and informal caregivers) share experiences. Are brought into contact with each other.
Self-*efficacy* - Confident about dealing with postprocedural pain, adhering to medical treatment plan, physical activity, psychological distress and body signals.	Motivational interviewing Guided practice Re-attribution Self-monitoring Goal setting Planning coping responses	*Consult with a health care provider.* - Self-efficacy of patients is stimulated by changing beliefs, attitudes and experiences. Patient formulates concrete, feasible goals and reflects on progress in the eHealth environment.
Health Care providers		
Knowledge - Having knowledge about common physical and psychological problems of patients and informal caregivers after hospital discharge. - Having knowledge about needs of cardiac patients and patients.	Chunking Advance organizers Discussion	- Health care providers follow mandatory workshops and gain knowledge about typical information and support needs of cardiac patients and know the best didactical approaches for assessing needs, using shared decision making. Health care providers gain knowledge about supporting and coaching cardiac patients.
Skills - Using assessment skills to assess needs of patients and informal caregivers - Are able to tailor the information to subgroups of patients.	Guided practice Feedback Tailoring	- Health care providers follow mandatory workshops aimed at learning and practicing assessment skills together with peers. - Learning to communicate with various subgroups of patients.

Theoretical determinants	Theory based methods	Practical strategies
Attitudes - Acknowledges that a broad and thorough assessment of patients and informal caregivers needs is essential. - Offers remote supports to patients and informal caregivers in the first phase after hospital discharge	Shifting perspective, Direct experience, Repeated exposure	- Health care providers are aware of the necessity of a thorough assessment to effectively start remote coaching. Health care providers are positive about remote coaching and using the eHealth platform.
Social Influence - Effectively assesses the social environment of the patient and involves the informal caregiver during the assessment - Coaches patient in mobilizing social support	Mobilizing social support Providing opportunities for social comparison	- Health care providers actively assesses barriers and facilitators for the intervention in the social environment of the patients. - The health care provider coaches the patients in gaining social support (informal caregiver, hospital, cardiac rehabilitation center).
Self-efficacy - Feels confident and capable in performing a comprehensive needs assessment - Has confidence in coaching patients using an eHealth platform	Guided practice Self-monitoring Goal setting	- Health care providers actively practices assessment skills with peers and gains trust in performing assessment. - Health care provider actively practices coaching skills with peers using the eHealth platform

MULTIMEDIA APPENDIX 6. SCREENSHOT OF EHEALTH PLATFORM

MULTIMEDIA APPENDIX 7. SCREENSHOT OF CORONARY ARTERY DISEASE AND PERCUTANEOUS CORONARY INTERVENTION.

MULTIMEDIA APPENDIX 8. SCREENSHOT OF PHYSICAL ACTIVITY AFTER CARDIAC HOSPITALIZATION INTERVENTION.

Chapter 8

General discussion

Important learning points from this thesis

- The TSK-NL Heart is a reliable, valid and responsive measurement tool and can be used to measure kinesiophobia in patients with CVD.
- Patients who score below the cut off score of 29 points on the TSK-NL Heart, may have clinically significant kinesiophobia.
- A categorical approach to define kinesiophobia is more suitable for patients and clinicians.
- Patients with high levels of kinesiophobia often have negative experiences with the health care system and have negative beliefs about physical activity.
- Although kinesiophobia seems a relatively stable construct, kinesiophobia scores decrease during cardiac rehabilitation. Therefore, cardiac rehabilitation is advised for patient with high levels of kinesiophobia.
- Kinesiophobia at hospital discharge decreases the likelihood of CR-initiation. Therefore, kinesiophobia needs to be identified at hospital discharge and an early (remote) coaching program should be offered to reduce kinesiophobia and bridge the gap between hospital discharge and the start of CR.
- Kinesiophobia at hospital discharge is negatively associated with self-efficacy and higher education. Understandable hospital discharge information should be offered.
- Kinesiophobia at hospital discharge is associated with cardiac anxiety and social complexity. Patients need to be offered social support during the first weeks after hospital discharge and the informal caregiver should be actively involved.
- Kinesiophobia is not associated with objectively measured physical activity, in the first 12 weeks after hospital discharge.
- In the first phase after hospital discharge patients with CAD require information and support concerning the following topics: *CAD and revascularization, physical activity, medication and side effects, psychological distress.* Information and support concerning these topics can be offered remotely, directly after hospital discharge.

GENERAL DISCUSSION

The overall aim of this thesis was to explore kinesiophobia in patients with cardiovascular disease. First, the psychometric properties of the TSK-NL Heart, in order to identify patients with kinesiophobia, were investigated. Second, the course of kinesiophobia was studied with a qualitative approach, by investigating the perspectives and needs of patients with kinesiophobia after cardiac hospitalization. Subsequently, a quantitative approach was used to assess which biological, psychological and social factors are associated with kinesiophobia. In addition, the impact of kinesiophobia on CR-initiation and objectively measured PA were investigated. Third, based on the findings of the previous studies, we developed an intervention to target kinesiophobia in the early phase after hospital discharge.

MAIN FINDINGS

Part 1: Measuring fear of movement in patients with cardiovascular disease
In **chapter 2** we found that the TSK-NL Heart has sufficient internal consistency, test-retest reliability and was significantly correlated to other anxiety measures (HADS and CAQ). In addition, our principal component analysis revealed a three factor model as most suitable, consisting of the factors: *fear of injury, avoidance of physical activity, perception of risk*. This study also showed that high levels of kinesiophobia were present at the start of CR in 45% of patients. In **chapter 3** we revealed that the TSK-NL Heart has moderate external responsiveness, using the HADS and CAQ as external validation tools and thus can be used to evaluate CR-interventions targeting kinesiophobia. Moreover, we found that high levels of kinesiophobia decreased from 40% before CR to 26% after CR. In addition, 31% improved at least 5 points on the TSK-NL Heart, indicating that relevant improvements are made during CR.

Part 2: The course of kinesiophobia in patients with cardiovascular disease
Perspectives and needs of patients with high levels of kinesiophobia
The results presented in **chapter 4** show that high levels of kinesiophobia, in the early phase after acute cardiac hospitalization, are related to a `disrupted health care process' and `negative beliefs about physical activity'. On the other hand, `understanding the necessity of physical activity' and `experiencing social support' are related to lower levels of physical activity. Patients reported `receiving tailored information and support' from a health care professional, as most important need after acute cardiac hospitalization. Patients emphasized the need for information and support but also stated that the time between hospital discharge and the start of CR was too long.

Factors associated with kinesiophobia and the impact of kinesiophobia on initiation of cardiac rehabilitation.
Our path-analysis (**chapter 5**) showed that kinesiophobia decreased the likelihood of CR-initiation, with 8% per point increase in the TSK-NL Heart. This is an important finding, since our previous study showed that participation in CR significantly decreased the level of kinesiophobia (**chapter 3**). In addition, this study shows that kinesiophobia is negatively associated with higher education and self-efficacy, and positively associated with cardiac anxiety and social vulnerability. These findings emphasize the need for attention for kinesiophobia in the early phase after hospital discharge and guide the development of strategies to improve kinesiophobia and the uptake of CR-initiation.

The longitudinal association between kinesiophobia and objectively measured physical activity
In **chapter 6** we explored the longitudinal association between objectively measured PA and kinesiophobia. No association was found between PA-intensity and kinesiophobia in the first 12 weeks after cardiac hospitalization. After re-examination, a new model was developed. Best model fit was found for a model were kinesiophobia was modelled as a stable *between* factor and PA-intensity as dynamic process in time. These results indicate that, in our study, kinesiophobia remains relatively stable in the first 12 weeks after hospital discharge and can be seen as a trait-like concept.

Part 3: Bridging the gap between hospital discharge and the start of cardiac rehabilitation
In **Chapter 7** we used the intervention mapping approach to develop a remote coaching program for patients with CAD in the early phase after hospital discharge. Based on our exploratory literature study and patient interviews, we found that after (acute) hospitalization, patients were in need of information and support concerning the following topics: *coronary artery disease and revascularization, medication and side effects, physical activity and psychological distress*. A remote coaching program consisting of health video clips and remote coaching was developed based on our findings. The overall aim of this remote coaching program is to improve self-efficacy, reduce psychological distress and provide tailored information.

IMPLICATIONS FOR RESEARCH

In **Chapter 2** and **3** we found that the psychometric properties of the TSK-NL Heart were sufficient. After establishing the psychometric properties, we found that kinesiophobia was present in 45.4% of patients at the start of cardiac rehabilitation. Few studies assessed the prevalence of kinesiophobia in patient with CVD since it was first described in patients with musculoskeletal disorders (MSD). However, kinesiophobia has been studied more frequently in patients with neurological disorders such as stroke, Parkinson's disease and multiple sclerosis,

Chronic Obstructive Pulmonary Disease (COPD), renal disease, and patients with various forms of cancer (1-5). Although kinesiophobia might behave different in other patient populations, the findings from this study will help researchers to develop hypotheses about the characteristics and outcomes associated with kinesiophobia in other populations. In line with other studies, we used a cut-off score of >28 to define `high levels of kinesiophobia' since there is no golden standard to measure kinesiophobia (6). A large variation of scores was found in our sample, with a substantial number of scores above the cut-off score. In a recent study the clinically meaningful severity levels of the TSK-pain were assessed in a sample of patients with musculoskeletal pain and divided as follows: *subclinical: 13–22; mild: 23–32; moderate: 33–42; and severe: 43–52* (7). It is unknown if these cut-off scores can be generalized to our population. However, it is useful to define several categories, since the presence of kinesiophobia is not dichotomous and is therefore of better use for the clinician and the patient (8). In addition, 31% of patients showed an improvement of at least 5 points on the TSK-NL Heart after CR, which was previously suggested to be a clinically relevant change in patients with chronic low back pain (9, 10). This finding indicates that relevant improvements are made during CR and is line with a recent study that shows the potential benefit of CR on fear avoidance beliefs (a concept closely related to kinesiophobia). During CR patients are exposed to PA which in turn helps to alleviate negative beliefs about PA (11). Graded exposure is also used in patients with low back pain and has been shown effective in reducing kinesiophobia (12) (13). Our study showed that the TSK-NL Heart has sufficient responsiveness to assess changes in kinesiophobia. Therefore, the TSK-NL Heart can be used in future studies to assess the effect of CR-programs on kinesiophobia.

In **chapter 4** we included patients 2-3 weeks after hospital discharge and performed semi-structured interviews to assess factors associated with kinesiophobia and to assess patient' needs with regard to PA and participation in CR. We used a cut off score >28 points on the TSK-NL Heart to define `high kinesiophobic scores'. This study shows that patients attributed high levels of kinesiophia to a `disrupted health care process' (c*ategories: negative experiences with the health care system and inconsistent information at hospital discharge*) and `negative beliefs and attitudes concerning physical activity' (*categories: distressing body signals during physical activity and passive coping style*). Previous studies have found an association between the ability to obtain and understand medical information (health literacy) and anxiety, readmissions and lower social support (14). This finding might also apply to cardiac patients with kinesiophobia and emphasizes the need for accessible and understandable information. Similar results have been found in qualitative analysis of patients with low back pain, where patients with kinesiophobia held the belief that PA results in injury and that pain during PA, results in more suffering and functional loss (15).

This study also shows that patients, who had already participated in CR, were more positive about PA and exercise and were looking forward to starting CR. Previous experience with CR is an important facilitator of participation in CR

(16). Patients who already participated in CR felt supported by patients who went through the same experience during CR. Based on the findings in this study, an early remote intervention was developed to support patients and informal caregivers in the early phase after hospital discharge (**chapter 7**).

Our path-analysis (**chapter 5**) showed that kinesiophobia decreases the likelihood of CR-initiation ($OR^{range13-52}$ = 0.92 95%CI: 0.84 to 0.99). A potential explanation is that patients with kinesiophobia have negative beliefs about PA and have negative experiences with the health care system (**chapter 4**). However, as shown in **chapter 3**, patients with high levels of kinesiophobia might benefit from CR and therefore need to be adequately referred. In addition, chapter 5 shows that kinesiophobia is negatively associated with high education (β=-0.18 95%CI:-0.34 to -0.02) and self-efficacy (β=-0.29 95%CI: -0.47 to -0.12) and positively associated with cardiac anxiety (β=0.33 95%CI: 0.19 to 0.48) and social complexity (β=0.23 95%CI: 0.06 to 0.39). This study confirms the finding by Brunetti et al. who found a negative correlation between kinesiophobia and educational level in patients with CVD (17). Zelle et al. reported that the relation between kinesiophobia and PA, in patients with renal disease, is largely mediated by self-efficacy and is therefore important to assess (3). Similar results have been reported by Cai et al 2018, who revealed that, after a knee arthroplasty, kinesiophobia is associated with lower education, negative coping styles, lower self-efficacy and less social support (18). In our study, a small but significant association was found between kinesiophobia and social complexity. This finding is in line with our findings in **chapter 4** where we concluded that patients with low levels of kinesiophobia experienced more social support than those with high levels of kinesiophobia. In patients with low levels of kinesiophobia, informal caregivers often stimulated patients to do PA and helped patients to cope with fear of movement (Quote: *Last weekend I went for a walk with my neighbor. I was a bit anxious, so we walked for a short while and that felt good. She really helped me through*). The presence of a partner has been shown to improve adherence to CR (19). Moreover, participation of partners in CR-programs improves PA-levels in patients. (20, 21). Future studies should evaluate the role of social support on levels of kinesiophobia.

In **chapter 5**, cardiac anxiety measured with the CAQ was associated with kinesiophobia, but only predicted CR-initiation indirectly with kinesiophobia as mediator. An explanation for this finding is that somatic symptoms such as chest pain or palpitations (cardiac anxiety) (22), can lead to negative beliefs about one's physical state (kinesiophobia), which in turn can lead to not initiating CR. In our study, the HADS only predicted CR-initiation in univariable analyses (P<0.10). The HADS measures generic anxiety and is therefore not suited to determine fear of PA or likelihood of CR-initiation. Future studies, using a causal design, can use the results of this study to investigate determinants of kinesiophobia and the effect of kinesiophobia on CR-initiation (23). Meanwhile, patients with kinesiophobia should be supported with early coaching programs to improve self-efficacy, reduce psychological distress, stimulate PA and the uptake of CR.

Our comprehensive random intercept cross lagged panel model found no

association between PA-intensity and kinesiophobia in the first 12 weeks after hospital discharge (**chapter 6**). In the first 12 weeks after hospital discharge, light and moderate PA fluctuated, while heavy PA was avoided by all patients. Contradictory findings are reported in the literature concerning the association between kinesiophobia and objectively measured PA. Recent studies, in patients with low back pain and whiplash, also shows that kinesiophobia is not associated with objectively measured PA, measured with an accelerometer (24, 25). In addition, other studies did not find an association between kinesiophobia and physical capacity measures such as: walking endurance, physical deconditioning and maximal oxygen consumption (VO2max) (26-28). In contrast, Bäck et al. found that patients with high levels of kinesiophobia took fewer steps than those without kinesiophobia 3 to 10 months after cardiac hospitalization (29). An explanation for these different findings, might be that all cardiac patients perform less PA in the first phase after cardiac hospitalization, thereby making discrimination between patients with and without kinesiophobia difficult. Our study clearly shows that all patients avoided activities with high intensity in the first 12 weeks after hospital discharge, while light to moderate PA gradually increased. Although we did not find an association with PA, kinesiophobia is associated with disability, low self-efficacy (**chapter 5**), and self-reported PA and is therefore important to target after cardiac hospitalization (30). Furthermore, this study shows that kinesiophobia remains relatively stable in the first 12 weeks after hospital discharge and therefore might be considered a trait like construct. PA, on the other hand, is a dynamic process that develops over time. Although kinesiophobia can be considered a trait-like construct, our previously conducted study shows that relevant improvements in kinesiophobia are made during CR (**chapter 3**). CR in the form of exposure in vivo, is recommended for patients with kinesiophobia to alter negative beliefs about PA (11). Our previous study (**chapter 4**) shows that in the early phase after hospital discharge, high levels of kinesiophobia are related to negative beliefs about PA such as: "*By being careful with unnecessary movements I can prevent my heart problems from worsening*" and "*If I tried to be physically active/exercise my heart problem would increase*". Unfortunately, exposure to PA, under the guidance of an experienced physical therapist, is limited to those that are referred to CR. Therefore, adequate referral to CR of those with high levels of kinesiophobia is important.

In **chapter 7** we developed a remote coaching program for patients with CAD in the early phase after hospital discharge, using the intervention mapping protocol (IM) (31). The IM-approach is theory based approach to intervention development and is often used to create behavioural (digital) interventions to reduce psychological distress, improve PA or target lifestyle factors such as the cessation of smoking or weight gain (32-34).

In this study, patients' needs and expectations were taken into account in the early phase of the design phase which contributes to the usability and utility of this intervention (35). Results from our literature study and interviews indicated that the interval between hospital discharge and CR was too long and that

patients wanted to be in contact with a health care provider to receive support and information directly after hospital discharge. It remains unclear, however, if this remote coaching program is applicable for older adult cardiac patients with comorbidities, as they are often reluctant to use eHealth apps (36). Despite the technological barriers, older adults might view digital coaching as social interaction, which is often desired by older adults. In addition, older adults might have more time to engage in digital technologies (37). This remote coaching program helps to bridge the gap from hospital discharge to the start of CR. Delayed participation in CR negatively impacts physical and psychological outcomes, while early initiation of CR positively impacts health outcomes (38-40). The findings of this study might also be useful for other patient- populations. For instance, initiation of pulmonary rehabilitation, in patients with COPD, within 3 months after hospital discharge significantly lowers mortality rates at 1 year follow up (41). An early remote coaching program, starting directly after hospital discharge might help to overcome logistical issues and delays in rehabilitation programs.

Future studies should focus on program refinement (IM step 4) of this remote coaching program and assess its feasibility and effectiveness in studies with larger sample sizes. It would be interesting to assess the effectiveness of this early remote coaching program on symptoms of psychological distress and participation in outpatient cardiac rehabilitation.

IMPLICATIONS FOR CLINICAL PRACTICE

Using the TSK-NL Heart at hospital discharge, helps to identify and refer patients with high levels of kinesiophobia. Patients with kinesiophobia might benefit from early (remote) coaching programs to improve self-efficacy, reduce psychological distress and improve physical activity and the uptake of CR. The Dutch guideline for multidisciplinary cardiac rehabilitation states that 'overcoming fear of movement' is one of the aims of cardiac rehabilitation (42). The validation of the TSK-NL Heart and development of an intervention provide in the need to objectify kinesiophobia in patients with cardiovascular disease. In addition, the TSK-NL Heart can be used, during CR to evaluate specific strategies aimed at targeting kinesiophobia. **Chapter 2** and **3** show that the TSK-NL Heart has good psychometric properties (reliability, construct validity, responsiveness) and can be of added value to cardiologists, registered nurses, physiotherapists and allied health care professionals. The cutoff point of >28 points to define `high levels of kinesiophobia' should not be used. The use of categories (subclinical, mild, moderate and severe) is more suitable and allows for useful differentiation between levels of kinesiophobia (before and after CR). Since an 8% per point increase on the TSK-NL Heart is associated with not initiating CR, we suggest using the TSK-NL Heart at hospital discharge to determine the presence of kinesiophobia and likelihood of CR-initiation. The TSK is also of use to physicians, nurses or physical therapists working with other clinical patients population including:

patients with COPD, Parkinson's disease, Multiple Sclerosis or Stroke or various forms of cancer (1-5).

After cardiac hospitalization, patients with high levels of kinesiophobia, are in need of tailored information and support provided by a health care provider. Patients often experience a gap between hospital discharge and the start of cardiac rehabilitation, in which they suffer from psychological distress and lack tailored information. For instance, patients often report to have distressing body signals after cardiac hospitalization. Insight in the origin of body signals, and learning to discriminate between `harmful' and `harmless' body signals may prevent avoidance behavior (43). We suggest providing tailored, understandable information and social support to patients with high levels of kinesiophobia (**chapter 5**). In addition, informal caregivers often perform all physical tasks as a result of hypervigilance. Research suggests that hypervigilance in spouses, although well intended, may undermine the patients' functional recovery (44) (**chapter 4**). After cardiac hospitalization, patients and informal caregivers could potentially benefit from an early remote coaching program aimed at reducing psychological distress and improving self-efficacy and physical activity (**chapter 7**).

IMPLICATIONS FOR EDUCATION

Currently, kinesiophobia is an important topic in the curriculum of physical therapy education, especially in patients with musculoskeletal complaints. However, kinesiophobia is often unrecognized in patients with CVD and other patient groups with chronic illnesses. More attention for kinesiophobia is needed in the curricula of health care professions to assure that students learn to recognize and adequately treat or refer patients with high levels of kinesiophobia. Moreover, as graduation thesis, kinesiophobia is an interesting topic which can be studied from multiple healthcare perspectives (biological, social, psychological) and is therefore of interest for physical therapists, occupational therapists, nurses, physicians, social workers and other allied healthcare professionals.

From hospital discharge to the start of cardiac rehabilitation, patients come into contact with a variety of health care providers (e.g. cardiologist, nurses, physical therapists). **Chapter 4** clearly shows that patients are in need of early information and support in the period between hospital discharge and the start of cardiac rehabilitation. Recognizing kinesiophobia and learning specific skills to reduce psychological distress are important for a variety of professionals in the process from hospital discharge to the start of cardiac rehabilitation. This thesis offers specific remote strategies to deal with psychological distress (including kinesiophobia) and can be implemented in the curricula of a variety of health care studies.

In **chapter 4**, bachelor thesis students were involved in interviewing patients at their homes or at the CR center. Based on their findings (partly), a remote coaching program was developed to bridge the gap between hospital discharge

and the start of CR (**chapter 7**). For future studies we suggest to create more Living Labs such as Polifysiek (at the Amsterdam University of Applied Sciences) or Fit for Practice (at the Heart Center of the Amsterdam UMC), where patient care, education and research are combined (45). In a Living Lab, patients, students and researchers with different backgrounds work together interprofessionaly, in cocreation, to develop new innovative healthcare products.

CONCLUSION

This thesis explored the construct kinesiophobia in patients with cardiovascular disease and shows that kinesiophobia is prevalent in a substantial proportion of patients at hospital discharge and at the start of cardiac rehabilitation. The following recommendations can be made:

First, the TSK-NL Heart has good psychometric properties but the cut off values should be further evaluated. We recommend categories when using the TSK-NL Heart. In addition, the TSK-NL Heart can be used to measure kinesiophobia in clinical practice and in studies where interventions to target kinesiophobia are tested. Second, patients with kinesiophobia are in need of tailored information and social support after hospital discharge. Specific information concerning coronary artery disease, medication and side effects, physical activity and psychological distress should be offered in an understandable manner (such as health video clips). In addition, social support should be provided in the early phase directly after hospital discharge to reduce psychological distress, improve self-efficacy and improve CR- initiation. Third, kinesiophobia at hospital discharge decreases the likelihood to initiate cardiac rehabilitation. At hospital discharge, patients with kinesiophobia should be adequately referred for cardiac rehabilitation and offered an early remote coaching program. Fourth, gradual exposure to PA during CR helps to alleviate symptoms of kinesiophobia by altering negative beliefs about physical activity. Fifth, although kinesiophobia is not associated with PA in the first weeks after hospital discharge, kinesiophobia is associated with cardiac anxiety, self-efficacy and social complexity. Therefore, evaluation and management of kinesiophobia is warranted. Future research should focus on determining specific clinical severity levels of the TSK-NL Heart for cardiac patients, determining the feasibility and effectiveness of a remote coaching program to target psychological distress, stimulate self-efficacy and stimulate the uptake of CR, and the development of treatment strategies for kinesiophobia during CR.

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Chapter 9

Summary
Samenvatting

SUMMARY

FEAR OF MOVEMENT IN PATIENTS WITH CARDIOVASCULAR DISEASE

Chapter 1 provides an overview of the framework of this thesis. Cardiovascular diseases (CVD's) represent 32% of all global deaths. Physical activity (PA) is a cornerstone of secondary prevention of CVD and a core component of cardiac rehabilitation (CR) as it improves functional capacity and quality of life. Only a minority of patients with CVD (17%) perform the recommended amount of PA (at least 150-300 min a week of moderate-intensity or 75-150 min a week of vigorous-intensity aerobic PA), after cardiac hospitalization. An explanation for these low PA levels, is anxiety that is often reported after cardiac hospitalization. Especially, fear of movement (kinesiophobia) is an important barrier for patients to achieve adequate levels of PA. Kinesiophobia is present in 20% of patients with CVD and is associated with reduced quality of life and non-adherence to CR, despite it's well known benefits such as: reduced mortality, morbidity, and unplanned hospital admissions. The overall aim of this thesis is to explore the influence of kinesiophobia on patients with cardiovascular disease. First, by developing a measurement tool to identify patients with kinesiophobia: The Tampa Scale for Kinesiophobia (TSK-NL Heart) Second, the course of kinesiophobia was investigated by exploring experiences and needs of patients with kinesiophobia after cardiac hospitalization. In addition, by assessing factors associated with kinesiophobia at hospital discharge, and by investigating the impact of kinesiophobia on initiation of CR and objectively measured PA. Third, based on the findings of the aforementioned studies, we developed an intervention to target kinesiophobia in the early phase after hospital discharge.

In **Chapter 2** we assessed the test-retest reliability, construct validity, and factor structure of the TSK-NL Heart, in patients attending cardiac rehabilitation (CR). In this cross-sectional cohort study, 151 patients (70,4% male) with a mean age (SD) of 61.5 (11.6) were included. The TSK-NL Heart, Cardiac Anxiety Questionnaire (CAQ) and the Hospital Anxiety and Depression Scale (HADS) were administered at the start of CR. The TSK-NL Heart has good test-retest reliability (ICC = 0.82, 95%, CI 0.75–0.86) and correlates well with the CAQ ($R^{spearman}$ = 0.61, 95%, CI 0.51–0.71) and HADS-anxiety ($R^{spearman}$ =0.60, 95%, CI: 0.48–0.70). Our exploratory factor analysis revealed that a 3-factor structure is most suitable for the TSK-NL Heart, consisting of the subscales: fear of injury, avoidance of physical activity, and perception of risk. In addition, high levels of kinesiophobia (TSK-NL Heart >28) were found in 45.4% of patients at the start of CR. In conclusion, chapter 2 shows that the psychometric properties of the TSK-NL Heart are sufficient and that kinesiophobia is prevalent in a substantial proportion of patients at the start of CR.

In **Chapter 3**, we determined the responsiveness of the TSK-NL Heart at the start of CR and at 3 months follow-up. In addition, we assessed changes in kinesiophobia during CR. In this longitudinal study, we measured kinesiophobia with the TSK-NL Heart in 109 cardiac patients (76.1% male) with a mean age (SD) of 61.1 (11.6). Internal and external responsiveness were determined using the effect size of change scores. For this step, the CAQ and the HADS were filled out as external measures in a subsample of 58 patients. The ES of the TSK-NL Heart for the full study population was small (0.29). In line with our hypothesis, the effect size was higher (moderate) for patients with improved CAQ (0.52) and HADS scores (0.54). Prevalence of high kinesiophobia levels (TSK-NL Heart >28) decreased from 40% pre-CR to 26% post-CR (p=0.004). This study shows that the TSK-NL Heart has moderate responsiveness and can be used to measure changes in kinesiophobia. Improvements in kinesiophobia were observed during CR. Nevertheless, high kinesiophobia levels were still highly prevalent at 3 months after the start of CR.

In **Chapter 4** we describe factors related to kinesiophobia after acute cardiac hospitalization. We performed semi-structured interviews with 16 patients (median age 65, 10 males), 2-3 weeks after acute cardiac hospitalization. High levels of kinesiophobia (TSK-NL Heart >28) were associated with: (1) `a disrupted healthcare process' (categories: *negative experience health care system* and i*nconsistent information at hospital discharge*) and (2) `negative beliefs and attitudes concerning physical activity (PA)' (categories: *body signals during PA* and *passive coping style*). Low levels of kinesiophobia were related to (1) `understanding the necessity of PA' (categories: *previous experience with serious illness* and *receiving and understanding information* and *positive experience with exercise and PA*) and (2) `experiencing social support' (category: s*ocial support network*). All patients formulated 'tailored information and support from a health care provider' (categories: c*onsistent information* and *guidance health care provider*) as most important need after hospital discharge. The findings of **chapter 4** can be used to develop an early intervention to stimulate PA and uptake of CR.

In **Chapter 5** we describe our path analysis by which we identified factors associated with kinesiophobia at hospital discharge, and by which we investigated the impact of kinesiophobia on initiation of CR at 3 months follow-up. In this study, 149 patients (78.5% male) with a median (interquartile range) age of 65 (14) were included, of which 82 (59%) were referred for CR. At hospital discharge, kinesiophobia was positively associated with cardiac anxiety (β=0.33, 95% CI: 0.19 to 0.48) and social complexity (β=0.23, 95%CI: 0.06 to 0.39) and negatively associated with higher education (β=-0.18, 95% CI:-0.34 to -0.02). In those referred for CR, kinesiophobia was negatively associated with self-efficacy (β=-0.29, 95% CI: -0.47 to -0.12) and positively associated with cardiac anxiety (β=0.43, 95% CI: 0.24 to 0.62). Kinesiophobia decreased the probability of CR-initiation ($OR^{Range13\text{-}52\ points}$ = 0.92, 95%CI: 0.84 to 0.99). In patients hospitalised for cardiovascular disease, we found that kinesiophobia is associated with cardiac anxiety, social complexity, educational level, and self-efficacy. Kinesiophobia

decreased the likelihood of CR-initiation with 8% per point on the TSK. Adequate referral of patients with high levels of kinesiophobia to CR is warranted.

In **Chapter 6** we present the longitudinal association between kinesiophobia and objectively measured PA. In this study 116 cardiac patients (83.6% male) with a median (interquartile range) age of 65.5 years (9.88) were included. PA was objectively measured with the Personal Activity Monitor (PAM). The PAM measures time spend per day in the following PA-intensity categories: light, moderate, heavy. The longitudinal association between PA-intensity and Kinesiophobia was assessed at 4 time-points (week 1: hospital discharge, 3, 6, 12 weeks) with a random intercept cross lagged panel model (RI-CLPM). This study shows that no cross-over effects were found between objectively measured PA and kinesiophobia on any occasion. Model fit for the original model, with cross-over effects, was poor ($X^2 = 44.646$, $P<0.001$). In our final model, we modelled kinesiophobia as a stable *between person* factor while objectively measured PA was modelled as autoregressive component (dynamic process). We found a good fit for this model ($X^2 = 27.541$, $P<0.12$). Kinesiophobia and objectively measured PA are not associated in the first 12 weeks after hospital discharge. This study shows that kinesiophobia remained relatively stable12 weeks after hospital discharge, despite fluctuations in light to moderate PA-intensity.

In **chapter 7** we present the design of a remote coaching program to bridge the gap from hospital discharge to the start of CR. For this study we used the intervention mapping approach. Three consecutive steps were completed in this study: (1) identification of information and support needs in patients with coronary artery disease (CAD), using an exploratory literature study and semi structured interviews, (2) definition of program objectives, and (3) selection of theory-based methods and practical intervention strategies. Our exploratory literature study (n=38) and semi-structured interviews in patients with CAD (n=17) identified that, after hospital discharge, patients with CAD report a need for tailored information and support about (1) CAD itself and revascularization, (2) medication and side effects, (3) physical activity, and (4) psychological distress. Based on the preceding steps, we defined the following program objectives for patients: gaining knowledge on how CAD and revascularization affect their bodies and health, gaining knowledge about medication and side effects, knowing which daily physical activities they can and can't do safely after hospital discharge and being physically active, knowing the psychosocial consequences of CAD and knowing how to discriminate between harmful and harmless body signals. Based on the preceding steps, a remote coaching program was developed with the theory of health behavior change as a theoretical framework, and with behavioral counseling and video modeling as practical strategies for the program. The overall objective of this program is to reduce psychological distress, improve self-efficacy and stimulate the uptake of CR.

Chapter 8 presents a general discussion on the main findings of this study and presents implications for research, clinical practice, and education. This thesis shows that kinesiophobia is prevalent in a substantial proportion of patients at

hospital discharge and at the start of cardiac rehabilitation. Based on the findings in this thesis, the following recommendations can be made. First, the TSK-NL Heart is a suitable measurement tool to identify patients with kinesiophobia. We recommend the use of categories (subclinical, mild, moderate and severe) when applying the TSK-NL Heart, since kinesiophobia is not a dichotomous construct. In addition, the TSK-NL Heart can be used to measure kinesiophobia in clinical settings and in future studies where interventions targeting kinesiophobia are tested. Second, patients with kinesiophobia are in need of tailored information and social support after cardiac hospitalization. Specific information concerning cardiovascular disease, medication and side effects, starting physical activity and dealing with psychological distress should be offered in an understandable manner (e.g. by using health video clips). In addition, social support should be provided directly after hospital discharge to reduce psychological distress and improve self-efficacy. Third, kinesiophobia at hospital discharge decreases the likelihood to initiate cardiac rehabilitation, therefore adequate referral to cardiac rehabilitation is necessary. Moreover, these patients should be offered a remote coaching program that facilitates tailored information and being in with contact a health care provider, from the privacy of their own home. Fourth, although kinesiophobia is not associated with PA in the first weeks after hospital discharge, our study shows that kinesiophobia is associated with cardiac anxiety, reduced self-efficacy and social complexity. Therefore, evaluation and management of kinesiophobia is warranted during hospital discharge and cardiac rehabilitation. Future research should focus on 1) determining specific clinical severity levels of the TSK-NL Heart for cardiac patients, 2) determining the feasibility and effectiveness of a remote coaching program to target psychological distress, stimulate self-efficacy and stimulate the uptake of CR, and 3) the development of treatment strategies for kinesiophobia during CR.

SAMENVATTING

KINESIOFOBIE BIJ PATIËNTEN MET HART- EN VAATZIEKTEN

In **Hoofdstuk 1** wordt het kader van dit proefschrift geschetst. Hart- en vaatziekten veroorzaken 32% van alle sterfte wereldwijd. Fysieke activiteit speelt een belangrijke rol in de secundaire preventie van hart en vaatziekten, en is een kerncomponent van hartrevalidatie. Het doen van fysieke activiteit verbetert het fysiek functioneren en de kwaliteit van leven. Slechts een minderheid van patiënten met hart- en vaatziekten (17%) voldoet aan de voorgeschreven hoeveelheid fysieke activiteiten na een hart-gerelateerde ziekenhuisopname (ten minste 150-300 minuten per week fysieke activiteiten met een matige intensiteit of 75-150 minuten per week fysieke activiteiten met zware intensiteit). Een verklaring voor deze lage mate van fysieke activiteit is angst voor bewegen (kinesiofobie), een fenomeen dat vaak wordt gerapporteerd na een hartincident. Kinesiofobie komt voor bij 20% van alle hartpatiënten en hangt samen met een verminderde kwaliteit van leven en een verminderde deelname aan hartrevalidatie, ondanks de gunstige effecten van hartrevalidatie zoals: verminderde mortaliteit, morbiditeit en ongeplande ziekenhuisopnames. Het doel van dit proefschrift is om de invloed van kinesiofobie op patiënten met hart- en vaatziekten te onderzoeken. Ten eerste, door het ontwikkelen van een meetinstrument om patiënten met kinesiofobie te identificeren: de Tampa Schaal voor Kinesiofobie Hart (TSK-NL Hart). Ten tweede, het in kaart brengen van het beloop van kinesiofobie door het onderzoeken van ervaringen en behoeftes van patiënten met kinesiofobie na een hart-gerelateerde ziekenhuisopname. Daarnaast door het bepalen van enerzijds factoren die samenhangen met kinesiofobie tijdens ziekenhuisontslag, en anderzijds de impact van kinesiofobie op het starten met hartrevalidatie en op fysieke activiteit. Gebaseerd op de bevindingen uit deze hier voorgenoemde studies is een interventie ontwikkeld die zich richt op kinesiofobie in de vroege fase na ziekenhuisontslag.

In **hoofdstuk 2** hebben we de test-hertest betrouwbaarheid, constructvaliditeit en factorstructuur van de TSK-NL Hart onderzocht bij 151 patiënten die gestart waren met hartrevalidatie (70,4% man en een gemiddelde (standaarddeviatie) leeftijd van 61.5 (11.6) jaar. Bij de start van de hartrevalidatie is de TSK-NL Hart, de Cardiale Angst Vragenlijst (CAQ) en de Hospital Anxiety and Depression Scale (HADS) afgenomen. De TSK-NL Hart heeft een goede test-hertest betrouwbaarheid (ICC = 0.82, 95% BI: 0.75-0,86) en correleert goed met de CAQ ($R^{spearman}$ = 0.61, 95% BI: 0.51-0.71) en de HADS-angst ($R^{Spearman}$ = 0.60, 95% BI: 0.48–0.70). Onze explorerende factoranalyse laat zien dat een 3-factorstructuur het meest geschikt is voor de TSK-NL Hart, bestaande uit de subschalen: angst voor letsel, vermijden van fysieke activiteit, risicoperceptie. Bij de start van de hartrevalidatie had 45.4% van de patiënten een hoge mate van kinesiofobie. Dit

hoofdstuk laat zien dat de psychometrische eigenschappen van de TSK-NL Hart voldoende zijn. Ook toont het dat kinesiofobie voorkomt bij een substantieel aantal patiënten bij de start van de hartrevalidatie.

In **Hoofdstuk 3** hebben we de responsiviteit van het TSK-NL Hart bepaald op twee momenten: bij de start en 3 maanden na de start van de hartrevalidatie. Daarnaast zijn veranderingen in kinesiofobie tijdens de hartrevalidatie gemeten. In deze longitudinale studie werd kinesiofobie gemeten met de TSK-NL Hart bij 109 hartpatiënten (76.1% man) met een gemiddelde leeftijd (standaarddeviatie) van 61.1 (11.6) jaar. Interne en externe responsiviteit zijn bepaald met de effect size van de verschilscores. De ES voor de interne responsiviteit was klein (0.29). In lijn met onze hypothese was de effect size groter (matig) bij patiënten die verbeterden op andere angstmaten (externe responsiviteit) CAQ (0.52) en op de HADS (0.54). De prevalentie van een hoge mate van kinesiofobie (TSK-NL Hart >28) nam af van 40% bij de start van hartrevalidatie naar 26% na afloop (p = 0.004). Te concluderen is dat de TSK-NL Hart een matige responsiviteit heeft en gebruikt kan worden om veranderingen in kinesiofobie te meten. Verbeteringen in kinesiofobie werden geobserveerd gedurende deelname aan hartrevalidatie, maar kinesiofobie kwam nog steeds veel voor 3 maanden na de start van hartrevalidatie.

In **Hoofdstuk 4** beschrijven we factoren die samenhangen met kinesiofobie na een acute cardiale ziekenhuisopname. We hebben semigestructureerde interviews afgenomen bij 16 patiënten (mediane leeftijd 65, 10 mannen) 2 tot 3 weken na een acute hart-gerelateerde ziekenhuisopname. Een hoge mate van kinesiofobie (TSK-NL Hart >28) werd in verband gebracht met (1) een verstoord zorgproces (categorieën: n*egatieve ervaring met de gezondheidszorg* en *inconsistente informatie bij ziekenhuisontslag*) en (2) negatieve overtuigingen en attitudes met betrekking tot het uitvoeren van fysieke activiteiten (categorieën: l*ichaamssignalen tijdens het uitvoeren van fysieke activiteiten* en *een passieve coping stijl*). Lage niveaus van kinesiofobie werden gerelateerd aan (1) het begrijpen van de noodzaak van het uitvoeren van fysieke activiteiten (categorieën: *eerdere ernstige ziekte* en *het ontvangen en begrijpen van informatie* en p*ositieve ervaring met training en fysieke activiteiten*) en (2) het ervaren van sociale steun (categorie: *sociaal netwerk*). Alle patiënten formuleerden 'op maat gemaakte informatie en ondersteuning van een zorgverlener' (categorieën: *consistente informatie* en *begeleiding van een gezondheidsprofessional*) als belangrijkste behoefte na ontslag uit het ziekenhuis. De bevindingen van hoofdstuk 4 kunnen gebruikt worden voor het ontwikkelen van een vroegtijdige interventie gericht op het ondernemen van fysieke activiteiten, en deelname aan hartrevalidatie.

In **Hoofdstuk 5** beschrijven we een pad analyse waarmee factoren werden geïdentificeerd die samenhangen met kinesiofobie tijdens ziekenhuisontslag, en waarmee we het effect van kinesiofobie op het starten van hartrevalidatie onderzochten, 3 maanden na ziekenhuisontslag. In deze studie werden 149 patiënten (78,5% man) met een mediane (interkwartielafstand) leeftijd van 65 jaar (14) geïncludeerd. Iets meer dan de helft (59%) werd doorverwezen naar HR. Tijdens ziekenhuisontslag was kinesiofobie gerelateerd aan cardiale angst (β=0.33 95%CI: 0.19 tot 0.48) en sociale complexiteit (β=0.23 95%CI: 0.06 tot 0.39) en hing

kinesiofobie negatief samen met een hoger opleidingsniveau (β=-0.18 95%CI:-0.34 tot -0.02). In de groep die werd doorverwezen voor hartrevalidatie (N=82) was kinesiofobie ook negatief gerelateerd met zelfeffectiviteit (β = -0.29 95% CI: -0.47 tot -0.12) en positief met cardiale angst (β= 0.43 95%CI: 0.24 tot 0.62). Kinesiofobie verminderde de kans op het starten van HR ($OR^{Range13-52}$ punten = 0.92 95%CI: 0.84 tot 0.99). Samenvattend, laat hoofdstuk 5 zien dat kinesiofobie tijdens ziekenhuisontslag positief gerelateerd is aan cardiale angst en sociale complexiteit, en negatief gerelateerd aan opleidingsniveau en zelfeffectiviteit. Daarnaast vermindert kinesiofobie de kans op het starten met HR.

In **Hoofdstuk 6** presenteren we de longitudinale relatie tussen kinesiofobie en objectief gemeten fysieke activiteits. In deze longitudinale cohortstudie werden 116 hartpatiënten (83.6% man) met een mediane (interkwartielafstand) leeftijd van 65,5 jaar (9.88) geïncludeerd. Fysieke activiteit werd objectief gemeten met de Personal Activity Monitor (PAM). De PAM meet het aantal minuten fysieke activiteiten per dag in de categorieën: licht, matig, zwaar. De longitudinale associatie tussen FA-intensiteit en kinesiofobie werd beoordeeld op vier tijdstippen (ontslag uit het ziekenhuis, 3, 6, 12 weken) met een random intercept cross lagged panel model (RI-CLPM). Er werden geen cross-over-effecten gevonden tussen objectief gemeten fysieke activiteiten en kinesiofobie. Model fit voor het oorspronkelijke model was slecht (X^2: = 44.646 P<0.001). In het uiteindelijke model hebben we kinesiofobie gemodelleerd als een stabiele *tussen persoons* factor en objectief gemeten FA als autoregressie componenten (dynamisch proces). Voor dit model vonden we een goede model fit (X^2 = 27.541 P<0.12). Kinesiofobie en objectief gemeten fysieke activiteiten zijn niet geassocieerd in de eerste 12 weken na ziekenhuisontslag. Deze studie laat zien dat kinesiofobie stabiel blijft in de eerste 12 weken na ziekenhuisontslag ondanks fluctuaties van lichte tot matige fysieke activiteit.

In **hoofdstuk 7** presenteren we het ontwerp van een coachingprogramma op afstand dat het doel heeft de periode tussen ziekenhuisontslag en de start van de hartrevalidatie te overbruggen. In deze studie is de intervention mapping-benadering gebruikt. In dit onderzoek werden drie opeenvolgende stappen doorlopen: (1) identificatie van informatie- en ondersteuningsbehoeften van patiënten met coronaire hartziekten, met behulp van een verkennende literatuurstudie en semigestructureerde interviews, (2) definitie van programmadoelstellingen, en (3) selectie van op theorie gebaseerde methoden en praktische interventiestrategieën. De verkennende literatuurstudie (n=38) en semigestructureerde interviews (n=17) lieten zien dat patiënten, na ontslag uit het ziekenhuis, behoefte hebben aan informatie en ondersteuning over (1) hart- en vaatziekten en re-vascularisatie, (2) medicatie en bijwerkingen, (3) het uitvoeren van fysieke activiteiten, en (4) psychologische factoren. Gebaseerd op de voorgaande stappen, zijn de volgende programmadoelstellingen gedefinieerd: (1) patiënten hebben kennis over hoe hart- en vaatziekten en re-vascularisatie hun lichaam en gezondheid beïnvloeden, (2) patiënten hebben kennis over medicatie en bijwerken en zijn trouw aan hun behandelplan, (3) patiënten weten welke dagelijkse activiteiten ze wel en niet

veilig kunnen uitvoeren na ziekenhuisontslag en zijn fysiek actief, en (4) patiënten kennen de psychosociale consequenties van hart- en vaatziekten en weten hoe ze schadelijke en onschadelijke lichaamssignalen van elkaar kunnen onderscheiden. Gebaseerd op de voorgaande stappen is een coaching programma op afstand ontwikkeld met de theory of health behavior change als theoretisch raamwerk. Als praktische strategieën is gekozen voor gedragstherapie en het gebruik van videoclips. De overkoepelende doelstellingen van dit programma zijn het verminderen van psychische stress, het verbeteren van zelfeffectiviteit en het stimuleren van deelname aan hartrevalidatie.

In **Hoofdstuk 8** wordt een discussie gepresenteerd over de bevindingen van dit proefschrift en worden implicaties voor onderzoek, patiëntenzorg en het onderwijs beschreven. Dit proefschrift onderzocht kinesiofobie bij patiënten met hart- en vaatziekten en laat zien dat kinesiofobie veel voorkomt bij patiënten, tijdens ziekenhuisontslag en bij de start van de hartrevalidatie. Op basis van bevindingen uit dit proefschrift, kunnen aanbevelingen worden gedaan. Ten eerste, de TSK-NL Hart is een geschikt meetinstrument om patiënten met kinesiofobie te identificeren. Bij het toepassen van de TSK-NL Hart raden we aan om categorieën te gebruiken (preklinisch, mild, matig, en ernstig), aangezien kinesiofobie geen dichotoom construct is. De TSK-NL Hart kan gebruikt worden in een klinische setting en in toekomstig onderzoek waar interventies, gericht op het verminderen van kinesiofobie, worden onderzocht. Ten tweede, patiënten met kinesiofobie hebben behoefte aan op maat gemaakte informatie en sociale ondersteuning na ziekenhuisontslag. Specifieke informatie over hart- en vaatziekten, medicatie en bijwerkingen, hoe fysieke activiteiten weer opgebouwd kunnen worden en het omgaan met psychische klachten, dienen aangeboden te worden op een begrijpelijke manier. We adviseren om patiënten te ondersteunen in de vroege fase na ziekenhuisontslag om psychische klachten te verminderen en zelfeffectiviteit te stimuleren. Ten derde, kinesiofobie bij ziekenhuisontslag blijkt de kans op het starten met hartrevalidatie te verminderen, daarom is adequate doorverwijzing naar hartrevalidatie van groot belang. Daarenboven, gezien de wachttijd tussen ziekenhuisontslag en de start van de hartrevalidatie, bevelen we aan om patiënten een coaching-programma op afstand aan te bieden waar zij duidelijke informatie kunnen vinden en in contact kunnen komen met een gezondheidsprofessional. Ten vierde, uit ons onderzoek blijkt dat er geen relatie is tussen kinesiofobie en objectief gemeten fysieke activiteit, in de eerste weken na ziekenhuisontslag. Echter, blijkt dat kinesiofobie wel samenhangt met cardiale angst, verminderde zelfeffectiviteit en sociale complexiteit. Om die reden is het signaleren en behandelen van kinesiofobie belangrijk tijdens ziekenhuisontslag en gedurende de hartrevalidatie. Toekomstig onderzoek zou gericht kunnen worden op 1) het bepalen van de klinische ernstniveaus van de TSK-NL Hart, 2) het bepalen van de haalbaarheid en effectiviteit van een coaching programma op afstand, gericht op het verminderen van psychische klachten, het stimuleren van zelfeffectiviteit en het starten met hartrevalidatie, 3) het ontwikkelen van behandelstrategieën gericht op kinesiofobie gedurende hartrevalidatie.

Addendum

Author contribution
List of publications
PhD portfolio
Dankwoord
Curriculum Vitae

AUTHOR CONTRIBUTION

Chapter 1

General introduction

Concept and design	Paul Keessen
Data collection	Not applicable
Statistical analysis	Not applicable
Interpretation of the data	Not applicable
Drafting the manuscript	Paul Keessen
Critical revision of the manuscript	Wilma J.M. Scholte op Reimer, Bart Visser, Corine H.M. Latour

Chapter 2

Keessen P, den Uijl I, Visser B, van den Berg-Emons HJG, Latour CHM, Sunamura M, Jørstad HT, ter Riet G, Scholte op Reimer WJM, Kraaijenhagen RA, ter Hoeve N. Fear of movement in patients attending cardiac rehabilitation: A validation study. J Rehabil Med. 2020;52(2):jrm00021. doi:10.2340/16501977-2653

Concept and design	Paul Keessen, Bart Visser, Corine H.M. Latour, Wilma J.M. Scholte op Reimer
Data collection	Paul Keessen, Iris den Uijl Nienke ter Hoeve
Statistical analysis	Paul Keessen, Iris den Uijl Nienke ter Hoeve
Interpretation of the data	Paul Keessen, Iris den Uijl, Nienke ter Hoeve, Gerben ter Riet, Bart Visser, Corine H.M. Latour, Wilma J.M. Scholte op Reimer
Drafting the manuscript	Paul Keessen, Iris den Uijl, Nienke ter Hoeve
Critical revision of the manuscript	Wilma J.M. Scholte op Reimer, Bart Visser, Corine H.M. Latour, Harald T. Jørstad, Madoka Sunamura, Roderik A. Kraaijenhagen, Henrika J.G. Emons-van den Berg

Chapter 3

N. ter Hoeve,*, P. Keessen,*, I. den Uijl, B. Visser, R.A. Kraaijenhagen4, M. Sunamura, W.J.M. Scholte op Reimer, C.H.M. Latour, H.T Jørstad, H.J.G. van den Berg-Emons. Assessing Changes in Fear of Movement in Patients attending Cardiac Rehabilitation: Responsiveness of the TSK-NL Heart Questionnaire. J Rehabil Med. 2022;54:jrm00328. Published 2022 Aug 26. doi:10.2340/jrm.v54.2519

Concept and design	Paul Keessen, Bart Visser, Corine H.M. Latour, Wilma J.M. Scholte op Reimer
Data collection	Paul Keessen, Iris den Uijl Nienke ter Hoeve
Statistical analysis	Paul Keessen, Nienke ter Hoeve
Interpretation of the data	Paul Keessen, Iris den Uijl, Nienke ter Hoeve
Drafting the manuscript	Paul Keessen, Iris den Uijl, Nienke ter Hoeve
Critical revision of the manuscript	Wilma J.M. Scholte op Reimer, Iris den Uijl, Bart Visser, Corine H.M. Latour, Harald T Jørstad, Madoka Sunamura, Roderik A. Kraaijenhagen, Henrika J.G. Emons-van den Berg

Chapter 4

Keessen P, Latour CHM, van Duijvenbode ICD, Visser B, van Proosdij A, Reen D, Scholte op Reimer WJM. Factors related to fear of movement after acute cardiac hospitalization. BMC Cardiovasc Disord. 2020;20(1):495. Published 2020 Nov 23. doi:10.1186/s12872-020-01783-9

Concept and design	Paul Keessen, Bart Visser, Corine H.M. Latour, Wilma J.M. Scholte op Reimer
Data collection	Paul Keessen, Ingrid van Duijvenbode, Anouk Proosdij, Daphne Reen
Analysis	Paul Keessen, Ingrid van Duijvenbode, Anouk Proosdij, Daphne Reen
Interpretation of the data	Paul Keessen, Corine HM Latour, Bart Visser
Drafting the manuscript	Paul Keessen, Corine HM Latour
Critical revision of the manuscript	Wilma JM Scholte op Reimer, Bart Visser, Ingrid van Duijvenbode

Chapter 5

Keessen P, Kan KJ, ter Riet G, Visser B, Jørstad HT, Latour CHM, van Duijvenbode ICD, Scholte op Reimer WJM. Impact of kinesiophobia on initiation of cardiac rehabilitation: a prospective cohort path analysis. Accepted BMJ Open

Concept and design	Paul Keessen, Bart Visser, Corine H.M. Latour, Wilma J.M. Scholte op Reimer
Data collection	Paul Keessen, Ingrid van Duijvenbode
Statistical analysis	Paul Keessen, Kees Jan Kan, Gerben ter Riet
Interpretation of the data	Paul Keessen, Kees Jan Kan, Gerben ter Riet, Bart Visser, Corine H.M. Latour, Wilma J.M. Scholte op Reimer
Drafting the manuscript	Paul Keessen, Kees Jan Kan
Critical revision of the manuscript	Wilma JM Scholte op Reimer, Bart Visser, Corine HM Latour, Harald T Jørstad, Gerben ter Riet, Ingrid van Duijvenbode

Chapter 6

Keessen P, Kan KJ, ter Riet G, Visser B, Jørstad HT, Latour CHM, van Duijvenbode ICD, Scholte op Reimer WJM. The longitudinal relationship between fear of movement and physical activity after cardiac hospitalization: a cross lagged panel model. Submitted

Concept and design	Paul Keessen, Bart Visser, Corine H.M. Latour, Wilma. J.M. Scholte op Reimer
Data collection	Paul Keessen, Ingrid van Duijvenbode
Statistical analysis	Paul Keessen, Kees Jan Kan, Gerben ter Riet
Interpretation of the data	Paul Keessen, Kees Jan Kan, Gerben ter Riet, Bart Visser, Corine H.M. Latour, Wilma J.M. Scholte op Reimer
Drafting the manuscript	Paul Keessen, Kees Jan Kan
Critical revision of the manuscript	Wilma JM Scholte op Reimer, Bart Visser, Corine HM Latour, Harald T Jørstad, Gerben ter Riet, Ingrid van Duijvenbode

Chapter 7

Keessen P, van Duijvenbode ICD, Latour CH, Kraaijenhagen RA, Janssen VR, Jørstad HT, Scholte op Reimer WJM, Visser B. Design of a Remote Coaching Program to Bridge the Gap From Hospital Discharge to Cardiac Rehabilitation: Intervention Mapping Study. JMIR Cardio. 2022;6(1):e34974. Published 2022 May 25. doi:10.2196/34974

Concept and design	Paul Keessen, Bart Visser, Corine H.M. Latour, Wilma. J.M. Scholte op Reimer
Data collection	Paul Keessen, Ingrid van Duijvenbode
Analysis	Paul Keessen, Ingrid CD van Duijvenbode
Interpretation of the data	Paul Keessen, Corine HM Latour, Ingrid CD van Duijvenbode, Bart Visser, Wilma J.M. Scholte op Reimer
Drafting the manuscript	Paul Keessen, Ingrid CD van Duijvenbode
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Chapter 8

General discussion

Concept and design	Paul Keessen
Data collection	Not applicable
Statistical analysis	Not applicable
Interpretation of the data	Not applicable
Drafting the manuscript	Paul Keessen
Critical revision of the manuscript	Wilma J.M. Scholte op Reimer, Bart Visser, Corine H.M. Latour

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LIST OF PUBLICATIONS

Scientific publications

1. **Keessen P**, Maaskant J, Visser B. The reliability and validity of the standardized Mensendieck test in relation to disability in patients with chronic pain. Physiother Theory Pract. Published 2018;34(8):629-636. doi:10.1080/09593985.2017.1423428

2. **Keessen P**, den Uijl I, Visser B, van den Berg-Emons HJG, Latour CHM, Sunamura M, Jørstad HT, ter Riet G, Scholte op Reimer WJM, Kraaijenhagen RA, ter Hoeve N. Fear of movement in patients attending cardiac rehabilitation: A validation study J Rehabil Med. 2020;52(2):jrm00021. Published 2020 Feb 27. doi:10.2340/16501977-2653

3. **Keessen P**, Latour CHM, van Duijvenbode ICD, Visser B, van Proosdij A, Reen D, Scholte op Reimer WJM. Factors related to fear of movement after acute cardiac hospitalization. BMC Cardiovasc Disord. 2020;20(1):495. Published 2020 Nov 23. doi:10.1186/s12872-020-01783-9

4. **Keessen P**, van Duijvenbode IC, Latour CH, Kraaijenhagen RA, Janssen VR, Jørstad HT, Scholte op Reimer WJM, Visser B. Design of a Remote Coaching Program to Bridge the Gap From Hospital Discharge to Cardiac Rehabilitation: Intervention Mapping Study. JMIR Cardio. 2022;6(1):e34974. Published 2022 May 25. doi:10.2196/34974

5. Ter Hoeve N*, **Keessen P***, den Uijl, Visser B, Kraaijenhagen RA, Sunamura M, Scholte op Reimer WJM, Latour CHM, Jørstad HT, van den Berg-Emons HJG. Assessing Changes in Fear of Movement in Patients attending Cardiac Rehabilitation: Responsiveness of the TSK-NL Heart Questionnaire. J Rehabil Med. 2022;54:jrm00328. Published 2022 Aug 26. doi:10.2340/jrm.v54.2519

6. **Keessen P**, Kan KJ, ter Riet G, Visser B, Jørstad HT, Latour CHM, van Duijvenbode ICD, Scholte op Reimer WJM. Impact of kinesiophobia on initiation of cardiac rehabilitation: a prospective cohort path analysis. Accepted BMJ Open

7. **Keessen P**, Kan KJ, ter Riet G, Visser B, Jørstad HT, Latour CHM, van Duijvenbode ICD, Scholte op Reimer WJM. The longitudinal relationship between fear of movement and physical activity after cardiac hospitalization: a cross lagged panel model. Submitted

Other publications

1. **Keessen P**, Maaskant J, Visser B. Studie Betrouwbaarheid en validiteit: van de Standardized Mensendieck Test in relatie tot functionele beperkingen bij patiënten met chronische pijn. Beweegreden. 2017 Aug;13(3):28-31.

2. **Keessen P**. Het hart is een hele gevoelige pomp (Interview). Trouw. 29 December 2018

3. **Keessen P.** Factors related to fear of movement after acute cardiac hospitalization (samenvatting) FysioPraxis nr 8|2022, oktober/november, pagina 31.

*Both authors contributed equally to this manuscript

PHD PORTFOLIO

Name PhD student:	Paul Keessen
PhD period:	2017-2022
Name PhD Supervisor:	Prof. Dr. W.J.M. Scholte op Reimer
PhD Supervisors:	Dr. B. Visser
	Dr. C.H.M. Latour

PhD training	**Year**	**Workload (ECTS)**
General courses		
- Observational Clinical Epidemiology	2017	0.6
- Basiscursus Regelgeving en Organisatie voor Klinisch Onderzoek (BROK)	2018	1.0
- Project Management	2018	0.6
- Scientific Writing in English for Publication	2018	1.5
- Advanced Topics in Biostatistics	2019	2.1
- Entrepreneurship in Health and Life Sciences	2019	1.5
Specific courses		
- Cursus Hartrevalidatie, Nederlands Paramedisch Instituut	2017	3.6
- Athletic Skills Model, Athletic Skills company	2019	0.6
- Ted talk training, debat.nl	2019	0.3
Oral presentations		
- Bewegingsangst bij hartpatiënten, opleiding Verpleegkunde Hogeschool van Amsterdam	2017	0.5
- Bewegingsangst bij hartpatiënten, opleiding Verpleegkunde Hogeschool van Amsterdam	2018	0.5
- Omgaan met bewegingsangst bij hartpatiënten, Congres voor Cardiovasculaire zorg (CarVasz), Ede	2018	0.5
- Het meten van bewegingsangst, Jubileum event. Vereniging van Oefentherapeuten Cesar Mensendieck (VvOCM) Bunnik	2019	0.5

Poster presentations

- Fear of movement in patients referred to cardiac rehabilitation, Europrevent, Lisboa	2019	0.5
- Fear of movement after an acute cardiac event, experiences, beliefs, barriers and support needs in patients and their caregiver, ESC, online	2020	0.5
- Bridging the gap from hospital discharge to cardiac rehabilitation using the intervention mapping approach (BRIDGE2CARE), ESC, online	2021	0.5
- Fear of movement (kinesiophobia) after cardiac hospitalization: predictors and impact in participation	2022	0.5
- in cardiac rehabilitation, ESC, online		

(Inter)national conferences

- Europrevent, European Society of Cardiology, Ljubljana, Slovenia	2018	0.5
- Preventive Cardiology, European Society of Cardiology Lisboa	2019	0.5
- Preventive Cardiology, European Society of Cardiology online	2020	0.5

Teaching

Lecturing		4.0
- Applied Research Methods, Minor Sports Physiotherapy	2017 - 2021	
- Minor Global Health	2021 - present	
- Bachelor thesis, Exercise therapy	2017 – present	

Mentoring		4.0
- Student Bachelor thesis: Face and content validity of the TSK-NL Heart (Hermans & Adema)	2017	
- Student Bachelor thesis: Factors associated with kinesiophhobia after an acute cardiac event (Reen & Proosdij)	2019	
- Student Bachelor thesis: Implementation of a Tele-stress management program during the COVID-19 pandemic (Tabibi)	2020	

- Student Bachelor thesis: Patients' experiences with kinesiophobia during cardiac rehabilitation (Lischer & Vennik)	2020	
- Student Bachelor thesis: Feasibility of a remote coaching program to bridge the gap form hospital discharge to the start of cardiac rehabilitation (Dekker & Rewijk)	2022	

Supervising

- Mieke Wever & Özlem Yurtkap, master thesis	2020	1.0
- Armanda Oudebeek & Kirsten van der Kolk, master thesis	2021	1.0

Other 4.0

- Development of a remote coaching program for cardiac patients, Cardiovitaal Cardiac Rehabilitation
- Development of a post-bachelor course for therapists delivering remote coaching, Cardiovitaal Cardiac Rehabilitation.

Grants

- Doctoral grant for teachers from the Dutch Research Council (NWO) The Hague, the Netherlands	2017

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CURRICULUM VITAE

Paul Keessen was born on the 4th of February 1983 in Hilversum, the Netherlands. Paul studied Cesar Kinetics Therapy at the Utrecht University of Applied Sciences. During his senior internship he worked at the Heideheuvel Pulmonary Rehabilitation Center and remained working there after his studies were completed. In 2013, he started working as lecturer/researcher the Amsterdam University of Applied Sciences. Additionally, he completed his master Evidence Based Practice in Health Care (Clinical Epidemiology) at the Amsterdam University Medical Center/University of Amsterdam. In 2017, he started his doctorate with a focus on fear of movement in patients with cardiovascular disease, under the supervision of Prof. dr. W.J.M. Scholte op Reimer. Paul is very grateful for the enormous support from his supervisors in finishing his doctorate.

Currently, Paul is a lecturer at the Amsterdam University of Applied Sciences and works as project manager of the Living Lab in the Faculty of Health.

Besides his activities at the Amsterdam University of Applied Sciences, Paul holds a 5th degree black belt (5th Dan) in Aikido and is a NOC-NSF recognized Aikido teacher who currently teaches in Weesp and Haarlem.

In his spare time, Paul likes to travel with his family. He loves snowboarding and hiking. Paul lives in Haarlem with Lucy and their son Mads (2020).