UNIVERSITY OF TWENTE.

Department of Psychology, Health & Technology

E-health in early cardiac rehabilitation: The role of anxiety and depression during cardiac treatment of patients who underwent open-heart surgery

Katharina Krahé
s1622994

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Supervisors
dr. Erik Taal
dr. L.M.A. Braakman-Jansen

University of Twente
Faculty of Behavioural, Management and Social Sciences
Department of Psychology, Health & Technology
Postbus 217
7500 AE Enschede

Abstract

Background: It is assumed that effective cardiac treatment after major cardiac incidents partly depends on mental health factors. Comorbid psychological distress, anxiety and depression, is likely to have adverse effects on physical outcomes of exercise-based cardiac rehabilitation (CR). Evidence suggest that early onset of exercise training is useful to increase patients' exercise capacity and thereby to decrease symptoms of distress. This study tested whether an early, online intervention before onset of the traditional, center-based CR program has beneficial effects on patients' exercise capacity and mental well-being. Further, it was tested whether severity of distress before the start of the online program impedes buildup of functional capacity.

Methods: In a controlled clinical trial 88 cardiac surgery patients of the MST Enschede were assigned to intervention group (n= 46) and control group (n= 42). Patients in the intervention group received a personalized, online exercise program during home phase, patients of the control group received usual post-operative care. After home phase, both groups received traditional, center-based CR. Patients' exercise capacity (measured by a six minutes walking test) and symptoms of distress (measured by the HADS) were assessed at baseline, after the online CR program, respectively usual care, and after traditional CR. Repeated measures analyses of variance were conducted to test the effectiveness of the early, online training and possible moderation by anxiety or depression.

Results: The increase rates in exercise capacity as well as the decrease rates of anxious and depressive symptoms within patients did not differ between groups. Also the effectiveness of the early, online program was not affected by severity of anxious or depressive symptoms at baseline.

Conclusion: Somewhat surprising, no difference in exercise capacity and distress rates was found between treatment conditions, indicating that the early, online program had no effects on patients' exercise capacity and perceived distress during the examined rehabilitation period. This study demonstrated that anxiety and depression do not play a rule during CR in relation to patients' progress in exercise training. Consequently, future studies are needed to investigate which aspects of successfully undergoing exercise-based CR are negatively affected by patients' distress.

Keywords: Cardiovascular disease, exercise-based CR, exercise capacity, anxiety and depression

E-health in early cardiac rehabilitation: The role of anxiety and depression during cardiac treatment of patients who underwent open-heart surgery

Cardiovascular diseases (CVDs) are among the leading causes for death and disability in Europe. Each year diseases of the heart and circulatory system, CVDs, cause 3.9 million deaths in Europe (Wilkins et al., 2017). Even though mortality rates decreased considerably in Europe during the last decades, CVDs are still accounting for 45% of all deaths. In addition to this large mortality burden, CVDs also make a considerable contribution to morbidity rates among the population. In 2015 more than 85 million people lived with CVDs in Europe. Besides affecting the population of the elderly, CVDs are also the leading cause for death in people younger than 65 years, accounting for 29% of all premature death (Wilkins et al., 2017). A majority of patients with severe CVDs undergo open-heart surgery, an invasive procedure where the rib cage is opened to operate on the heart. The most common type of open heart surgery is the so-called Coronary Artery Bypass Grafting (CABG) in which blocked coronary arteries are bypassed with healthy arteries or veins (National Heart, Lung and Blood Institute, n.d.). The increasing number of people suffering from CVDs, who in general tend to live longer probably also longer with symptoms of CVDs, led to growing interest in understanding and addressing determinants in prevention and treatment of cardiovascular diseases. To understand the determinants of CVDs it is relevant to look at the risk factors of CVDs. Identified risk factors for the pathogenesis and expression of CVDs can be summarized as modifiable, psychosocial risk factors (smoking, unhealthy eating behaviour and lifestyle, high body mass, physical inactivity, psychological distress, low socioeconomic and social isolation) and non-modifiable risk factors (genetic dispositions, high age, male sex) (Achttien et al., 2011). From a psychological point of view the psychosocial risk factors are particularly interesting as these issues are largely related to mental health and well-being. Psychosocial risk factors increase risks for cardiac incidents, and additionally have impeding effects on cardiac treatment after a major cardiac event (Pogosova et al., 2015; Lavie, Milani, Artham, & Gilliland, 2007). Also psychological comorbidities are common among patients suffering from cardiovascular diseases (Pedersen & Andersen, 2018). About 20%- 30% of patients suffer from depression and/or anxiety in the aftermath of major cardiac incidents (Pedersen & Andersen, 2018; Gili, Comas, Garcia-Garcia, Monzón, Antoni, & Roca, 2010).

There appears to be a clear link between psychosocial distress and cardiovascular diseases. A large body of systematic reviews and meta-analyses reveals this interdependence

(Pogosova et al., 2015). Psychosocial risk factors, among them anxiety and depression, and the cardiovascular system most likely interact in a bidirectional way. Firstly, there is consistent evidence that anxiety and depression affect the cardiovascular system via neuroendocrine, immune and behavioural pathways. Secondly, the experience of cardiovascular symptoms, diagnoses and medical or surgical treatment is likely to evoke distress in patients (Pogosova et al., 2015). Further, behavioural mechanisms are assumed to play a role among cardiac patients as unhealthy lifestyles, associated with depressive symptoms, increase the risk for cardiac incidents (Whalley, Thompson, & Taylor, 2014). The likelihood of engaging in unhealthy behaviour increases as the patients experience distress or depression related symptoms. In summary, behavioural, psychological and physiopathological factors play a key role in the emergence, progression and clinical manifestation of CVDs (Pogosova et al., 2015). Thus, anxiety and depression are likely to not only be a serious risk factor but also the consequence of CVDs. Therefore, the relationship between psychological and cardiac mechanisms might be crucial to cardiac treatment and rehabilitation.

One of the most common post-operational treatment approaches for CVDs is exercise-based cardiac rehabilitation (CR). A large body of evidence supports the benefits of CR (Abell, Glasziou, Briffa, & Hoffmann, 2016). CR is a tailored, multidisciplinary treatment approach aiming to improve physical and psychosocial functioning, reducing mortality and increasing the health related quality of life of cardiac patients. CR usually encompasses four subsequent stages; a preoperative phase for patients undergoing open-heart surgery, a clinical phase I beginning with hospitalization, a polyclinic rehabilitation phase II starting six weeks after discharge from the hospital, and a post-revalidation phase which commonly takes place outside institutional health care (Achttien et al., 2011).Exercise training is mostly the core component of rehabilitation programs as it promotes cardiopulmonary as well as mental health in cardiac patients. Exercise training improves everyday physical functioning of patients and thereby supports a (more) active and healthy lifestyle. Regular aerobic exercise training is associated with reduced symptoms, lower relapse rates, reduced mortality rates, improved bodily functioning and improved quality of life (Anderson et al., 2016). Furthermore, exercise capacity and exercise tolerance are viewed as the most important factors in the assessment of a patient's clinical condition and thereby for making a prognosis about the rehabilitation process (Zielińska, Bellwon, Rynkiewicz, & Elkady, 2013). Especially the evaluation of change in functional, physical capacity has become a common clinical outcome measure in CR programs.

Recent literature suggests that timing of CR, especially the onset of treatment programs, might also be important for patients' physical and mental health outcomes. Evidence suggests that early enrollment in CR (< 2 weeks after hospital discharge) is safe for post-surgical patients since it does not increase risk for clinical adverse effects following early CR (Pack, Dudycha, Roschen, Thomas, & Squires, 2015). Studies, in which early enrollment was defined as within 28 days after hospital discharge, found that early CR has advantageous effects not only on exercise capacity but also is a significant predictor for positive mental health outcomes (Fell, Dale, & Doherty, 2016; Sumner, Böhnke, & Doherty, 2018). Starting CR early is assumed to have positive effects on cardiopulmonary and physical functioning, mortality and facilitates prevention of secondary cardiac incidents. Further it was shown that the extent of fitness- related improvement was reduced for late CR attendees (starting CR > 28 days after hospital discharge) (Fell, Dale, & Doherty, 2016). Sumner, Böhnke, and Doherty (2018) found that increased wait time until CR is also associated with increased likelihood of experiencing symptoms of anxiety and depression after CR treatment. Yet, the explanatory power of these findings is limited and requires further research. Despite this, timely treatment seems advisable for successful cardiac treatment.

Furthermore, it is assumed that psychosocial distress plays an important role during the cardiac rehabilitation process. There appears to be a bidirectional link between exercising behaviour and psychosocial distress as the former affects the later and vice versa. On the one hand, psychosocial distress is likely to impede rehabilitation progress and exacerbate the underlying cardiac conditions as mental health issues pose barriers for successful attendance of CR programs (Sumner, Böhnke, & Doherty, 2018). Research showed that depression and anxiety hinder appropriate risk factor management, increase the risk of non-adherence or drop-out of therapies (Pedersen & Andersen, 2018). Even though some CR programs added mental health treatment (mostly psychotherapy and antidepressants) to the regular exercise-based treatment, there is limited evidence for their effectiveness (Verschueren et al., 2018; Richards et al., 2018). On the other hand, exercise training is assumed to have advantageous effects on patients' mental well-being. In addition to cardiovascular improvements, exercise training is also associated with decreased symptoms of anxiety and depression among cardiac patients (Smith, Sherwood, Mabe, Watkins, Hinderliter, & Blumenthal, 2017). During and after cardiac rehabilitation patients with higher physical activity levels showed lowest anxiety and depression symptoms. Especially higher physical activity levels over time, as found in 30-60% of patients 6 months after completion of CR, was associated with lower anxiety and depression levels in a one year follow up after cardiac incidents. Lower depression rates in turn appear to have significant influence on mortality levels. Research showed that already minor improvements in exercise capacity significantly reduced risk of depression and accompanying high mortality risk (Lavie, Milani, Artham, & Gilliland, 2007). It was found that exercise-based CR and mental health treatments both have small to moderate effects on the severity of depressive symptoms and in the prevention of secondary cardiac incidents (Rutledge et al., 2013). However, only exercise-based CR was effective in reducing mortality rates. Verschueren et al. (2018) argued that physical activity is likely to have advantageous effects on mental well-being through several mechanisms. Firstly, exercise training might improve mood as the mastery of new skills is likely to increase self-efficacy and self-esteem. Secondly, exercise training has physiological effects since it facilitates a reduction in stress hormones and an increase in endorphine and monoamine levels. Nevertheless, the precise effects of exercise training on anxiety and depression among cardiac patients currently remain unclear.

Despite large evidence for the benefits of exercise-based CR, research showed that patients often do not follow prescribed activities during CR, or do not complete rehabilitation phase II (Alsaleh, Blake, & Windle, 2012). The key issues identified for non-attendance or deficient participation can be categorized poor communication from health care professionals, or personal, physical barriers (Neubeck at al., 2011). Personal barriers include insufficient motivation, competing work or family commitments, embarrassment about participation or misunderstanding about cardiac diseases and the benefits of CR. Physical barriers affecting CR attendance include lacks of transportation, financial costs, inconvenient scheduling of therapy units, personal safety concerns or language barriers (Kotb, Hsieh, & Wells, 2014; Neubeck at al., 2011)

Electronic health (eHealth) interventions aim to overcome some of the identified barriers for CR participation, like required mobility, financial costs or the fixed scheduling of therapy units. Numerous studies have focused on the effectiveness of online interventions for CR patients as an alternative to center-based, supervised CR programs. In this light eHealth interventions emerged as a possibly effective alternative to center-based CR and were shown to have similar physical outcome rates in some patient groups (Huang et al., 2015). However, less is known about online CR treatments compatible with or in addition to regular center-based treatment. Regardless of the specific implementation, online CR programs allow for personalization and specific tailoring to individual patient needs. Training units are accessible anytime and anywhere with decent internet connection, patients have the possibility to rely on self-management and self-delivery of exercise training (Maddison et al., 2014). Furthermore, online exercise programs provide the possibilities to monitor daily health behaviours, they are easily equipped with disease education, and manage communication with healthcare providers (Coorey, Neubeck, Mulley, & Redfern, 2018).Yet, evidence for the effectiveness of CR online treatments currently still requires further research. Harrison and Doherty (2018) found that patients' psychosocial well-being did not differ between self-delivered and center-based CR treatment. Therefore, the utilization of personalized online exercise programs might offer several advantages, yet evidence is still limited.

All in all it can be assumed that effective cardiac treatment partly depends on psychological factors. Appropriate identification and management of mental health conditions then appears to be crucial. A better understanding of the role that psychological distress (anxiety and depression) plays during cardiac rehabilitation is needed to gain valuable insights in rehabilitation processes and implications for new therapy approaches. The Medisch Spectrum Twente (MST) conducted a quasi-experimental study comparing patients who received usual post-operative care until begin of the traditional, center-based CR program with patients who received an early, online exercise CR program prior to the traditional CR program. The data from this MST study will be used to to investigate whether early, online CR training before onset of the traditional CR increases patients' psychological well-being and physical exercise capacity. As exercise capacity seems to be an important determinant for both psychological well-being and cardiovascular functioning, it is assumed that an early online exercise training has beneficial effects on overall physical activity levels after completion of this online program as well as after completion of the traditional rehabilitation program.

The following hypotheses will be tested in the MST trial:

H1: After completion of the early online program (T2) and after completion of the traditional cardiac treatment (T3) patients in the intervention group improved significantly more on exercise capacity than patients in the control group.

H2: *After completion of the early online program (T2) and after completion of the traditional cardiac treatment (T3) patients in the intervention group have decreased significantly more in anxiety and depression than patients in the control group.*

Further it can be assumed that higher levels of anxiety and depression at the start of the early, online CR are associated with less increase of exercise capacity.

H3: The early online intervention is less effective in improving exercise capacity in patients with higher levels of anxiety and depression at baseline, compared to patients with lower levels of anxiety and depression

Methods

Design

From June 2016- April 2018 a quasi-experimental study has been conducted at the Medisch Spectrum Twente (MST). Patients were assigned to groups in chronological order. First, all patients who were qualified (see inclusion criteria below), were allocated to the control group. As a sufficient number of participants was reached, subsequent MST patients who were qualified, were assigned to the intervention group until a sufficient number of participants was reached.

In this trial MST patients who received usual post-operative care before participating in the traditional, center-based CR (control group) were compared with MST patients who first completed an early, online exercise CR program and subsequently completed traditional, center-based CR (intervention group). The early, online exercise program took six weeks and started in the first week after discharge from the hospital. Patients in the intervention group completed the online exercise CR program prior to the start of the traditional CR. For both groups the traditional, center-based CR started 7 weeks after discharge from the hospital and took six weeks.

The study was approved by the local medical ethics committee.

Participants

For the sample size calculation the online program ClinCalc was used by the researchers (see study protocol). The mean exercise capacity of patients in intervention and control group as measured by the 6 minutes walking test was derived from the reviewed literature (to be found in the study protocol). This mean exercise capacity, in combination with a power of 80% and a significance level of 0.05 lead to a sample size of 2x 42 patients. Adjusting for non-compliance and drop out it was aimed to include 2x 50 patients in this trial.

MST patients who underwent Coronary Artery Bypass Graft (CABG) surgery or valve surgery and intended to participate in cardiac rehabilitation as part of usual care, were asked to participate by the researchers.

To be entitled to participate in this study, patients had to meet the following criteria:

- CABG or valve surgery
- Intended to participate in the regular CR outpatient program

- Clinically stable and capable of performing an exercise program as judged by the treating cardiologist
- Age >18 years
- Access to internet
- Mastery of Dutch language
- Living in adherence area of the MST

No exclusion criteria were defined.

Initially 143 patients were asked to participate in this study of which n=71 completed all assessments, as shown in Figure 1.

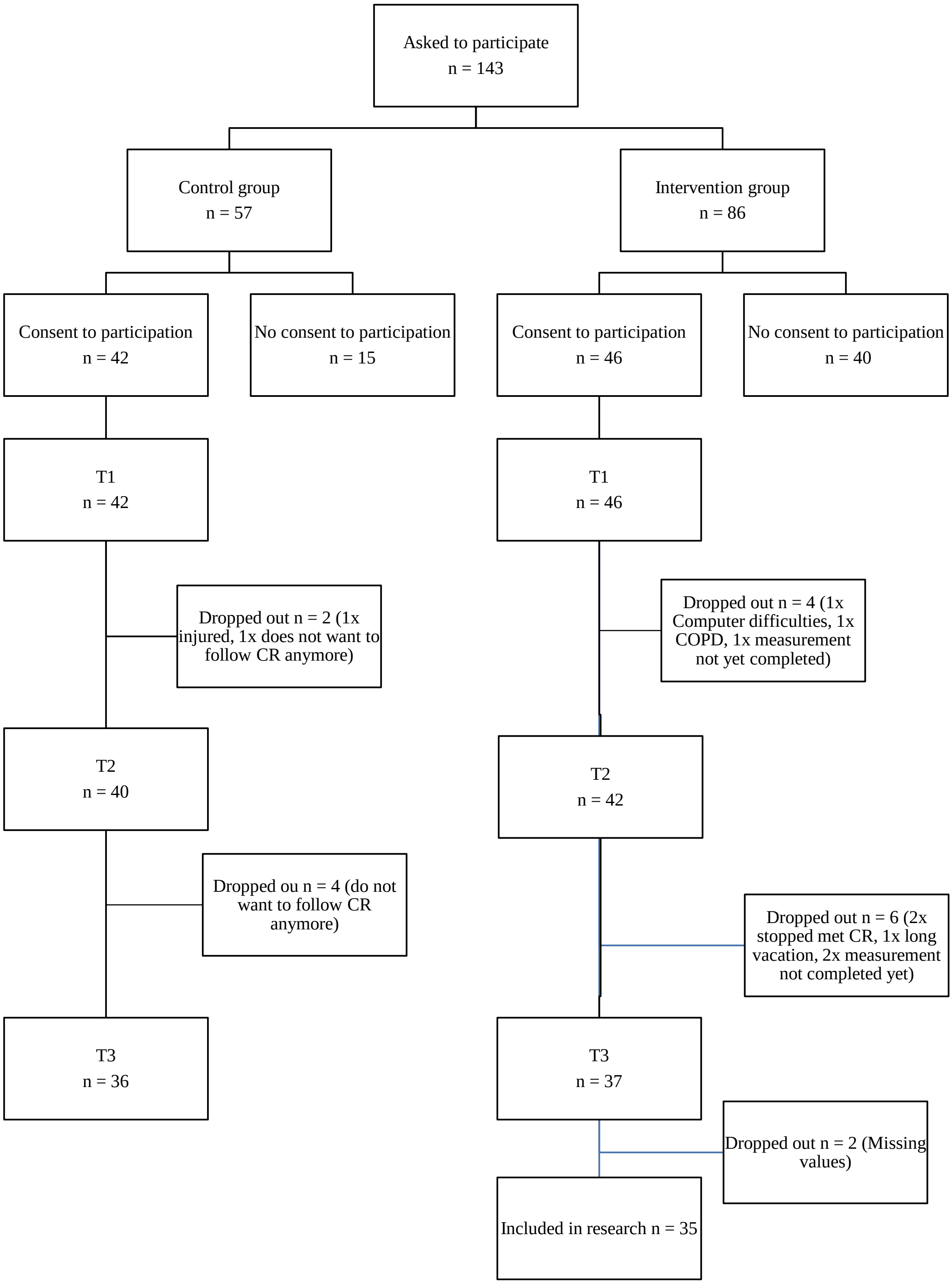

Figure 1 Flow diagram of recruitment process.

The groups were homogeneous regarding sociodemographic characteristics, as displayed in Table 1.

Table 1

Sociodemographic variables of patients

Variables	Control group n=42 (48%)	Intervention group n= 46 (42%)
Mean Age (SD)	66.2 (8.6)	65.7 (9.9)
Sex		
Female	7 (17%)	11 (24%)
Male	35 (83%)	35 (76%)
Marital Status[a]		
Partner/Child	35 (83%)	40 (87%)
Single	7 (17%)	5 (11%)
Education[b]		
Higher (secondary education and higher)	26 (62%)	29 (63%)
Lower (Mbo and lower)	15 (36%)	16 (35%)
Employment[a]		
Full- or part-time	29 (69%)	29 (63%)
none	13 (31%)	16 (35%)
Diagnosis		
Cabg	31 (74%)	27 (59%)
others	11 (26%)	19 (41%)

Note. Groups were not significantly different on sociodemographic variables ($p > .05$);

Cabg= Coronary Artery Bypass Grafting

[a] n= 87

[b] n=86

All participants signed an informed consent. Participating patients did not receive any compensation.

Materials

Online exercise CR program

Basis for the concept of the online exercise program for cardiac surgery patients was an existing home-based exercise program used for other diagnostic groups (chronic pain, oncology etc.)

The content of this exercise program was tailored to the needs of CR and established in focus groups with physiotherapists and patients. The online CR program was in line with the guidelines of the Dutch Royal Society for Physical Therapy for CR.

Patients and treating physiotherapists had to log into a web portal to gain access to the exercise program.

In total the online exercise program encompassed 60 videos of different exercises, with written and spoken instructions, composed and recorded by physiotherapists. Exercises can be grouped in five main categories: strength, thoracal mobility, breathing, relaxation and balance. Relaxation and balance exercises were only included on indication. Additionally a minimum amount of steps to be walked by patients was prescribed weekly.

Patients only had access to their personal exercise program as composed by the treating physiotherapist. For each patient the specific content (prescribed exercises) and the intensity of exercises were tailored to initial exercise capacity, specific needs and individual rehabilitation progress. The treating physiotherapist selected a patient's program weekly, following a predefined schedule. In the first week, starting level and content were determined by judgement of the treating physiotherapist, based on an assessment briefly before patients were discharged from the hospital. Subsequently, content and level of intensity per exercise and the preset walking goal were adjusted on basis of the patient's performance in the previous week. Additionally the Borg Scale of Perceived Exertion was completed to assess a patient's perceived level of exertion. Treating physiotherapists also had insights in their patient's trainings progress via the web portal, where feedback was given about which exercises were performed by the patient and during which moment of the day. These information were used to identify health problems and to optimize treatment, for instance to modify the exercise program. Patients were asked to carry out about six exercises per session and exercise three times a week.

The online exercise program also provided telecommunication tools for communication between physiotherapists and patients. Patients and physiotherapists were notified when they received new messages upon log in to the web portal.

Figure 2 Example of one exercise in the early, online program

Usual post-operative care

Cardiac patients who underwent open-heart surgery commonly receive some generic advices on how to improve their physical condition. Patients do not receive specific instructions but are asked to walk on a regular basis.

Measures

Sociodemographic Variables

Participants were asked for their age and gender. Further several rating scales were employed for 'marital status' ("Single/Married/Divorced/Living together with a partner/living together with children/other"), 'highest education' ("none/ elementary school/ lower vocational education/ secondary education/ MBO/ secondary education (Havo/Vwo), higher professional education/ scientific education"), 'employment' ("full time/ part time/ pension/ incapacitated/ not working") and 'diagnosis' ("Coronary Artery Bypass Graft/ Aortic Valve Replacement/ Mitral Valve Prolapse/ CABG or AVR/ others").

Anxiety and Depression

Symptoms of anxiety and depression were measured using the Dutch version of the Hospital Anxiety and Depression Scale (HADS) by Zigmond & Snaith (1983). The HADS is a 14-items self-assessment scale, consisting of one 7-item subscale for anxiety (eg. "I feel tense and ‘wound up’”) and one 7-item subscale for depression (eg. “I still enjoy the things I used to enjoy”). Items are rated on a 4-point Likert scale (eg. “Most of the time/ A lot of the time/ From time to time, occasionally/ Not at all”; ” Definitely as much/ Not quite so much/ Only a little/ Hardly at all”). Sumscores of both subscales can range from 0-21, with higher scores indicating more severe symptoms of anxiety and/or depression. Scores on the anxiety scale ≥ 8 indicate mild to severe symptoms of anxiety, respectively do scores on the depression scale ≥ 8 indicate mild to severe symptoms of depression.

The HADS has been found a reliable screening instrument for detecting mild anxiety and depression in adult and elderly general medical outpatients (Spinhoven et al., 1997). Little is known about the validity of the dutch HADS, yet the english version of the HADS is regarded a robust screening instrument for several dimensions of anxiety and depression, with good to very good concurrent validity irrespective of his briefness (Bjelland, Dahl, Haug, & Neckelmann, 2002).

In this study the HADS reached acceptable internal consistency. Reliability ranged between Cronbach’s α= .816 and α =.769 for anxiety and depression over all three measurement points. In total the Person correlation of distress between baseline and post traditional CR assessment was α= .55 (p < .001)

Exercise capacity

Exercise capacity functioned as the primary outcome measure of this study. Patients’ exercise capacity was measured by a 6 minutes walking test (6MWT). The 6MWT measures the maximal distance a person can walk in six minutes on flat, hard surface.

The 6MWT was shown to be a reliable and valid method in assessing physical capacity and functioning in cardiac patients in phase II and III of cardiac rehabilitation (Hamilton & Haennel, 2000). The 6MWT showed acceptable correlations (Pearson’s r= .64) with peak oxygen uptake in patients with advanced heart failure and shows strong concurrent validity with other established measures of functional capacity (Montana, 2011).

Procedure

The study can be divided in three phases: The clinical phase, the home phase and the outpatient phase. The clinical phase refers to the timespan patients are hospitalized (until discharge), the home phase refers to the period between discharge from the hospital and start of the traditional CR program, in which only the intervention group receives the online exercise treatment (week 1-6 after discharge), the outpatient phase refers to the period of the traditional CR program as part of the usual care for both groups (week 7-13 after discharge). Both groups went through all three phases and were assessed in like manner.

All participating patients signed an informed consent prior to the begin of the study. At the end of the clinical phase (one day before discharge from the hospital), patients completed the first assessment unit in the hospital. Patients received several questionnaires, among them the HADS and other questionnaires not relevant to this study in paper and pencil format. Also, sociodemographic variables (sex, age, education, marital status, employment) and disease-related variables (diagnosis, co-morbidity, complications after surgery, medication, morbidity) were asked by use of a questionnaire. Further, patients completed the first six minutes walking test in a hallway of the MST building, patients were encouraged verbally during this test. All patients received a wearable accelerometer (Fitbit) and instructions how to use it. During the next six weeks home-phase, patients of the intervention group followed their prescribed online exercise training program. Patients in the control group continued rehabilitation by themselves based on the general post-operative care they received before discharge from the hospital. During the first week of the homephase all patients wore the accelerometer. Patients of the intervention group continued to wear the Fitbit during the entire home phase until the start of center-based CR, whereas patients of the control group only wore the Fitbit once again in the last week of the home phase. In week six after discharge patients of both groups visited the hospital for administration of the second assessment unit. Patients completed the second six minutes walking test in the hospital and received the same unit of questionnaires as before. Patients were asked to fill in these questionnaires during the next days at home.

In week seven after discharge from the hospital, the traditional CR program at the MST began for patients of both groups. Patients followed the traditional CR program for 6 weeks, after completion of this program the third test unit was administered. Patients completed the third six minutes walking test in the MST and received the usual questionnaires to be filled in at home.

Data Analysis

All data was analyzed using IBM SPSS statistics 23 and Process macro by Hayes for SPSS. First, data was checked for normality by using normal Q-Qplots. To identify possible covariates, it was checked whether sociodemographic variables were distributed equally between groups. Given the relatively small number of participants, the sociodemographic variables ‘marital status’, ‘highest education’, and ‘working’ were each further recoded into two subgroups (eg. married and/or children vs single; secondary education and higher vs. MBO and lower education; full-/part-time employment. vs pensions/ incapacitation/unemployment) to allow for better comparison. Also the variable 'diagnosis' was divided into coronary artery bypass graft vs other diagnoses. For 'age' an independent-sample t-test was used, for all other categorical variables chi-square tests of independence were used. Results are displayed in Table 1, to be found in the 'Particpants section'.

Next, for the variables 'anxiety' and 'depression' sumscores per measurement point were calculated by summing over all seven anxiety, respectively depression, items of the HADS.

To test hypothesis 1, two repeated measures Anovas over measurement point T1 and measurement point T2, and over measurement point T1 and measurement point T3 were conducted, with 'exercise capacity' as dependent variable and 'group' as an independent, within-subjects variable. Since there is a proportionally large number of missing values for outcome variables from first to last measurement point, n=16 missing cases for exercise capacity at T3, n=14 missing cases for anxiety at T3, and n=13 missing cases for depression at T3, it was chosen to conduct two separate repeated Anovas, one for each timespan. This allows to keep as many observations as possible and therefore increases reliability of results, yet encounters the problem of multiple testing.

To test hypothesis 2, the same procedure was repeated for anxiety and depression scores. First a repeated measures Anova with 'anxiety' as dependent variable and 'group' as independent variable has been conducted between T1 and T2, then between T1 and T3. Then the same procedure was repeated for depression scores.

To test hypothesis 3, Process macro was used within Spss for analysis of covariance. It was tested whether anxiety, respectively depression, scores at baseline had influence on the relationship between 'group' and 'exercise capacity' within subjects between T1 and T2. Moderation Model 1 within Process was used to calculate the interaction effect between 'group' and the moderator variables 'anxiety' and 'depression'. 'Exercise capacity' at baseline was taken into the model as covariate, 'exercise capacity' at T2 as dependent variable.

The significance of the between-subjects and within-subject effects was tested with an F-test and an alpha of .05 was used to establish significance.

Results

Q-qplots showed that the residuals of ‘exercise capacity’, ‘anxiety’ and ‘depression’ were distributed normally. Distress scores were highly positively skewed and leptocurtic at T2 and T3. The distribution of sociodemographic variables was homogenous between groups.

In table 2 the mean descriptives of ‘exercise capacity’, ‘anxiety’ and ‘depression are displayed.

Table 2

Descriptive Statistics for control group and intervention group per measurement point

	Control group			Intervention group		
	N	Mean (SD)	Sympt.	N	Mean (SD)	Sympt.
Exercise Cap T1	42	305.55 (79.60)		45	304.03 (107.12)	
Exercise Cap T2	40	443.29 (90.12)		41	454.98 (87.47)	
Exercise Cap T3	36	483.68 (101.17)		35	493.92 (101.29)	
Anxiety T1	42	4.62 (2.95)	7 (17%)	45	5.78 (4.31)	18 (40%)
Anxiety T2	40	2.08 (2.26)	0 (0%)	42	3.07 (3.08)	3 (7%)
Anxiety T3	36	1.61 (2.61)	2 (6%)	37	2.78 (2.79)	4 (11%)
Depression T1	41	4.44 (3.83)	7 (17%)	45	4.84 (4.10)	14 (31%)
Depression T2	40	1.73 (1.79)	0 (0%)	42	2.83 (3.57)	4 (10%)
Depression T3	36	1.19 (1.64)	0 (0%)	37	2.81 (3.29)	4 (11%)

Note. Sympt. = indication for mild to severe symptoms. Scores on the anxiety scale ≥ 8 indicate mild to severe symptoms of anxiety, scores on the depression scale ≥ 8 indicate mild to severe symptoms of depression.

Wilks’ Lambda indicates that all patients’ exercise capacity between baseline (T1) and the second assessment (T2) increased significantly F (78,1) = 291,76, p<0.001. However, the interaction effect of treatment condition by time was not significant F (78,1) =0.487, p=.487. These results indicate that the early online intervention did not have a significant effect on exercise capacity increase, since all patients’ exercise capacity increased significantly, regardless of their treatment condition.

Further Wilks’ lambda indicates that patients’ exercise capacity between baseline (T1) and the last assessment (T3) also increased significantly F (68,1) = 299.510, p<.001. Yet, there was no significant effect of the intervention on exercise capacity increase, as indicated by a non-significant interaction effect of treatment condition by time (F (68,1) = 0.128, p=.722).

In like manner it was found that the anxiety rates of all patients decreased significantly between baseline (T1) and the second assessment (T2) F (79,1) = 54.523, p< .001 and baseline (T1) and the last assessment (T3) F (70,1) = 48.124, p< .001. Between T1 and T2 there was no significant difference in anxiety rate change between groups (F (79,1) =0.55, p= .815), likewise no significant interaction of treatment condition by time was detected between T1 and T3 (F (70,1) =0.291, p= .591), suggesting that treatment condition had no influence on the decrease of anxious symptoms within patients.

The same procedure was repeated for symptoms of depression. Between baseline (T1) and the second measurement point (T2) depression scores of all patients decreased significantly F (78,1) =35.136, p< .001. Again, treatment group did not have a significant effect on change in depression scores between patients F (78,1) = 0.771, p=.383. Between T1 and T3 a significant decrease in all patients' depression scores was found F (69,1) = 37.538, p <.001. Again, a non-significant interaction effect of F (69,1) =3.092, p=.083 indicated that there was no significant difference in depression decrease over time between groups.

Regression analysis with the dependent variable 'exercise capacity T2' and the covariate 'exercise capacity T1' showed that the interaction between 'group' and 'anxiety' at baseline was not significant, t (75) =1,322, p= .190. This showed that in both groups patients' anxiety scores before the early, online intervention, respectively the usual care, did not affect exercise capacity increase during this period. Therefore moderation did not occur. Further, no significant effects of 'group' or 'anxiety' on exercise capacity increase within patients was found, which is in line with the results stated earlier.

The same procedure was repeated for 'depression T1'. Results showed that there is no significant interaction between depressive symptoms and treatment condition, t (74) = 0.143, p= .828. Also depression scores before onset of the early treatment, respectively onset of the usual care, did not have a significant effect on exercise capacity of patients during homephase. Likewise treatment condition and symptoms of depression did not have influence on the increase of patients' exercise capacity.

Discussion

This study aimed to determine whether an early, online exercise program prior to the start of traditional, center-based cardiac rehabilitation has beneficial effects on patients' exercise capacity and perceived distress during the rehabilitation period. Earlier studies had noted the usefulness of early treatment and emphasized the role of anxiety and depression during exercise-based CR. Therefore it was hypothesized that (1) patients receiving the early, online training increase significantly more on exercise capacity, (2) anxiety and depression scores decrease significantly more in patients receiving the online training, and that (3) the online treatment is less effective in improving exercise capacity when patients show more severe symptoms of distress at the start of this training.

Somewhat surprising, the findings of the current study show that patients who received early, online exercise training did not improve significantly more on exercise capacity during home or outpatient phase than patients who received usual care. Furthermore, anxious and depressive symptoms did also not decrease more in patients who received the early exercise training compared to patients receiving usual care. Lastly, levels of anxiety and depression prior to the start of the early, online training were not associated with rates of exercise capacity increase during home phase. Therefore, all three hypotheses formulated earlier have to be rejected. Contrary to these former assumptions however, this study found that all patients' mental well-being and physical capacity improved significantly during the examined rehabilitation period, regardless of treatment condition. In fact all patients' exercise capacity improved significantly and no difference in increase rates was detected between groups. Also symptoms of distress decreased to a similar extent in both groups. Moreover symptoms of anxiety and depression did not have an influence on buildup of exercise capacity in patients. Consequently it can be assumed that perceived distress did not impact stamina increase of patients during home phase. Eventually this study did not detect evidence for the effectiveness of the early, online CR program. These findings imply that anxiety and depression do not affect exercise training during CR. Therefore it can be assumed that exercise training does not need to be tailored to patients' perceived distress. Nevertheless, these findings stress the importance of exercise training once more, yet the regular amount of exercising during usual care already seems to be sufficient.

There are several possible explanations for the discrepancy between these findings and the expected results. Firstly, many studies referred to earlier, described the adverse effects of anxiety and depression on the CR progress in relation to increased non-adherence, higher drop-out rates (Pedersen & Andersen, 2018), or by more severe cardiac symptoms, increased difficulties with lifestyle changes or lower health related quality of life (Pogosova et al., 2015). These studies did not measure the direct effect of distress on exercise capacity but focused on other relevant concepts for functional and physical recovery of cardiac patients. It might be that the outcomes of self-reported measures (health related quality of life, lifestyle changes) differ from objectively measured exercise capacity as patients perceive their physical capacity differently under the influence of negative emotional states. Further it appears that not the exercise training itself but rather participation and continuation of therapy units is difficult for patients experiencing anxiety and depression. Secondly, Verschueren et al. (2018) argued that exercising is likely to have beneficial effects on anxiety and depression during CR when exercise training was compared to no-training interventions, community care and/ or group counselling, pamphlets, or routine medical care. Even though all the different types of interventions named above were evaluated in relation to patients' psychological well-being, different outcome measures might explain dissent findings. The usual amount of exercising during CR already seems sufficient to decrease perceived distress considerably. Lastly, there are several possibilities for the ineffectiveness of the early, online training. Insufficient patient participation can be excluded as a possible reason, since the adherence rate was measured in another thesis and found to be 63.3%. Here adherence was determined by patients' log data and expressed as the ratio of performed exercises versus prescribed exercises. This adherence rate is equal to rates found in similar studies and shows decent to good participation. It might be that the exercise program either did not differ notably from what patients of the control group did by themselves, or that the effects of the diverse exercising training did not play out in a generic walking test. Patients in the control condition received generic advice to improve their exercise capacity during homephase and to practice walking in particular. Accordingly, it is unknown if or how patients exactly trained during this period. It might be that patients of the control group focused more on walking whereas the intervention group received a comprehensive exercise training. The online training also prescribed a weekly step goal but additionally encompassed a variety of strength, breathing and mobility exercises as well as balance and relaxation exercises on indication. As exercise capacity was solely measured by a walking test it might be other physical capacities were inadequately represented.

Strengths and Limitations

It is important to notice that the post-operative care for the control group differed from standard care inasmuch as patients wore an accelerometer (Fitbit) during two out of six weeks homephase. Wearable step counters are not only objective measurement devices but also allow for monitoring of daily personal activity, goal-setting, reward and comparison (Chiauzzi, Rodarte, & DasMahapatra, 2015). Step counters can function as a motivational tool and were associated with increased physical activity among cardiac patients wearing these (Thorup et al., 2016). Therefore it can be assumed that patients of the control group had some additional motivation which might have led to a slightly higher walking capacity than usual and accordingly limits generalizability of the current findings. This assumption is further supported by fact that the walking capacity of patients in the control group increased considerably more during homephase than expected based on the reviewed literature (Bellet et al., 2012). On average patients walking capacity improved by 86 meters more (~ +24 %) compared to expectations. The mean exercise capacity improvement of patients in the intervention group was also higher than anticipated, but only 38 meters (~ +9%).

Besides, a floor effect among anxiety and depression scores might have biased the current results. Even though the detected prevalence of mild to severe distress symptoms at baseline was slightly higher (17% in the control group, but 30%- 40% in the intervention group) than the incidence rate of the 20-30% as proposed by Pedersen and Andersen (2018), it is remarkable how much symptoms decreased or disappeared between baseline and second assessment. As skewness and kurtosis of observations increased more with every measurement point, there might be a floor-effect. This makes it more difficult to compare and interpret distress data.

Despite shortcomings in patient recruitment and non-probability sampling, the distribution of sociodemographic variables was homogenous between groups which allowed for optimal comparison. Also the employed materials were of good quality. The HADS was found to have a good reliability in this study (Cronbach's α between .82 and .77) and moderate pre- to post-test correlations (α= .55). The six minute walking test is easily administered, objective and reliable measurement of exercise capacity. Patients' walking capacity and perceived distress were monitored closely during the 13 weeks of rehabilitation which allowed for precise assertions over the progress and development of patients' exercise capacity and distress symptoms.

Conclusion

All in all this study adds to the limited set of research about novel, multimodal treatment approaches for cardiac rehabilitation. The results of this study showed that the early, online intervention did not have extra beneficial effects on patients exercise capacity and psychological well-being. Moreover this study did not find evidence for a relationship between distress and exercise capacity as symptoms of anxiety and depression did not affect physical exercise capacity. These findings have several important implications for future practice of cardiac rehabilitation. First of all this study contributes additional evidence for the essential importance of exercise training during cardiac rehabilitation. Secondly, comprehensive early exercise training is not necessary for patients if usual exercise-based CR starts within six weeks after discharge from the hospital. Yet, the onset of CR after six weeks is standard in the Netherlands, but wait time can increase considerably in other countries. Therefore future studies are needed to determine whether early (online) training becomes relevant for patients who have to wait considerably longer until the onset of CR. Next, the current results imply that exercise training does not have to be adapted or tailored to mild to severe symptoms of anxiety and depression, if these symptoms are present in 20%- 40% of patients shortly after open-heart operation. Moreover it was demonstrated that these symptoms of distress do not impede the buildup of exercise capacity and exercise training itself, but might rather have adverse effects on enrolment, participation or continuation of exercise-based CR programs. Eventually the evidence from this study suggests that anxiety and depression do not play a rule during CR in relation to patients' progress in exercise training and their exercise capacity. Consequently, future studies are needed to investigate then which aspects of successfully undergoing exercise training are negatively affected by patients' distress. In order to obtain a better understanding about the emotional states crucially for successful completion of CR programs, it might be worthwhile to also take positive emotional states into account. Additionally examining patients' perceived well-being, positive functioning or flourishing might help to elucidate which kind of psychological support cardiac patients need to successfully run through exercise-based CR programs. Lastly, it seems advisable to also investigate whether eHealth interventions might be more suited to support patients' exercise training during or after supervised CR.

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Appendix

Hospital Anxiety and Depression Scale (HADS)

Naam:

Geslacht

Leeftijd:

Datum::

Het is bekend dat emoties bij de meeste ziektes een belangrijke rol kunnen spelen.
Deze vragenlijst dient als hulpmiddel om te weten te komen hoe u zich voelt. Lees iedere vraag
en onderstreep het antwoord dat het beste weergeeft hoe u zich gedurende de laatste week gevoeld heeft.
Denk niet te lang over uw antwoord. Uw eerste reactie op elke vraag is waarschijnlijk betrouwbaarder dan een lang doordacht antwoord.
.

1. Ik voel me gespannen:

Meestal
Vaak
Af en toe, soms
Helemaal niet

2. Ik geniet nog steeds van de dingen waar ik vroeger van genoot:

Zeker zo veel
Niet zo veel als vroeger
Weinig
Haast helemaal niet

3. Ik krijg een soort angstgevoel alsof er elk moment iets vreselijks zal gebeuren:

Heel zeker en vrij erg
Ja, maar niet zo erg
Een beetje, maar ik maak me er geen zorgen over
Helemaal niet

4. Ik kan lachen en de dingen van de vrolijke kant zien:

Net zoveel als vroeger
Niet zo goed als vroeger
Beslist niet zoveel als vroeger
Helemaal niet

5. Ik maak me vaak ongerust:

Heel erg vaak
Vaak
Af en toe maar niet te vaak
Alleen soms

6. Ik voel me opgewekt:

Helemaal niet
Niet vaak
Soms
Meestal

7. Ik kan rustig zitten en me ontspannen:

Zeker
Meestal
Niet vaak
Helemaal niet

8. Ik voel me alsof alles moeizamer gaat:

Bijna altijd
Heel vaak
Soms
Helemaal niet

9. Ik krijg een soort benauwd, gespannen gevoel in mijn maag:

Helemaal niet
Soms
Vrij vaak
Heel vaak

10. Ik heb geen interesse meer in mijn uiterlijk:

Zeker
Niet meer zoveel als ik zou moeten
Waarschijnlijk niet zoveel
Evenveel interesse als vroeger

11. Ik voel me rusteloos en voel dat ik iets te doen moet hebben:

Heel erg
Tamelijk veel
Niet erg veel
Helemaal niet

12. Ik verheug me van tevoren al op dingen:

Net zoveel als vroeger
Een beetje minder dan vroeger
Zeker minder dan vroeger
Bijna nooit

13. Ik krijg plotseling gevoelens van panische angst:

Zeer vaak
Tamelijk vaak
Niet erg vaak
Helemaal niet

14. Ik kan van een goed boek genieten, of van een radio- of televisieprogramma:

Vaak
Soms
Niet vaak
Heel zelden

Wilt u controleren of u alle vragen beantwoord heeft?

BEDANKT.