2013•2014
FACULTEIT GENEESKUNDE EN LEVENSWETENSCHAPPEN
master in de revalidatiewetenschappen en de kinesitherapie

Masterproef

Telerehabilitation and e-health implementation in the care of coronary artery disease patients

Promotor :
Prof. dr. Paul DENDALE

Copromotor :
De heer Kenneth VERBOVEN

Anne-Leen Hindrikx , Doukje Vermijl

Proefschrift ingediend tot het behalen van de graad van master in de revalidatiewetenschappen en de kinesitherapie

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Thank you all for the support.

Godsheide, 26/05/2014 A.H.
Helchteren, 26/05/2014 D.V.

RESEARCH CONTEXT

The current project focuses on rehabilitation strategies in the care of cardiac patients. Attendance to a rehabilitation program is highly recommended for patients after a cardiovascular event. Cardiac rehabilitation significantly reduces the risk of developing future cardiovascular events and decreases mortality. Unfortunately, studies establish that barely a small number of patients actually start with a rehabilitation program.[1] Possible explanations these disappointing numbers are for example geographic problems, age or work commitments.

Telerehabilitation can be an effective alternative to overcome the above-mentioned limitations. It could be a possible method to encourage patients to increase their physical activity levels and subsequently maintain a certain level of fitness. Literature shows positive effects of this alternative in other populations.[2]

Therefore, the purpose of this study is to evaluate the short and long term effects of a physical activity telerehabilitation program on physical activity level, physical fitness and cardiovascular risk profile of cardiac patients.

This thesis is part of an ongoing research project called Tele-rehab III. The study is a multi-centered project (Jessa Hospital, Hospital Oost-Limburg and Sint-Fransiscus Hospital Heusden-Zolder) and is led by Prof. dr. Paul Dendale, Head of Department Cardiology of the Jessa Hospital.

After writing the literature study (MP part I) last year, our contribution to the study this year consisted of sending nutrition and diet tips to patients in the intervention group. These messages were send twice a week and were kept in a logbook. The purpose of our MP part II is to give an overview of the preliminary results of the Tele-rehab III project.

Telerehabilitation and e-health implementation in the care of coronary artery disease patients

Abstract

Background**:** The aim of this study was to evaluate the short and long term effects of a telerehabilitation program on daily physical activity level, physical fitness and cardiovascular risk profile in patients with coronary artery disease (CAD).

Design**:** Randomized controlled trial

Methods**:** 28 CAD patients were randomly assigned to a telerehabilitation group or control group. Intervention patients (N=14) wore a Yorbody motion sensor continuously for twenty-four weeks. Each week these patients received a step count goal and exercise- and nutritional recommendations. Control patients (N=14) wore an unreadable motion sensor three times for nine consecutive days during the first, sixth and twenty-fourth week of the study. At week one, week six and week twenty-four an ergospirometry, the IPAQ, the HeartQoL and body mass index were evaluated. A blood sample was taken at baseline and after twenty-four weeks.

Results**:** In the intervention group, HDL-cholesterol (p = 0,046), total cholesterol (p = 0,026) and HR max (p = 0.007) increased significant during follow-up. The number of steps showed significant differences between groups at week one (p = 0,001), week six (p = 0,002) and week twenty-four (p = 0,002). There is a significant increase in number of steps in the intervention group between week one and week six (p = 0,035).

Conclusions**:** This study demonstrated that CAD patients in a telerehabilitation program could improve the patient's number of steps and HR_{max}. In combination with regular recommendations about nutrition and lifestyle this could led to positive changes in biochemical characteristics, like HDL-cholesterol.

Keywords: Physical activity, telemonitoring, 3D accelerometer, coronary artery disease

Introduction

Cardiovascular diseases are the first cause of death in Belgium. Each year 200.000 patients with cardiovascular diseases are admitted to the hospital. Participation in a cardiac rehabilitation program significantly reduces the risk of developing future cardiovascular events and decreases mortality. Cardiac rehabilitation programs mostly provide education and counseling services to help cardiac patients to increase their physical fitness, reduce cardiac symptoms, improve health and quality of life, and reduce the risk of future cardiac events.[3]

First of all, attendance to an exercise intervention helps cardiac patients to become more physically active. It helps to improve patient's energy levels and to reduce the chances of future cardiovascular events and mortality. According to The American Heart Association Recommendation adults should perform at least 30 minutes of moderate intensity aerobic activity for at least five days a week for a total of 150 minutes, or at least 25 minutes of vigorous aerobic activity for at least three days a week for a total of 75 minutes. For additional health benefits, this should be combined with moderate to high intensity muscle-strengthening activity at least two days a week.[3]
Second, education and counseling are key-factors in cardiac rehabilitation. A dietitian can help the patient to create a healthy eating plan. This may help patients to lower their blood pressure and cholesterol levels. Patients who smoke may get counseling on how to stop. Counseling could also help patients to cope with depression, anger and stress.[3]

Unfortunately, despite the benefits, only few patients actually follow a rehabilitation program. Possible reasons are geographic and transport problems, age, lack of time due to work commitments, etc.
Thanks to technological innovations during the last years, telerehabilitation can be an effective method to overcome the above-mentioned problems. Telerehabilitation refers to all different technologies designed to manage and monitor patient's health status and symptoms. Patients are monitored from a distance and receive regular feedback. Several devices can be used, such as a weight scales, blood pressure and heart rate monitors. Patient's data are transmitted to the medical staff by mobile phone or the internet.

Telerehabilitation is effective in different patient populations, including cardiac patients. Telerehabilitation studies with diabetic patients indicated a trend toward a better glycaemic control.[3] Trials with asthma patients showed significant improvements in the peak expiratory flow and a significant reduction in the symptoms associated with asthma.[3] All studies that included patients with hypertension demonstrated that home-telemonitoring can reduce systolic and/or diastolic blood pressure.[3]

In the Tele-Rehab II study patients in the intervention group wore a motion sensor during a period of eighteen weeks.[4] Patients were asked to weekly upload their physical activity data on their computer. Each individual received weekly personalized automated feedback by email or SMS. The aim of the study was to gradually increase the physical activity level of the patients. This study demonstrated that the addition of a physical activity telemonitoring program to conventional cardiac rehabilitation could improve the patient's physical fitness, compared with standard cardiac rehabilitation, during an follow-up period of eighteen weeks.[4] The improvement in $VO2_{peak}$ correlated with the number of daily aerobic steps. Furthermore, a trend toward fewer re-hospitalizations in the intervention group was found.

The aim of the Tele-Rehab III study is to evaluate the short and long term effects of a physical activity telerehabilitation program on physical activity level, oxygen uptake capacity and cardiovascular risk profile in cardiac patients.

Materials and methods

Participants

Patients were recruited by a cardiologist or a physiotherapist in the Rehabilitation Centre of a hospital (Jessa, Oost-Limburg, Sint-Fransiscus), or through the website of the Tele-rehab III study. Patients were included if they were diagnosed with heart failure (systolic or diastolic dysfunction) or if they were diagnosed with coronary artery disease (CAD) for which a percutaneous coronary intervention (PCI) or coronary artery bypass graft (CABG) was performed. All patients had to have access to a computer with internet connection, were able to read and understand Dutch language and were able to go to the ReGo.

Patients that (i) were not capable to perform physical activity due to orthopedic or neurological problems, (ii) could not follow a diet because of cultural reasons, or (iii) had already participated in a similar study (Tele-rehab I or II) were excluded. Subjects were informed about the experimental procedures of the study and gave written informed consent before taking part in the study. The study protocol was approved by the Ethical Committee of Hasselt Jessa Hospital.

Study Protocol

The study was a randomized controlled trial, including an intervention of twenty-four weeks.
At the beginning of the study patients' diet was evaluated by a dietician and the body mass index (BMI), waist circumference and blood pressure were measured. A blood sample was taken to determine risk factors such as fasting glucose, HbA1c, CRP and lipid profile. Patients had to undergo an ergospirometry for defining the physical fitness level. Also the International Physical Activity Questionnaire (IPAQ) and the Heart Quality Of Life questionnaire (HeartQoL) were completed at the beginning of the study. At week six, a new ergospirometry was taken and IPAQ and Heart QoL were filled. At the end of the study, an ergospirometry and a blood sample were taken to evaluate the long term effects of the telerehabilitation intervention on physical fitness level and on cardiovascular risk factors, respectively. Here again the IPAQ and HeartQoL were completed.

Intervention group

At baseline, patients in the intervention group received a motion sensor (an accelerometer provided by Yorbody). The motion sensor was able to record the daily total number of steps, an estimation of the number of burned calories, walking distance and time spent on physical movement/activity. The Yorbody sensor had a memory that can store data up to fourteen days. Therefore, daily uploading of data is not required. Patients in the intervention group were instructed to wear the motion sensor during the entire study period of twenty-four weeks.
They were instructed to take the accelerometer off while asleep or bathing. Intervention patients were able to read their registered activities on the display of the motion sensor. All modalities of exercise training were allowed (walking, running, bicycle, etc.).

The patients were instructed to weekly upload their registered data on their computer by means of an USB-connection. An individual physical training program was established for each patient depending on the measured physical fitness level at baseline. Every week the number of steps increased with 10% of baseline steps/day. Patients were informed weekly about their activity goals by means of e-mail or SMS. In addition, patients received exercise and nutritional recommendations on a regular basis. These recommendations contained useful tips concerning methods to increase patient's daily activity or to improve their diet. Figure 1 gives an overview about the study protocol for the intervention group.[5]

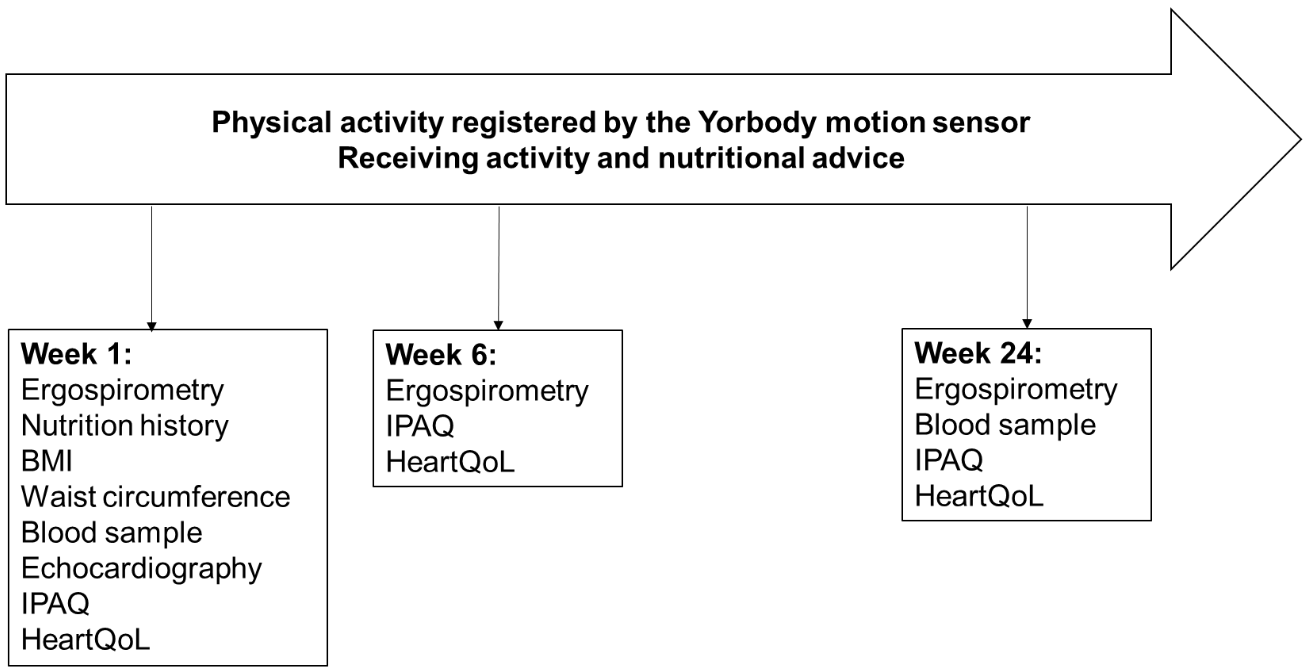

Figure 1: Study protocol intervention group

Control group

Patients in the control group were instructed to wear the motion sensor three times for nine consecutive days during the first, sixth and twenty-fourth week of the Tele-rehab study. The display of the accelerometer was taped wherefore patients could not see the amount of measured physical activity. Patients in the control group did not upload their physical activity data themselves. They brought back their sensors to the rehabilitation center were a study co-operator uploaded it. These patients did not received any feedback about their physical activity. None exercise and nutritional recommendations were sent. Figure 2 gives an overview about the study protocol for the control group.[5]

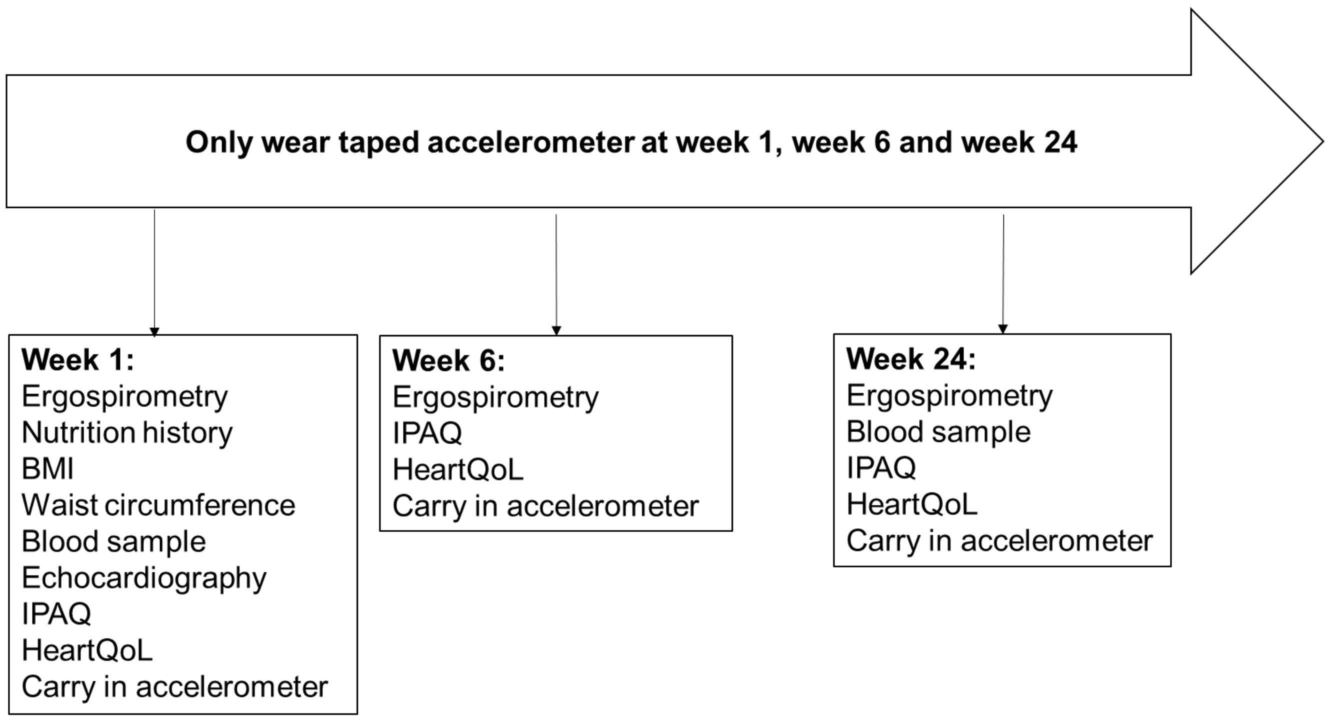

Figure 2: Study protocol control group

Outcome measures

A data-analysis was done to determine the short and long term effects of this telerehabilitation intervention on physical fitness level ($VO2_{max}$, HR_{max}, W_{max} and RER_{max}) and on cardiovascular risk factors such as weight, blood pressure, cholesterol, glucose, triglycerides, CRP and HbA1c. Also possible effects on physical activity level (IPAQ) and symptoms (Heart QoL) were evaluated.

Statistical analysis

SPSS software (v. 22.0) was used for the analysis of the data. The data are expressed as means ± SD. The Sharpiro-Wilk test confirmed that data were not normally distributed. To compare continuous parameters between groups the Mann-Whitney U-test was used and the Chi-Square test was used to compare the categorical data between groups. The Wilcoxon Signed Ranks test was used for the within group analysis.

A one-way ANOVA was used for the analysis over the three visits between groups. A two-tailed probability level of $P<0.05$ was considered to be significant.

Results

Subjects

A total of 61 patients were randomized in the study. In the control group (n = 32), five patients dropped out (15%) and in the intervention group (n = 29), four patients dropped out (14%). Reasons for drop-out were the loss of interest in the Tele-rehab program or an incorrect inclusion of a patient. The data assessment was performed for only 28 patients, 14 in the control group and 14 in the intervention group, due to incomplete data (n=24). Figure 3 gives an overview of the patient flow in the study.

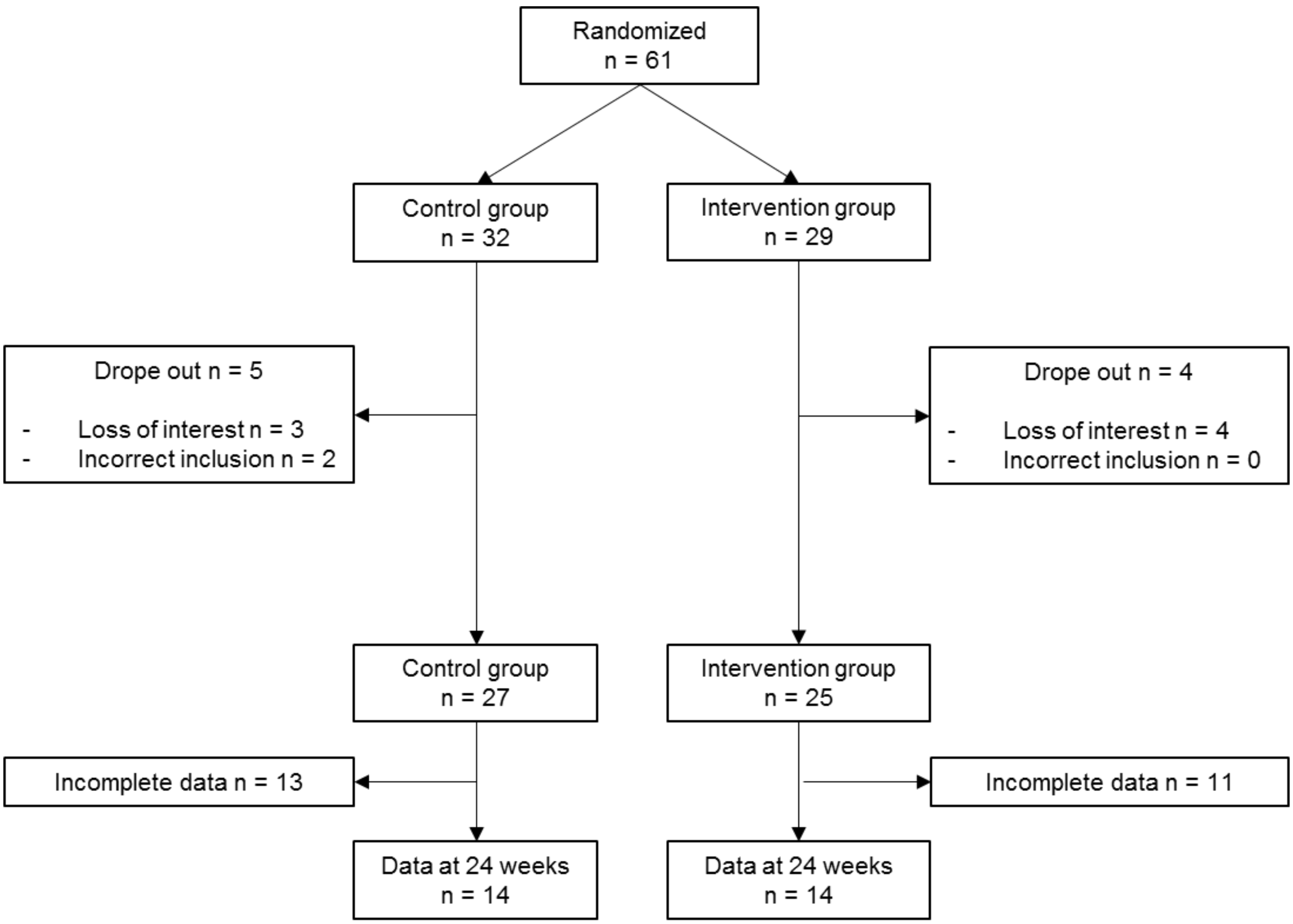

Figure 3. Patient flow in the study

At baseline, groups were similar for demographic characteristics, blood parameters, exercise tolerance, cardiovascular risk factors, indication and questionnaires. Except HbA1c was significant higher in the control group than in the intervention group. Table 1 gives an overview of the baseline characteristics of the patients.

Table 1. Baseline characteristics of patients

	Control group (N=14)	Intervention group (N=14)	P-value
Demographic characteristics			
Male (%)	85,7	100	ns
Age (years), mean ± SD	61 ± 6,73	62 ± 7,13	ns
Length (meters), mean ± SD	1,71 ± 8,58	1,74 ± 6,43	ns
Weight (kg), mean ± SD	84,4 ± 15,12	86,8 ± 19,46	ns
BMI (kg/m2), mean ± SD	29,0 ± 4,87	28,4 ± 4,98	ns
HRrest (beats/minute), mean ± SD	68 ± 13,03	66 ± 12,48	ns
SBPrest (mmHg), mean ± SD	133 ± 17,7	128 ± 16,35	ns
DBPrest (mmHg), mean ± SD	86 ± 21,32	85 ± 18,47	ns
Blood Parameters			
CRP (mg/dl), mean ± SD	1,13 ± 1,84	0,84 ± 1,81	ns
Fasting glycemia (mg/dl), mean ± SD	116,2 ± 24,23	107,1 ± 15,08	ns
HbA1c (%), mean ± SD	6,2 ± 0,86	5,6 ± 0,57	0,016*
HDL-cholesterol (mg/dl), mean ± SD	44,0 ± 7,55	42,4 ± 13,38	ns
LDL-cholesterol (mg/dl), mean ± SD	72,1 ± 32,86	66,1 ± 29,32	ns
Total cholesterol (mg/dl), mean ± SD	142,9 ± 36,78	123,6 ± 31,35	0,085
Triglyceriden (mg/dl), mean ± SD	134,9 ± 52,5	96,1 ± 45,13	0,056
Exercise tolerance			
VO^2max (ml/min), mean ± SD	1821,2 ± 491,59	1918,2 ± 306,43	ns
Wmax (Watt), mean ± SD	148 ± 40,76	158 ± 30,84	ns
HRmax (beats/minute), mean ± SD	124 ± 17,6	122 ± 20,0	ns
RERmax, mean ± SD	1,15 ± 0,09	1,11 ± 0,08	ns
Cardiovascular risk factors			
Smoking (%)	71,4	78,6	ns
Hypertension (%)	50	35,7	ns
Hypercholesterolemia (%)	35,7	28,6	ns
Hyperglycemie (%)	57,1	42,9	ns
Obesitas (%)	35,7	35,7	ns
Indication			
PCI (%)	64,3	57,1	
CABG (%)	28,6	28,6	ns
HF (%)	7,1	14,3	
Questionnaires			
IPAQ Low (%)	42,9	14,3	
IPAQ Moderate (%)	28,5	50	ns
IPAQ High (%)	28,6	35,7	
HeartQoL	34 ± 5,68	34 ± 6,46	ns

BMI: body mass index; SBP: systolic blood pressure; DBP: diastolic blood pressure; HbA1C: glycosylated haemoglobin; LDL-cholesterol: low-density lipoprotein cholesterol; HDL-cholesterol: high-density lipoprotein cholesterol; RER: respiratory gas exchange ratio; HR: heart rate; VO2: oxygen consumption; ACE inhibitor: angiotensin converting enzyme inhibitor; PCI: percutaneous coronary intervention; CABG: coronary artery bypass graft; HF: heart failure; IPAQ: international physical activity questionnaire; HeartQoL: heart quality of life questionnaire. Data are presented as mean values±SD.; *P<0.05.

Changes in parameters during follow-up: demographic characteristics

Some patient characteristics were evaluated, such as length, weight and BMI. No significant differences were found for these characteristics after study follow-up. In the intervention group a trend was found toward lower weight (p = 0,056) and better BMI (p = 0,062) after six weeks.

Changes in parameters during follow-up: biochemical characteristics

In the control group (p = 0,008) and in the intervention group (p = 0,017) CRP exhibited a significant change during twenty-four weeks follow-up. Also, in the intervention group, HDL-cholesterol (p = 0,046) and total cholesterol (p = 0,026) increased significant during follow-up. There was a trend toward higher levels of HDL-cholesterol (p = 0,051), LDL-cholesterol (p = 0,084) and total cholesterol (p = 0,084) in the control group at the end of the study. At the end of follow-up, a trend was found toward better HbA1c levels in the intervention group in comparison with the control group (p = 0,082). Between group analysis yielded significant differences for fasting glycaemia (p = 0,032) and Hba1c (p = 0,006) and a trend was found for CRP (p = 0,059) and HDL-cholesterol (p = 0,075).

Changes in parameters during follow-up: ergospirometrical characteristics

HR_{max} increased significant in the intervention group after twenty-four weeks follow up (p = 0,007). No significant change for HR_{max} was found in the intervention group after six weeks follow-up. Neither a significant result was found in the control group. In the control group a trend was found toward a lower SBP (p = 0,059) after six weeks.

Changes in parameters during follow-up: Questionnaires

No significant differences were found for IPAQ or HeartQoL after study follow-up.

Table 2 shows the changes in blood parameters and exercise tolerance during follow-up.

Table 2. Changes in blood parameters and exercise tolerance during follow-up

	Week 1		Week 6		Week 24		Within group analysis (W1 vs W6)		Within group analysis (W1 vs W24)		Between group analysis
	Control subjects	Intervention subjects	Control subjects	Intervention subjects	Control subjects	Intervention subjects	Control (P-value)	Intervention (P-value)	Control (P-value)	Intervention (P-value)	(P-value)
Demographic characteristics											
Length (meters), mean ± SD	1,71 ± 8,58	1,74 ± 6,43	1,71 ± 8,58	1,75 ± 6,46	1,71 ± 8,48	1,74 ± 6,48	ns	ns	ns	ns	ns
Weight (kg), mean ± SD	84,4 ± 15,12	86,8 ± 19,46	83,7 ± 15,07	84,6 ± 20,52	82,2 ± 15,54	85,9 ± 20,68	ns	0,056	ns	ns	ns
BMI (kg/m2), mean ± SD	29,0 ± 4,87	28,4 ± 4,98	28,7 ± 4,68	27,6 ± 5,33	28,3 ± 4,59	28,1 ± 5,20	ns	0,062	ns	ns	ns
Biochemical characteristics											
CRP (mg/dl)	1,13 ± 1,84	0,84 ± 1,81			4,01 ± 8,52	2,69 ± 2,99			0,008*	0,017*	0,059
Fasting glycemia (mg/dl)	116,2 ± 24,23	107,1 ± 15,08			112,9 ± 21,26	105,7 ± 16,19			ns	ns	0,032*
HbA1c (%)	6,2 ± 0,86	5,6 ± 0,57			6,1 ± 0,53	5,5 ± 0,55			ns	0,082	0,006*
HDL-cholesterol (mg/dl)	44,0 ± 7,55	42,4 ± 13,38	No blood sample taken		48,3 ± 6,07	48,2 ± 13,42			0,051	0,046*	0,075
LDL-cholesterol (mg/dl)	72,1 ± 32,86	66,1 ± 29,32			84,6 ± 37,86	75,9 ± 41,42			0,084	ns	ns
Total cholesterol (mg/dl)	142,9 ± 36,78	123,6 ± 31,35			151,9 ± 32,14	136,6 ± 32,10			0,084	0,026*	ns
Triglyceriden (mg/dl)	134,9 ± 52,5	96,1 ± 45,13			147,3 ± 111,41	109,8 ± 51,84			ns	ns	ns
Ergospirometrical characterstics											
VO^{2}max (ml/min)	1821,2 ± 491,59	1918,2 ± 306,43	1763,1 ± 563,57	1814,8 ± 356,93	1799,8 ± 592,32	2072,0 ± 449,33	ns	ns	ns	ns	ns
Wmax (Watt)	148 ± 40,76	158 ± 30,84	149 ± 45,86	155 ± 36,6	145 ± 53,19	169 ± 41,77	ns	ns	ns	ns	ns
HRrest (beats/min)	68 ± 13,03	66 ± 12,48	70 ± 11,07	69 ± 15,69	68 ± 10,84	75 ± 30,56	ns	ns	ns	ns	ns
HRmax (beats/minute)	124 ± 17,6	122 ± 20,0	122 ± 19,81	127 ± 17,8	126 ± 22,19	136 ± 16,38	ns	ns	ns	0,007*	ns
RERmax	1,15 ± 0,09	1,11 ± 0,08	1,12 ± 0,13	1,14 ± 0,11	1,13 ± 0,12	1,14 ± 0,11	ns	ns	ns	ns	ns
SBPrest (mmHg)	133 ± 17,7	128 ± 16,35	123 ± 15,29	128 ± 21,24	131 ± 17,46	134 ± 22,41	0,059	ns	ns	ns	ns
DBPrest (mmHg)	86 ± 21,32	85 ± 18,47	77 ±15,69	84 ± 19,79	90 ± 20,03	86 V 24,53	ns	ns	ns	ns	ns
Questionnaires											
IPAQ Low (%)	42,9	14,3	35,7	21,4	28,6	28,6					
IPAQ Moderate (%)	28,6	50	35,7	35,7	35,7	35,7	ns	ns	ns	ns	ns
IPAQ High (%)	28,6	35,7	28,6	42,9	35,7	35,7					
HeartQoL	34 ± 5,68	34 ± 6,46	35 ± 6,39	35 ± 5,14	33 ± 7,97	34 ± 8,44	ns	ns	ns	ns	ns

BMI: body mass index; HBA1c: glycosylated haemoglobin; LDL-cholesterol: low-density lipoprotein cholesterol; HDL-cholesterol: high-density lipoprotein cholesterol; RER: respiratory exchange ratio; HR: heart rate, SBP: systolic blood pressure; DBP: diastolic blood pressure; VO^2: oxygen consymption; Data are presented as mean values ± SD; *P<0,05

Number of steps

Significant differences were found between the control group and the intervention groups at week one (p = 0,00), week six (p = 0,002) and week twenty-four (p = 0,002). The within group analysis found a trend toward more steps a week for patients in the intervention group, comparing the begin of the study and week six (p = 0,053). No significant change was found between week one and week twenty-four, or between week six and week twenty-four. Also in the control group, no significant differences were found. Table 3 gives an overview of the number of steps a week. Figure 4 shows the mean of the numbers of steps/week.

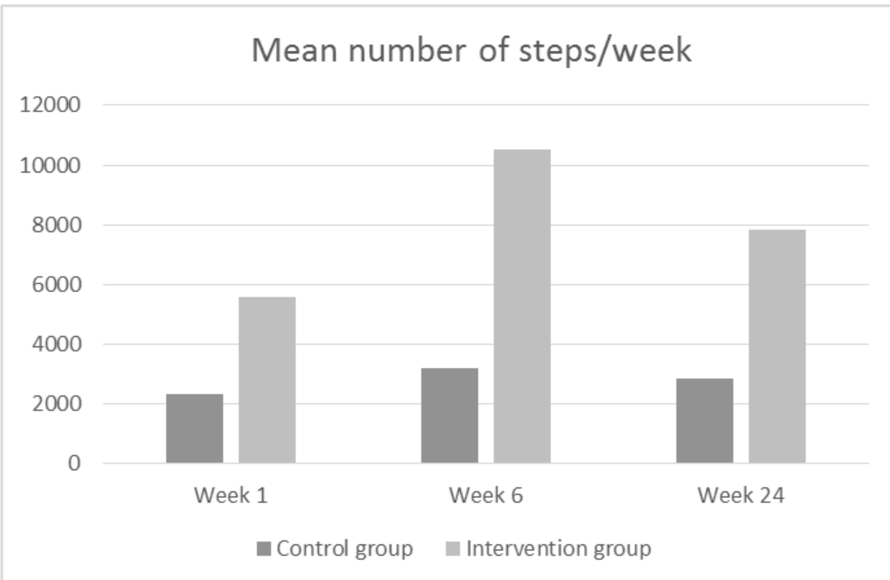

Figure 4. The mean of the numbers of steps/week

Table 3. Number of steps a week

	Control group (N=14)	Intervention group (N=14)	P-value	Within group analysis (W1 vs W6)		Within group analysis (W6 vs W24)		Within group analysis (W1 vs W24)	
				Control (P-value)	Intervention (P-value)	Control (P-value)	Intervention (P-value)	Control (P-value)	Intervention (P-value)
Number of steps/week									
Week 1	2334 ± 1097,63	5578 ± 2301,28	0,001*	0,158	0,035*	0,730	0,221	0,397	0,177
Week 6	3207 ± 2344,94	10519 ± 9911,81	0,002*						
Week 24	2846 ± 2209,37	7818 ± 5296,37	0,002*						

Data are presented as mean values±SD.; *P<0.05

Discussion

As a result of the technological innovations during the last decade, telerehabilitation is a rehabilitation strategy which has been implemented more and more in the care of different patient populations. Telerehabilitation refers to all different technologies designed to manage and monitor patient's health status and symptoms. Telemonitoring can be defined when patients are monitored from a distance and receive regular feedback. Several devices can be used, such as a weight scales, blood pressure and heart rate monitors. Patient's data are transmitted to the medical staff by mobile phone or the internet. In the present study the monitoring of vital signs occurred in the rehabilitation center at the begin, week six and the end of the study, and therefore not in the home-setting. Telerehabilitation is when a rehabilitation program is carried out in a home-setting. In the present study an accelerometer was used in combination with individualized step goals for the patient. Also recommendations about lifestyle, nutrition and exercise were send by means of email or SMS.

With this paper, a preliminary result is written about the Tele-Rehab III project. Up to now 61 patients had ended the study follow-up. 32 patients were randomized in the control group and 29 in the intervention group. In total, nine patients dropped out, five in the control group and four in the intervention group. The rate of drop-out is comparable between the intervention group (14%) and control group (15%). Reasons for drop-out were loss of interest in the Tele-Rehab program, an incorrect inclusion of a patient, patients that would not undergo an ergospirometry, patients that would not receive SMS messages, or patients that were not available anymore. From the remaining subjects, complete data were only available of 28 patients. For the other patients, some important data were incomplete, like questionnaires that are not filled in yet or are not send back to the rehabilitation center and blood samples or ergospirometries that were not taken.

Telerehabilitation studies with diabetic patients indicated a trend toward a better glycemic control [6]. Trials with asthma patients showed significant improvements in the peak expiratory flow and a significant reduction in the symptoms associated with asthma.[6] Available evidence suggests that telerehabilitation could be an effective method to reduce mortality and hospitalizations in heart failure patients.[7,8,9,10]

Some previous papers already explored the use of a telerehabilitation program with cardiac patients. In one study a home-based telemonitoring program consisted of an ECG-recording device with automated data transfer to a monitoring center. This intervention led to a significantly greater improvement in NYHA class ($p = 0{,}007$) compared to the standard cardiac rehabilitation. Another trial showed that a telemonitoring intervention where patients should measure body weight, heart rate and blood pressure on a daily basis could decrease all-cause mortality ($p = 0{,}012$) in comparison with usual care.[11]

Kaminsky et al. included eighteen cardiac patients and assessed the effectiveness of a pedometer-based physical activity intervention.[12] Intervention patients were given individualized daily step goals (increase 10% of baseline steps/day each week). After eight weeks of cardiac rehabilitation the subjects in the intervention group increased their daily steps by 42% (2,297±1,606 steps/day, $p = 0.001$).[12]

The main finding in this study was that in CAD patients the implementation of a telerehabilitation program was effective to improve the level of physical activity. Patients in the intervention group had significant more number of steps a week at week one, after six weeks and after twenty-four weeks compared to the control group. So the use of an accelerometer with accompanying individualized step goals motivates the patient to be more physically active and to get more steps a week compared with patients in the control group. Furthermore, patients in the intervention group showed a trend (p = 0,053) toward becoming more physically active during the study follow-up of six weeks. However, no significant difference in number of steps was found in the intervention group between week one and week twenty-four. Patients in the intervention group received individualized step goals on a weekly basis with the aim to improve the number of steps. Every week the number of steps increased with 10% of baseline steps/day. Therefore, the achievement of the step goal is easier in the first weeks of the study. This could be a logical explanation for the fact that the number of steps in the intervention group showed a positive trend between week one and week six, and not between week six and week twenty-four. Decreased motivation and therapy compliance could be another reason for this decline in number of steps since week six.
The IPAQ is a questionnaire that can be used to evaluate health-related physical activity. Patients are asked about their physical activity in different domains, including leisure time, domestic and gardening activities, work-related and transport-related activity. In both the control group and in the intervention group, there is a noticeable improvement relating to physical activity (IPAQ). However, this improvement is not significant between groups (p = 0,262)

Despite the fact that intervention patients improved their level of physical activity, no significant change was found for $VO2_{max}$. The calculation of the difference from week twenty-four compared to week one in both groups for $VO2_{max}$, results in an increased $VO2_{max}$ in the intervention group. This increase is not significant (p = 0.271). There is a non-significant decrease of $VO2_{max}$ in the control group. On the other hand, in the Tele-Rehab II study $VO2_{peak}$ increased significantly in the intervention group during eighteen weeks of follow-up and in the control group it did not.[4] In the Tele-Rehab II study a significant correlation was found between daily aerobic steps count and improvement of $VO2_{peak}$. So to improve physical fitness, it is not enough to increase only the volume of exercise. Also the applied exercise intensity is important. A certain intensity of physical activity is needed to improve physical fitness. Patients should select an exercise intensity of minimum 100 steps/min while walking.

Within group analysis showed that the use of a telerehabilitation program by means of an accelerometer can result in an improved HR_{max}. Apparently, a rehabilitation of six weeks is not sufficient to cause an improvement in HR_{max}. The change in HR_{max} is only seen after a follow-up of twenty-four weeks. In the control group, none significant differences were found.

Regarding blood parameters, within group analysis showed that CRP was significant different between week one and week twenty-four, both in the control group and in the intervention group. In both groups, CRP has risen from week one compared to week twenty-four. In some patients high levels of CRP were measured after twenty-four weeks causing a high average. Some CRP levels were higher as 10 mg/dl, indicating an inflammation.

HDL-cholesterol ("good" cholesterol) improved significantly between week one and the end of the follow-up, but only in the intervention group. By the increase of HDL-cholesterol, also an increase of total cholesterol is seen in the intervention group at the end of the study. So by the combination of physical activity and sending nutritional recommendations on a regular basis, biochemical characteristics can positively change. Additionally, in the intervention group a trend was found toward lower weight (p = 0,056) and better BMI (p = 0,062) after six weeks. Maybe these results become significant when more patients are analyzed.

In the telemedicine study of Blasco et al., patients should measure their cardiac risk factors themselves. Blood pressure, heart rate and weight are taken every week, glucose and lipids every month.[13] These results are send through their mobile phones and evaluated by a cardiologist. Afterwards, patients received individualized messages. As a result, patients in the intervention group were more likely to experience improvement in cardiovascular risk factors after a follow-up of twelve months. Patients who measure their own risk factors on a regular basis could be extra stimulated to improve their lifestyle, diet and consequently their risk factors. Additionally, recommendations can be send to provide patients with tips about nutrition, lifestyle and exercise.

Further, between group analysis yielded significant differences for fasting glycaemia (p = 0,032) and HbA1c (p = 0,006). Fasting glycaemia has decreased noticeable in the two groups, but this is not significant. Between the groups, however, there is a significant difference noticeable. In the control group, the decline is stronger than in the intervention group. At baseline, significant differences were found between both groups for HbA1c. Between group analysis show that these differences are still present at the end of follow-up.

The Heart QoL questionnaires evaluates the patient's cardiac related symptoms. Fourteen questions can be scored between 3 (no symptoms) or 0 points (a lot of symptoms). The total score is 42 for a patient without any symptom. No significant changes were found for Heart QoL. Not in the intervention group, neither in the control group. Other studies also investigated the effect of telerehabilitation on quality of life. In the study of Piotrowicz et al. QoL improved significantly in both the intervention group and the control group.[14] No significant differences were found between groups.

Other important factors are number of hospitalizations, mortality and patients satisfaction. Telemonitoring is an effective method to reduce the number of hospitalizations and mortality. In one trial patients should measure their weight and blood pressure daily, and they had to take an electrocardiogram once a week.[15] Also symptom related questions on a mobile phone were asked daily. This approach showed a reduction of heart failure hospitalizations.

In the study of Dendale et al. patients were asked to measure body weight, heart rate and blood pressure daily.[11] These data were transferred by a cell phone to a hospital and compared with predefined limits. This intervention resulted in significant difference (p = 0,012) in all-cause mortality between the intervention group and the group which received usual care. In this way telemonitoring could be an effective method to observe cardiac patients in a home-setting and to intervene when is necessary. In the present study no analysis was done of number of hospitalizations or mortality. In future studies this is an interesting and important outcome to investigate, as well as patient satisfaction and cost analysis.

Limitations

We acknowledge that this is only a preliminary result of the Tele-rehab III study. Up to now, only 28 patients have been evaluated. Data-assessment of a larger number of patients is needed to confirm and complement these results. The intervention was comprised of an exercise training program by using an accelerometer. Data about physical activity and number of steps depends on the correct wearing of the accelerometer by the patients.

Conclusion

This study demonstrated that in CAD patients a telerehabilitation program could improve the patient’s physical activity level. In particular, the use of an accelerometer could increase the patient’s number of steps. Also, HR_{max} changed significant due to the telerehabilitation intervention. The combination of physical activity and regular recommendations about nutrition and lifestyle could led to positive changes in biochemical characteristics, such as HDL-cholesterol.

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