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STEP COUNTER USE AND SELF-DETERMINED MOTIVATION FOR WALKING IN A CARDIAC TELEREHABILITATION PROGRAM

A MIXED METHOD STUDY

BY
CHARLOTTE BRUN THORUP

DISSERTATION SUBMITTED 2016

AALBORG UNIVERSITY
DENMARK

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A mixed method study

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CV

Charlotte Brun Thorup was educated as a nurse at Aarhus Hospital (now Aarhus University Hospital) in 1995. Her first years of working as a nurse were within the field of gastroenterology surgery. After that, her interest in the development of nursing care increased, and she began a job in which she was responsible for implementing fast-track care for colorectal surgery patients.

From 2001 – 2004, Charlotte Brun Thorup was employed at the Department of Cardiothoracic Surgery, Aalborg University Hospital, with the responsibility of educating and training nursing staff.

From 2005 – 2006, she was employed as a lecturer at University College Aalborg, Department of Nursing Education.

In 2005, she received her Master of Science in Nursing at Aarhus University.

Since 2006, Charlotte Brun Thorup has been employed as a Development Nurse and a Clinical Nurse Specialist in the Department of Cardiothoracic Surgery, Aalborg University Hospital.

Regarding her work related to development and research, Charlotte Brun Thorup has developed guidelines, for example for postoperative mobilization after cardiac surgery. She has been responsible for research projects at Aalborg University in collaboration with the Clinical Nursing Research Unit at Aalborg and has participated as a researcher in the Nordic Research Network focusing on the ethics of care.

Since November 2012, Charlotte Brun Thorup has been enrolled as a PhD student at the Faculty of Medicine, Aalborg University.

ENGLISH SUMMARY

Cardiac patients benefit from cardiac rehabilitation, but only a small proportion of these patients receive this intervention. Exercise plays a central role in cardiac rehabilitation by reducing risk factors and providing positive outcomes. Despite these benefits, only half of cardiac patients participate in regular exercise up to 18 months after a cardiac event. By using telerehabilitation technologies, Teledi@log intends to increase both attendance to cardiac rehabilitation and long-term adherence to recommendations. As walking has the potential to play an important role in secondary prevention of cardiovascular disease, the step counter Fitbit Zip has been implemented as a self-monitoring technology in Teledi@log, using the Self-determination Theory as the theoretical framework for motivation.

Research suggests that the Fitbit Zip is an appropriate technology for use in clinical settings and research. However, its accuracy needs to be determined at normal speeds on treadmills and in real life among cardiac patients. There is a lack of consensus regarding how many steps cardiac patients walk during the period up to one year after a cardiac event; therefore, important knowledge that could benefit efforts to provide realistic and appropriate goals for patients' daily steps in cardiac telerehabilitation is lacking. Moreover, no studies have explored patients' and health professionals' experience of self-determined motivation for walking when using the step counter Fitbit Zip in a cardiac telerehabilitation programme.

The overall aim was to determine the accuracy of the step counter (Study 1) and to generate new knowledge on cardiac patients' walking activity after a cardiac event (Study 2). Furthermore, the aim was to explore self-determined motivation for walking as experienced by cardiac patients and health professionals when using a step counter as a part of a cardiac telerehabilitation programme (Study 3).

The purpose of Study 1 was two-fold:

a) To investigate the accuracy of the step counter Fitbit Zip in measuring steps taken by healthy adults when walking on a treadmill (treadmill study). It was hypothesised that a Fitbit Zip step counter would have a step-count error of $\leq 3\%$ compared to a gold standard, when tested by healthy adults on a treadmill.
b) To use same motion measurement equipment to investigate the accuracy of the Fitbit Zip in measuring steps taken by cardiac patients both at the hospital and in the patient's home (real-life study).

The purpose of Study 2 was to explore cardiac patients' walking activity. Their walking activity was analysed in relation to the numbers of steps taken and the duration of step counter use to determine the correlations between walking activity, demographics, and medical and rehabilitation data.

The purpose of Study 3 was to explore step counter use and self-determined motivation for walking during a cardiac tekerehabilitation programme based on the patients' and health professionals' experiences.

In this PhD research, a mixed methods approach was used, inspired by a convergent mixed methods design. The results and findings were presented separately and then merged into a joint display with the aim of revealing integrated findings from the three studies. The integrated findings led to a more comprehensive understanding of the results and findings.

In Study 1, 20 healthy adults wore Fitbit Zips while walking on a treadmill at different speeds, and 24 cardiac patients wore Fitbit Zips during hospitalisation and at home. A Shimmer3 device was used as criterion standard. In Study 2, a total of 64 cardiac patients from Teledi@log were included. The monitoring of step activity continued for 12 months. In Study 3, a qualitative research design consisting of observations, individual interviews and patient documents provided the basis for a content analysis. Data were analysed deductively using the Self-determination theory as a framework for the analysis and discussion, focusing on the psychological needs of autonomy, competence and relatedness. Twelve cardiac patients, 11 health professionals; six physiotherapists and five registered nurses were included.

The research presented in this thesis concluded the following:

- The accuracy of Fitbit Zip depends on the walking speed. A speed of 3.6 km/h and higher provided a step inaccuracy rate of less than 3%. However, 24-hour measurements showed a high inaccuracy in step readings. Nevertheless, the participants did not spontaneously think about the inaccuracy when using the Fitbit Zip.

- The Fitbit Zip supported autonomy as it created independence from standardised rehabilitation, and patients in the cardiac telerehabilitation at Call Centre had the highest mean steps/day; still, only a small proportion of the patients chose the cardiac telerehabilitation at Call Centre.

- The Fitbit Zip seemed to support competence and thereby self-determined motivation for walking, and a slight increase in walking activity over time was observed. Furthermore, there was a significant relationship between long-term use and high step activity. Nevertheless, the patients walked less than recommended and less than patients in comparable studies.

- The Fitbit Zip supported relatedness regarding health professionals and the patients' next of kin, but including co-patients in group sessions for exercise was not mentioned as a motivational factor.

In conclusion, the step counter supported a feeling of self-determined motivation for walking, when used in a cardiac telerehabilitation programme. However, the patients walked less than recommended and less than patients in comparable studies. Furthermore, the step counter was inaccurate in 24-hours measurements and in slow speed; still, participants did not pay spontaneous attention to inaccuracy.

DANSK RESUME

Hjerterehabilitering reducerer hertepatienters morbiditet og mortalitet, dog modtager kun en mindre de af hjertepatienter rehabilitering. Fysisk træning spiller en væsentlig rolle for hjertepatienters sundhed ved at reducere risikofaktorer og komplikationer til hjertesygdom. På trods af dette deltager kun halvdelen af hjertepatienter i regelmæssig motion 18 måneder efter et hjertetilfælde. Teledi@log er et forskningsprojekt, der ved brug af telemedicinsk udstyr forsøger at øge hjertepatienters deltagelse og fastholdelse i rehabilitering. I Teledi@log anvendes en skridttæller, en Fitbit Zip, til at understøtte hjertepatienters gå-aktivitet, idet gang og gåture har betydning for bevarelse af hjerte-sundhed. Motivation er væsentlig for at fastholde fysisk træning, derfor er teorien om Selv-determination implementeret i Teledi@log for at understøtte patienternes motivation.

Forskning har vist, at Fitbit Zip kan være en passende skridttæller til anvendelse i klinisk praksis og til forskning. Trods dette mangler der studier, som undersøger Fitbit Zip's nøjagtighed under normal gang på et løbebånd og i autentiske omgivelser blandt hjertepatienter. Desuden er der begrænset viden om hvor mange skridt hjertepatienter gennemsnitlig går dagligt efter en hjertesygdom. Denne manglende viden har medført, at det er svært at forudse hvor mange skridt hjertepatienter forventes at gå for at kunne bevare og fremme egen sundhed.

Formål med forskningen præsenteret i denne afhandling var at bestemme, hvor nøjagtigt skridttælleren Fitbit Zip målte skridt (Studie 1) samt, hvor meget hjertepatienter gik efter et hjertetilfælde (Studie 2). Derudover var formålet at afdække sundhedsprofessionelle og hjertepatienters oplevelse af selv-determineret motivation for at gå, når Fitbit Zip anvendes som en del af et telerehabiliterings forløb (Studie 3).

Formålet med Studie 1 faldt i to dele:

a) At undersøge Fitbit Zip's evne til at tælle skridt nøjagtigt under anvendes af raske forsøgspersoner på et løbebånd ved forskellige hastigheder. Det blev forventet at skridttælleren havde en skridt-fejlmargen $\leq$ 3 % sammenlignet med referenceværdi målt af en avanceret bevægelsessensor (Shimmer3).
b) At anvende samme måleudstyr til at undersøge nøjagtigheden af Fitbit Zip, under anvendes af hjertepatienter i autentiske omgivelser, dvs. ved 24 timers målinger under sygehus-indlæggelse og i egne hjem.

Formålet med Studie 2 var at afdække hjertepatienters gå-aktivitet. Gå-aktiviteten blev analyseret med udgangspunkt i hvor mange skridt hver enkelt patient gik, set i relation til, hvor længe patienterne fortsatte med at bruge skridttælleren samt deres alder, køn, sygdom og valg af sted for telerehabilitering.

Formålet med Studie 3 var at afdække sundhedsprofessionelles og hjertepatienters oplevelse af selv-determineret motivation for at gå når en skridttæller anvendes som en del af et telerehabiliterings forløb.

Forskningen havde et konvergerende mikset metode design (mixed methods) med undersøgelser af både kvantitativ og kvalitativ karakter. At designet var konvergerende, betød at indsamling af data i de tre studier skete uafhængigt af hinanden. Mixed methods blev anvendt for at opnå omfattende forståelse af forskningsspørgsmålene.

I Studie 1 gik 20 raske voksne på løbebånd mens de bar fire Fitbit Zip (to på overkroppen og to ved bukselinningen) og en Shimmer3 bevægelses sensor. Derudover bar 24 hjertepatienter en Fitbit Zip og en Shimmer3 i 24 timer, mens de var indlagt på sygehuset samt fire uger efter udskrivelsen. I Studie 2 anvendte 64 patienter fra interventionsgruppen i Teledi@log Fitbit Zip i op til et år efter et hjertetilfælde. I Studie 3 blev 12 af patienterne fra Teledi@log's interventionsgruppe konsekutivt udvalgt til at deltage i kvalitative interviews og observationer undersøgelse hvor også kommunikation fra patientens personlige rehabiliterings plan blev anvend som data for analyse. Desuden blev 11 sygeplejersker og fysioterapeuter valgt som informanter til yderligere interview. Rammen for interview af både patienter og sundhedsprofessionelle var inspireret af begreberne i motivationsteorien om selv-determination.

Resultaterne af alle tre studier blev samlet i et joint display, hvorfra fire integrerede fund udsprang og ledte til følgende konklusion:

- Fitbit Zip's nøjagtighed var afhængig af ganghastighed og ved en hastighed på 3.6 km/t og opefter var unøjagtigheden ≤ 3 %. Dette viste sig både på løbebånd og ved evident gang i autentiske omgivelser (på sygehuset og i hjemmet). Modsat viser 24 timers målinger i autentiske omgivelser stor skridt-unøjagtighed. Trods dette, har ingen af informanterne fra interviewene givet spontant udtryk for bekymring om unøjagtighed.
- Skridttælleren understøttede autonomi, så patienterne følte frihed fra standardiseret rehabilitering, og de patienter som valgte det mest

individuelle rehabiliterings forløb (telerehabilitering i Call Center) havde det højeste gennemsnitlige antal daglige skridt. Dog valgte kun en lille del af patienterne telerehabilitering i Call Center.

- Skridttælleren understøttede oplevelsen af at være kompetent og i stand til selv at varetage træning ved at gå. Der sås en let øgning af gennemsnitlig antal daglige skridt i løbet af monitoringsperioden (på 12 måneder). Derudover var der en signifikant sammenhæng mellem lang tids anvendelse af skridttælleren, og høj gennemsnitligt antal skridt per dag. På trods af dette gik personerne i denne undersøgelse mindre en hjertepatienter i sammenlignelige studier.
- Skridttælleren understøttede patienternes oplevelse af samhørighed i relationen til sundhedsprofessionelle egne pårørende, en samhørighed der motiverede til at gå og anvende skridttælleren. Modsat gav patienterne ikke udtryk for samme oplevelse af samhørighed med medpatienter på trænings hold.

Skridttælleren gav dermed en selv-determineret motivation for at gå ved deltagelse i et telerehabiliteringsprogram for hjertepatienter. På trods af dette gik hjertepatienterne mindre en anbefalet og mindre end patienter i sammenlignelige studier. Desuden var skridttælleren unøjagtig ved 24-timers målinger og ved langsom gang, hvilket informanter ikke spontant gav udtryk for bekymring over.

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This project was part of the research project Teledi@log, which was conducted from 2012 – 2014.

First of all, I wish to thank all of the patients, health professionals and healthy volunteers who participated in this research, including all of the patients from the Teledi@log project who consented to the interview on step counter use and the other patients who wore the activity sensors both at the hospital and in their homes. Furthermore, I would like to thank all of the health professionals from the Teledi@log study who agreed to participate in the interview. Lastly, I would like to thank all of the healthy volunteers who spent time wearing the step counters and the activity sensor while walking on a treadmill.

I would like to thank the Department of Cardiothoracic Surgery, Aalborg University Hospital, for its support during this PhD period. This department has been the place of my employment, and I would like to say a special thank you to my former superiors Margrethe Bisgaard and Jan Jesper Andreasen who supported the initiation of this PhD project.

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Last but not least, a warm thank you to my friends and my whole family, who have been most supportive during this period.

ABBREVIATIONS, TABLES, FIGURES AND DEVICES USED IN THE RESEARCH

Abbreviations

CTR	Cardiac telerehabilitation
CHD	Coronary Heart Disease
HF	Heart Failure
CR	Cardiac Rehabilitation
RCT	Randomised Controlled Trial
SDT	Self-determination theory
ACS	Acute Coronary Syndrome
CABG	Coronary Artery Bypass Grafting
CTR-Healthcare Centre	Cardiac Telerehabilitation at Healthcare Centre
CTR-Hospital	Cardiac Telerehabilitation at Hospital
CTR-Call Centre	Cardiac Telerehabilitation at Call Centre
PHR	Personal Health Record
Zip	Fitbit Zip step counter
QUAN	Quantitative study
QUAL	Qualitative study
BMI	Body Mass Index
SD	Standard Deviation
Shimmer	Shimmer3
TP24h	Time Periods of 24-hour recordings
TP3min	Time Periods of 3 minutes
E_{rel}	Relative Error
ICC	Intraclass Correlation Coefficient
P	Statistically significant
RN	Registered Nurse
Kg	Kilogram
Cm	Centimetres
Hz	Hertz

Tables

Figures

Appendices

LIST OF PUBLICATIONS

Papers

1. Thorup CB, Andreasen JJ, Sørensen EE, Grønkjær M, Dinesen, BI, Hansen J. Accuracy of a step counter during treadmill and daily life walking by healthy adults and cardiac patients. Submitted and awaiting reviewer selection at the 2th March 2016 to *BMJ Open*

2. Thorup CB, Hansen J, Grønkjær M, Andreasen JJ, Nielsen G, Sørensen EE, Dinesen BI. Cardiac Patients' Walking Activity Determined by a Step Counter in Cardiac Telerehabilitation: Data From the Intervention Arm of a Randomized Controlled Trial. Accepted for publication the 26th December 2016 in *Journal of Medical Internet Research.*

3. Thorup CB, Grønkjær M, Spindler H, Andreasen JJ, Hansen j, Dinesen BI, Nielsen G, Sørensen EE. Pedometer use and self-determined motivation for walking in a cardiac telerehabilitation program: A qualitative study. Submitted the 29th December to *BMC Sports Science, Medicine and Rehabilitation.* Re-submitted to and under peer-review the 7th February 2016.

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CHAPTER 1. INTRODUCTION

This research was part of a cardiac telerehabilitation (CTR) project: Teledi@log (1). In Teledi@log, cardiac patients were randomly assigned to either traditional cardiac rehabilitation or cardiac telerehabilitation. Teledi@log covered multiple research topics (i.e., cost-utility, quality of life, self-determination, and qualitative perception of telerehabilitation). This thesis studied the step counter used in Teledi@log and cardiac patients' walking activity and motivation for walking when using this step counter in CTR.

1.1. CARDIAC DISEASE AND CARDIAC TELEREHABILITATION

Cardiac disease includes a range of diseases such as coronary heart disease (CHD) and heart failure (HF). CHD is common and is considered the leading cause of death, accounting for 13 – 15% of all deaths worldwide (2) and 24.8% of all deaths in Europe in 2011 (3). The prevalence and incidence of HF is steadily increasing, with approximately 15 million patients in Europe and more than 5 million in America (4). Due to the improved prevention and treatment of CHD and HF in recent decades, the related mortality has been declining, leading to increased morbidity among survivors (3).

Cardiac rehabilitation (CR) aims to improve cardiac patients' functional capacity, recovery, psychosocial well-being and health-related quality of life through risk factor modification (3,5). The European Society of Cardiology, the American Heart Association and the American College of Cardiology recommend CR to patients with cardiac disease, as it is a cost-effective intervention that improves prognosis by reducing recurrent hospitalization and health care expenditures (3,5); furthermore, it reduces morbidity and mortality (3,5).

CR has been defined as the "*coordinated sum of interventions required to ensure the best physical, psychological and social conditions so that patients with chronic or post-acute cardiovascular disease may, by their own efforts, preserve or resume optimal functioning in society and, through improved health behaviours, slow or reverse progression of disease*" (Heran, Chen, S Ebrahim, et al. 2011. p.1).

CR is a multidisciplinary programme and intervention, consisting of patient assessment, physical activity counselling, exercise training, diet/nutrition counselling, weight control management, lipid management, blood pressure monitoring, smoking cessation and psychosocial support. CR programmes vary depending on the type and severity of the cardiac disease (3,5). It is suggested that CR should start as soon as possible after hospital admission and continue as structured in-hospital CR or outpatient CR to reach and maintain CR goals in the long term (3,5). In Europe, less than half of all patients with cardiac disease receive cardiac prevention and CR, despite the rich evidence for both these interventions (7).

Telerehabilitation has the potential to increase the availability of and adherence to rehabilitation (8), provide specialty clinical services in geographically remote communities and reduce the costs associated with travel and time (9,10). Telerehabilitation is the application of telemedicine and telecommunication technology to support rehabilitation services (11,12). Telemedicine is defined as: "*The delivery of health care services, where distance is a critical factor, by all health care professionals using information and communication technologies for the exchange of valid information for diagnosis, treatment and prevention of disease and injuries, research and evaluation, and for the continuing education of health care providers, all in the interests of advancing the health of individuals and their communities*" (World Health Organization Global Observatory for eHealth 2010. p.9).

This definition notes that distance may be a reason for using telemedicine, yet telemedicine may also provide new ways of delivering person-centred health care. A review found that patients who use telemedicine for support, education and virtual consultation felt more independent, confident and empowered, had better knowledge of their own illness and had improved health outcomes, as well as better nurse-patient relationships (14). In the definition, another essential point is the exchange of valid information, e.g., by telemonitoring, that allows the patient to live in their own homes while their health and safety are monitored remotely by health professionals (11). Moreover, a continuous monitoring of health status provides the patients with knowledge of their own health/disease progress.

Telemedicine may help patients manage their condition, as it can provide independence. Telemedicine has the opportunity to become a supplement or an alternative to traditional face-to-face care, e.g., by using video conferences and by transferring information electronically (10).

Telerehabilitation has been implemented for cardiac patients, and CTR has proven to reduce travel costs (15) and to be just as effective in decreasing morbidity and mortality as centre- and hospital-based CR programmes (16). In addition, CTR may be effective in increasing both attendance rates and long-term adherence to rehabilitation recommendations because CTR is performed in the participants' natural environment and is incorporated into their daily routine at home (8).

1.2. EXERCISE-BASED CARDIAC REHABILITATION

Physical activity and exercise are central elements of CR (17). Heran et al. (Heran, Chen, S Ebrahim, et al. 2011. p.4) state that "*exercise-based CR is defined as a supervised or un-supervised inpatient, outpatient, or community- or home-based intervention including some form of exercise training that is applied to a cardiac patient population*."

Exercise-based CR results in improved cardiorespiratory fitness, leading to a reduction in morbidity and all-cause and cardiovascular disease mortality (18). Furthermore, the risk of re-hospitalisation is decreased (17) and reinfarction (19) in patients with CHD is reduced. In addition, exercise-based CR reduces levels of depression, anxiety, hostility and total psychological stress (18).

In HF patients, exercise interventions reduce re-hospitalisation due to HF and improve health-related quality of life (20). Physical activity decreases mortality (21,22) and functional limitations, delays progression of disease and promotes independence (21,23).

There is a distinction between physical activity and exercise. Physical activity has been defined as "any bodily movement, produced by skeletal muscles that results in energy expenditure (24) above resting (basal) levels" (25). Physical activity becomes exercise when physical activity is planned, structured, repetitive, and purposeful, in the sense that improvement or maintenance of physical fitness is the aim (24,25). Both physical activity and exercise can be quantified by intensity (how hard?), duration (how long?) frequency (how often?) and mode/type (what kind?) (26).

To achieve health benefits, there seems to be no lower threshold, as 'something is better than nothing,' and a relatively small increase in physical activity by sedentary individuals will result in health benefits even if the recommended level of physical activity is not achieved (26). For all patients with cardiac disease, it is recommended to participate in 30 – 60 minutes of continuous or accumulated moderate intensity aerobic physical activity, such as brisk walking, at least 5 and preferably 7 days per week (27,28). Furthermore, resistance exercise an additional 2 – 3 days per week is recommended to further optimize the benefits of exercise (26).

International research shows that up to 50% of cardiac patients do not participate in regular exercise 6 and 18 months after a cardiac event (29). Adherence to exercise in HF patients has been shown to decline substantially after the period of supervised training (21). A review of telemedical interventions that aimed to increase physical activity indicated that telemedicine may enhance participants' daily steps, walking minutes and level of physical activity, leading to increased fitness and decreases in body fat (30).

In summary, these findings indicate that exercise-based CR is essential and that CTR may provide an opportunity to improve both initiation of and adherence to CR recommendations including recommendations for physical activity.

1.3. PRESENTATION OF THE RESEARCH PROJECT TELEDI@LOG

The research project Teledi@log is a CTR trial that consists of telerehabilitation technologies to support CR (31). In the following section, the Teledi@log project is presented, as it framed the research conducted in this PhD project.

Teledi@log was a randomized controlled trial (RCT) that was developed and tested from 2012 – 2014. The aim of Teledi@log was to develop new programmes in telerehabilitation for cardiac patients by using telemedicine and telecommunication technology. Furthermore, the basic idea was to tailor CTR based on the patient's individual needs, motivation and self-management; as such, the Self-determination theory (SDT) was used as a theoretical framework for human motivation (the SDT is described in section 2.2.4).

In Teledi@log, patients were recruited from Aalborg University Hospital, Aalborg, Denmark, and Vendsyssel Hospital, Hjoerring, Denmark. Block randomisation was performed to ensure an even distribution between the intervention and control groups. The inclusion and exclusion criteria are displayed in Table 1.

Table 1. In- and exclusion criteria in Teledi@log

Criteria
Inclusion
Must be men and women ≥ 18 years of age
Must have signed 'Informed Consent'
Must understand study information
Must be inhabitants in Hjoerring or Frederikshavn municipality
Must be able to use IT[1] or have a close family member who can use IT
Must be hospitalised with acute coronary syndrome (ACS), Heart failure (HF) (ejection fraction < 40%) or coronary artery bypass grafting (CABG) or valve surgery.
Exclusion
Patients who, in the investigator's judgement, will not be able to participate in the study
Patients who, lack the ability to speak and understand Danish
Patients who are pregnant or breastfeeding
Patients with neurological disease
Patients who use wheelchair or lack the ability to walk
Patients who participate in other studies that could influence the outcomes in this study

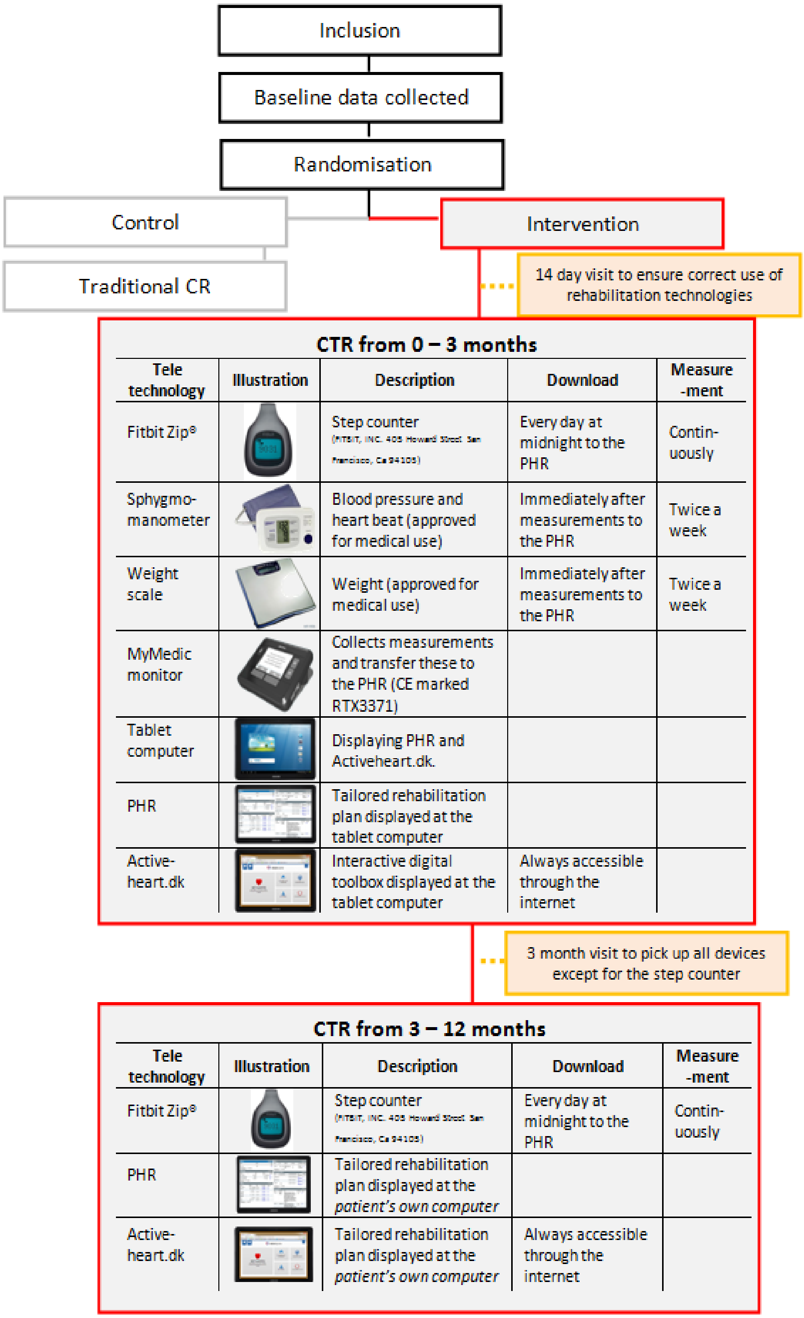
[1] IT, information technology

Patients who met the inclusion criteria were approached by a project nurse before being discharged from the hospital. Patients who agreed to participate signed an informed consent form before randomisation, and their baseline data were registered.

After randomisation and before discharge from the hospital, a cardiac nurse performed an interview with each patient to identify his or her needs for rehabilitation. The patients' tailored rehabilitation plans were then created and displayed in their personal health record (PHR). Furthermore, patients in the intervention group were instructed on how to use the telerehabilitation technologies. The telerehabilitation technologies consisted of a Fitbit Zip® (Zip) step counter, a weight scale, a sphygmomanometer, a tablet computer and a monitor (MyMedic) that collected data from the devices and transferred them to the tablet computer

Monitoring started immediately after discharge from the hospital, and fourteen days after inclusion, each patient was visited by a research assistant to ensure confidence in and correct use of the telerehabilitation technologies. The telerehabilitation programme consisted of a three-month rehabilitation and monitoring period.

Figure 1. Telerehabilitation programme in Teledi@log.



The patients selected one of three rehabilitation settings: CTR at a community healthcare centre (CTR-Healthcare Centre), at the hospital (CTR-Hospital) or a call centre with telerehabilitation (CTR-Call Centre) (Table 2).

Table 2. Rehabilitation settings in Teledi@log

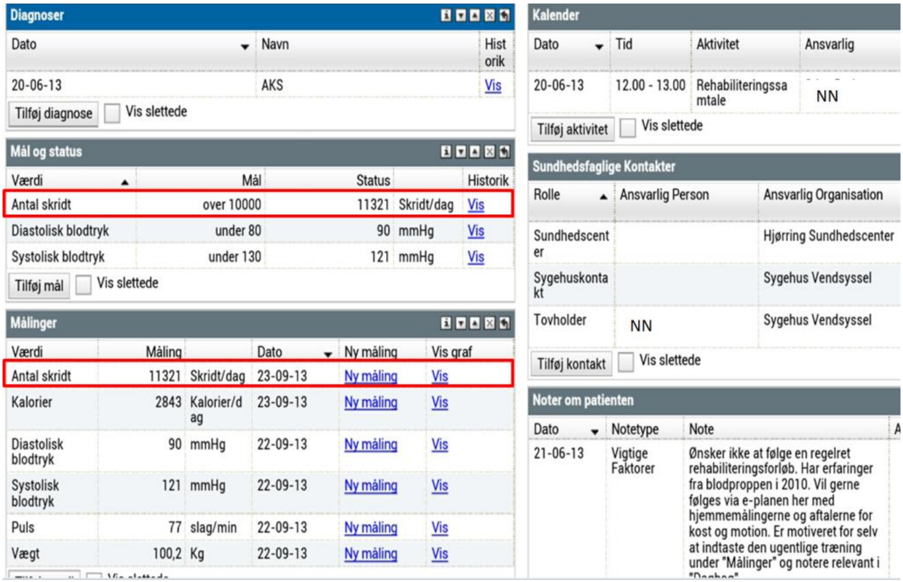
	CTR-Healthcare Centre	CTR-Hospital	CTR-Call Centre
In charge of CTR[1]			
	Rehabilitation nurse and physiotherapist from the healthcare centre	Cardiac nurse and physiotherapist from the hospital	Cardiac nurse and physiotherapist from the hospital
CTR provided through			
	Self-monitoring and learning via PHR	Self-monitoring and learning via PHR	Self-monitoring and learning via PHR
	Exercise through Zip and in group sessions at the healthcare centre, jointly with other patients receiving rehabilitation (primary patients with diabetes)	Exercise through Zip and in group sessions at the hospital, jointly with other cardiac patients receiving rehabilitation	Exercise through Zip
	Individual and group sessions[1] at the healthcare centre	Individual and group sessions[1] at the hospital	
CTR individually planed by			
	Project nurse at the discharging hospital and the patient (and relatives)	Project nurse at the discharging hospital and the patient (and relatives)	Project nurse at the discharging hospital and the patient (and relatives)
Follow-up time			
	Follow-up time was based upon individual needs.	Follow-up time was based upon individual needs.	Follow-up time was based upon individual needs.

[1] All rehabilitation activities were planned in accordance with recommendations from the European Association of Cardiovascular Prevention and Rehabilitation; thus physical activity counselling, exercise training, diet/nutrition counselling, weight control management, lipid management, blood pressure monitoring, smoking cessation and psychosocial support were provided (3,5).

At the time of discharge from the hospital, all patients were assigned a nurse and a physiotherapist who were responsible for their CR. This was a nurse or a physiotherapist from the Healthcare Centre (rehabilitation nurse/physiotherapist) or the Hospital (cardiac nurse/physiotherapist) (Table 2) who followed the monitoring of the patients and interacted with them throughout the telerehabilitation period (three months). The nurse was the patient’s contact person and had the overall responsibility for the CR, and the physiotherapists specifically focused on walking activity and exercise.

The patient's personal rehabilitation plan was displayed on the tablet computer in a PHR (Figure 2), which both the health professionals and the patients had access to and used for communication.

Figure 2. Patient's PHR.

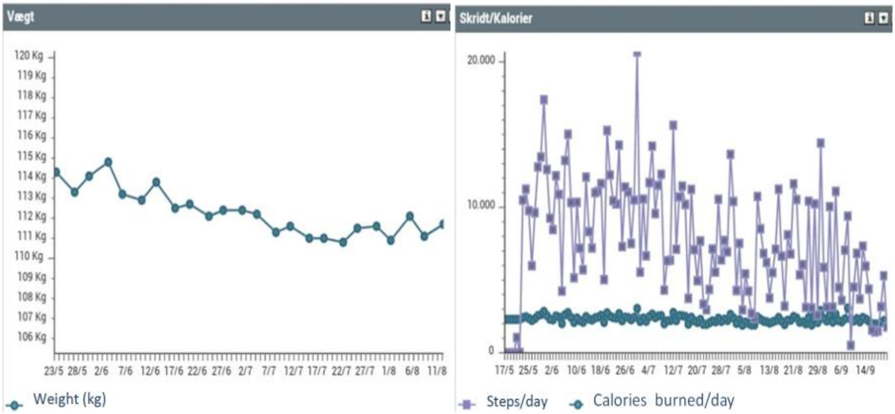


An example of a patient's PHR as it was displayed on the patient's tablet computer. The left hand side shows the diagnosis, the aims and status of CR and the data from measurements. On the right hand side, the patient's appointments, contact person and notes and communication from the patients or the health professionals (nurses or physiotherapists) are shown. Marked with red are the patient's goals for steps and the actual steps walked.

The patients measured their pulse, blood pressure and weight twice a week. Deviation from the standard measurements was only made when advised by cardiologists or cardiothoracic surgeons. Steps were measured every day and were continually visible on the step counter's display. Each day at midnight, all data (incl. step data) were downloaded into the patient's PHR. All patients had personal goals for daily steps and were able to view their own walking activity.

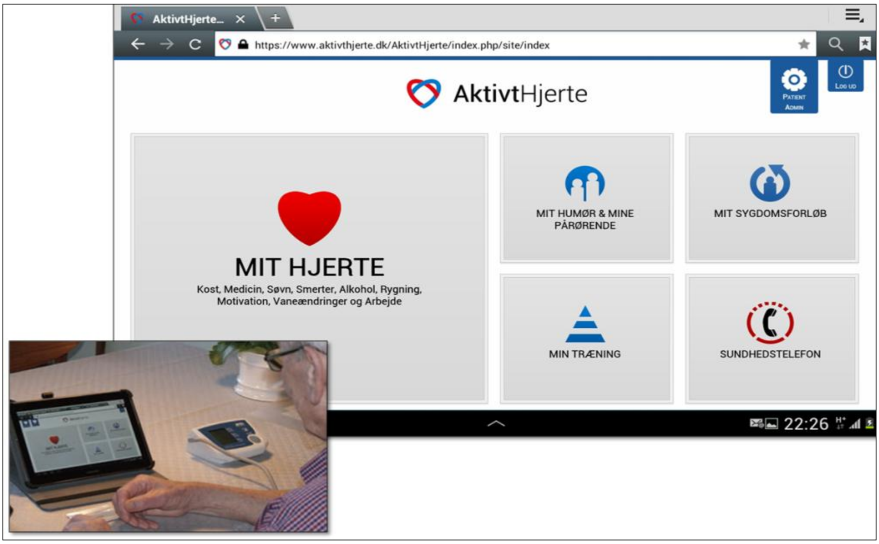
In the PHR, the rehabilitation nurses and physiotherapists wrote encouraging notes and gave feedback to the patients regarding their rehabilitation and walking activities. Furthermore, the patients and their relatives were provided access to a digital toolbox (Activeheart.dk) that contained videos and written information on CR topics (cardiac diseases, physical activity, psychological issues, sleep, other cardiac patients' experiences of living with the disease and exercise videos for patients with or without surgery).

Figure 3. Patient weight curve and daily steps displayed on the PHR.



On the left hand side, a patient's three-month weight curve is displayed, and on the right, the same patient's walking activity over a period of 4 months is displayed (with calories burned).

Figure 4. Activtheart.dk.

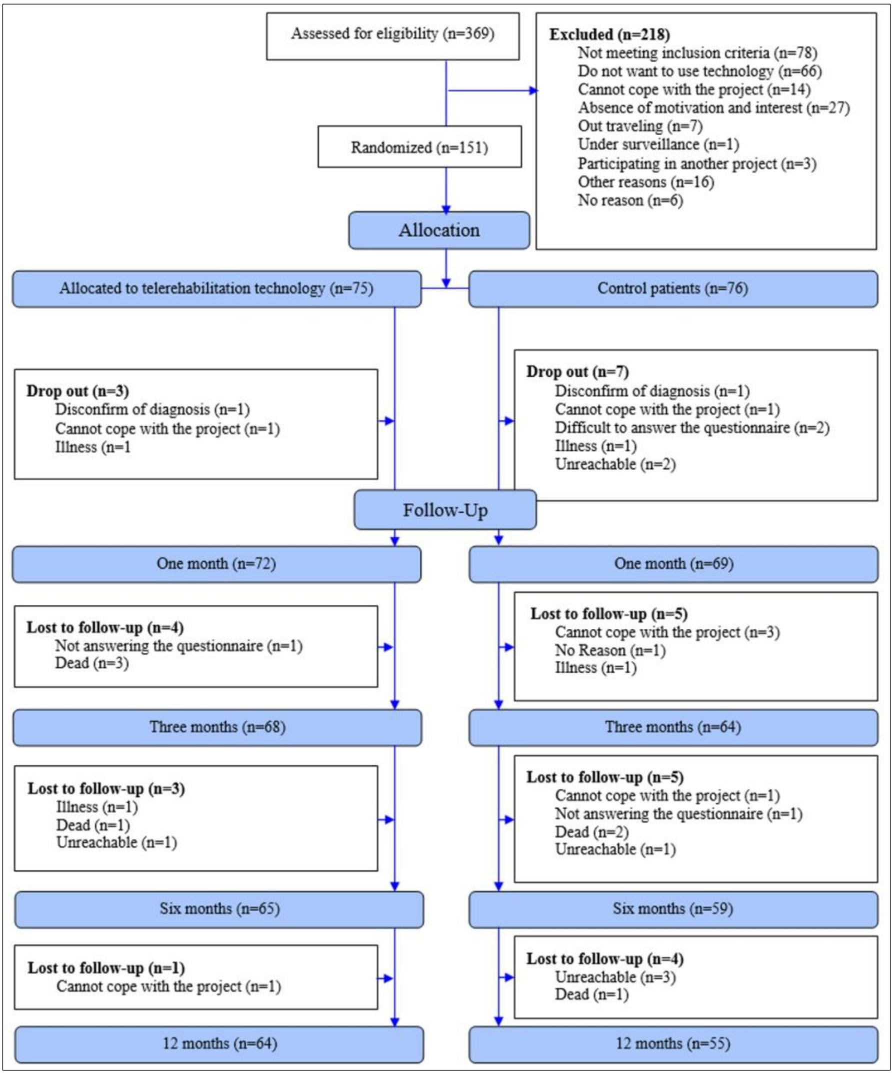


The display of Activeheart.dk showed a digital toolbox with access to information sorted by headings.

The monitoring period was three months, and the research follow-up period was 12 months. In that period, the patients maintained access to Activeheart.dk and kept the Zip; thus the monitoring of steps continued for 12 months.

A total of 151 cardiac patients participated. Of these, 72 were included in the intervention group that received the telerehabilitation technologies, and 79 were in a control group that received traditional CR. Figure 5 displays the consort diagram of Teledi@log.

Figure 5. Teledi@log consort diagram.



The research conducted in this PhD focused on the part of Teledi@log that concerned walking activity and step counters as a component of CTR. In the following sections, the state of the research on walking activity and step counters is presented.

1.4. WALKING AS PHYSICAL ACTIVITY

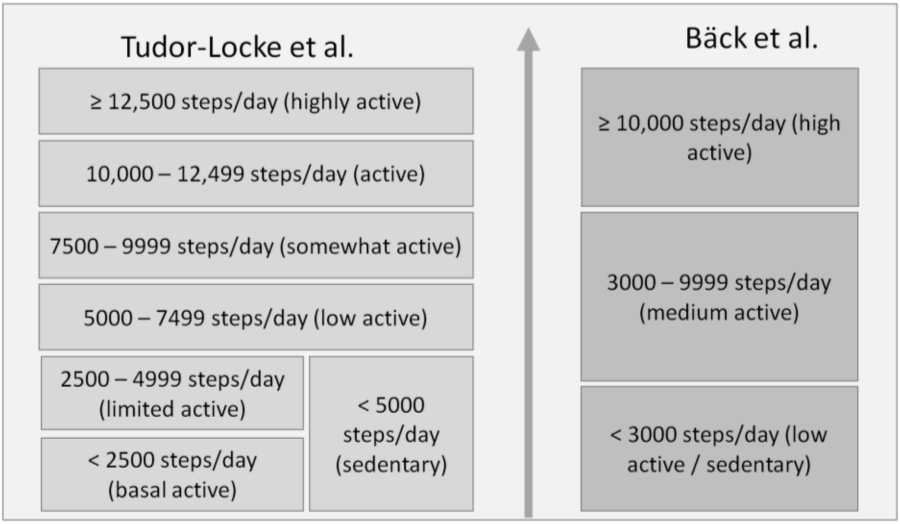
Walking is a simple, low cost and low injury risk form of physical activity (32) that forms a large part of daily activity in both sedentary and active individuals (33,34). Walking may be accessible and appropriate to a population who may be obese, sedentary or at risk of cardiovascular disease (35). Evidence suggests that even a small increase in the amount of daily walking is better than no walking and that greater improvements result in better fitness, body composition, blood pressure and lipid profiles; the longer term benefits include a reduced risk of cardiac disease, coronary events and mortality (33,34,36).

As a result, walking has the potential to play an important role in primary and secondary prevention of cardiovascular disease and may advantageously be included in CR (34,37). Walking is suitable for cardiac patients because it is safe and feasible for the majority of the patients and provides an alternative form of activity (37). Additionally, it has an important function in resuming work and daily life (37).

It is expected that healthy adults have a baseline level of activity of 5,900 – 6,900 steps per day (38), and research suggests that the recommended 30 minutes of physical activity at moderate intensity at the least is accomplished if an individual's total daily steps reaches 10,000 (23,25). A rate of approximately 100 steps per minute is considered to represent moderate intensity activity (or 3,000 steps in 30 minutes), and approximately 130 steps per minute is similar to vigorous intensity activity (3,250 steps in 25 minutes) (38,39). The target of 10,000 steps per day is a result of adding the baseline level of activity to the 30 minutes of moderate intensity activity, or 25 minutes of vigorous intensity activity, recommended. A review on step counter-determined walking activity in healthy older adults and in special populations revealed that healthy older adults walked an average of 2,000 – 9,000 steps per day and that special populations walked an average of 1,200 – 8,800 steps per day (40); this indicated a broad range in steps per day.

Tudor-Locke et al. (40) has proposed a graduated step index to describe step counter-determined habitual physical activity in adults (displayed in figure 6). Another index has been presented by Bäck et al. (41), who proposed a broader step index for step counter-determined physical activity in cardiac patients (displayed in figure 6).

Figure 6. Graduated step index.

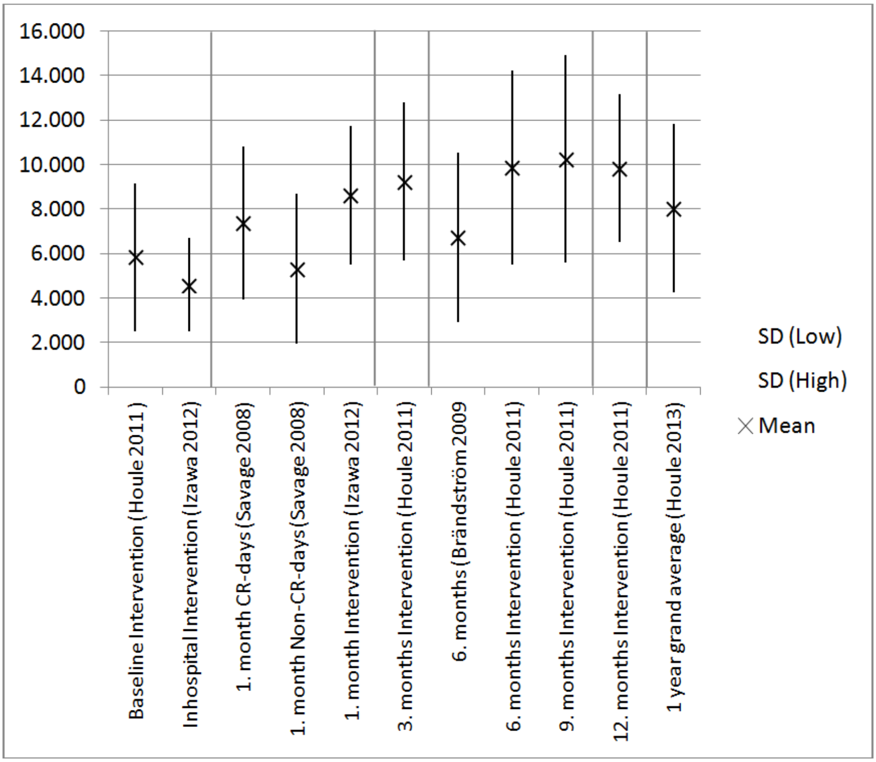


Joint display of graduated step index to describe step counter determined habitual physical activity in adults (Tudor-Locke et al.) and for cardiac patients (Bäck et al.)

The use of step counters can provide insight into daily physical activity in a performance-based manner and may offer information about the intensity, duration, and frequency of CR activity and adherence to CR (23). In clinical settings, step counters have been used to observe activity and provide feedback and as a motivational tool to support physical activity (42–44). Step counters seem suitable for verifying whether the user achieves expected objectives for personal physical activity level (43).

There is a lack of consensus regarding how many steps cardiac patients walk during the period up to one year after a cardiac event (45,46). A one-year follow-up is considered relevant because sustained behavioural changes require a long observation period (47). In an attempt to increase patients' physical activity, it is important to identify realistic and appropriate goals (33,48–50). Six studies have been identified that explore the amount of walking by patients with cardiac disease (33,41,45,46,48,51,52), and these studies show diverse results. Despite devirsity in measurement methods, step counters and population a detailed overview of the six studies can be observed in Appendix A, and step measurements from five of these studies are displayed in figure 7. The study by Bäck et al. is not displayed in figure 7 because they measured the median and interquartile range and not the mean and SD.

Figure 7. Cardiac patients walking activity (from literature) mean (±SD) steps/day.



Joint display of the mean (±SD) steps/day for comparable studies at different times over one year. Baseline (or inhospital) and at one, three, six, nine and 12 months. Houle 2013 only measured the mean for the whole year.

These studies reveal that cardiac patients while in the hospital walked an average of 4588-6037 steps per day (45,53). At one month after discharge, patients who continuously used pedometers walked 8609 steps per day on average, compared with the 5512 steps per day in patients with no pedometers (53). Three months after discharge, cardiac patients who had received a behaviour change intervention walked an average of 9234 steps per day, compared to 7972 steps/day in a control groups (45). Six months after discharge, the behaviour change intervention group walked 9856 steps per day compared to 6980 steps per day in the control group (45). Two studies without any intervention found that cardiac patients walked a median of 7027 steps per day (41) (Back 2012) and 6719 steps per day (51) after six months. At nine months, Houle et al. determined that the patients who received a behaviour change intervention walked an average of 10261 steps per day compared to 7591 steps per day in the control group (45). At 12 months, patients in the intervention group walked 9850 steps per day, while the control group on average walked 7970 steps per day (45).

In summary, there is a tendency towards higher walking activity in cardiac patients who receive an intervention compared to control groups, and walking activity increases over one year. For health professionals who want to encourage change in physical activity, it is important to identify realistic and appropriate goals. Despite that fact, only these six studies were identified concerning the amount of walking activity done by patients with cardiac disease. Thus, further studies on cardiac patients' walking activity are needed.

1.5. STEP COUNTERS

The new and evolving movement of the Quantified Self is a trend in which technology is used to monitor aspects of a person's daily life regarding different inputs (e.g., food consumed), states (e.g., mood, arousal), and performance (mental and physical) (54). It can be described by the phrase "You are your data," and it aims to improve various aspects of life and health through recording and reviewing daily activities (55). Self quantifiers are expected to not only collect personal health measurements but also to transform these data into actionable knowledge that support health management activities (54,56). The Quantified Self movement supports the principles of user knowledge and engagement and can be used in health care to create knowledge and potentially improve patient participation in ambulatory health care (57).

Step counters such as wearable pedometers and accelerometers are self-quantification activity monitors that are designed to track steps and/or physical activity and are used in CTR programmes (27). Reviews on step counter-based programmes have shown a positive effect on walking behaviour and a reduction in cardiovascular risk factors, such as a significant decrease in weight (58,59) and systolic blood pressure (60).

In HF patients, step counters as part of CTR have supported an increase in activity (53) and adherence to exercise (49) up to one year after the HF event (45,61). In patients with CAD, a pedometer-based programme on physical activity revealed an improvement in average steps per day, a reduction in waist circumference and an improved lipid profile in one year after an acute coronary syndrome (45,46). Sangster et al. (59) reported that pedometers as part of CTR were both feasible and effective in increasing physical activity. Defining a realistic step goal and monitoring step achievements are key motivational factors in increasing physical activity (42,43). In that sense, the ability of step counters to provide feedback seems important; however, there is a lack of knowledge about cardiac patients' adherence to and use of step counters during CTR. Thus, further studies on walking activity and use of step counters are needed.

Step counters have been increasingly used for research in clinical settings and in laboratories, and they may be categorised into different groups: pedometers, accelerometers and integrated multisensory systems (62).

Pedometers often use a lever-arm technology. Lever-arm pedometers have an electrical circuit that switches on and off, activating a digital counter. This is accomplished by using a spring-suspended horizontal lever-arm that moves up and down during walking, which creates an electrical contact (circuit) and thus adds steps to the counter (62–64). Lever-arm pedometers respond to vertical movements (i.e., up and down motions) of the hip (62).

Accelerometers measure acceleration, which is change in speed with respect to time (65). Most accelerometers use piezoelectric sensors that generate an electric voltage when compressed and detect acceleration(s) in one to three orthogonal planes (anteroposterior, mediolateral and vertical) (65). When using accelerometers to measure physical activity, raw acceleration signals can be transformed into speed and distance, making it possible to calculate the step values and the intensity, frequency and duration of physical activity (62,63,65). Most accelerometers have enough internal memory to store data for several weeks (64).

Integrated multisensory systems provide another option to measure activity that combines accelerometers with other sensors that capture body responses to exercise e.g., heart rate or skin temperature (62,65) or inclinometers and gyroscopes (44). Gyroscopes provide knowledge on the angular velocity; in combination with accelerometers, these can be useful for assessing rotational movement (66). Integrated multisensory systems are increasingly used and may be used as a criterion standard to validate cheaper and simpler monitors, such as pedometers and accelerometers (Chen & Bassett 2005).

The acceptance of step counters in research and clinical settings has been limited by the little scientific evidence regarding their reliability and validity. Their reliability is subject to technical (i.e., problems in capturing signals and processing data) and human-related (i.e., altering of the position of the device) sources of error (67).

The accuracy of step counters has typically been studied in controlled conditions and by healthy adults, i.e., on a treadmill (Ryan et al. 2006; Takacs et al. 2014; Beevi et al. 2015). Although treadmill walking cannot represent normal walking patterns, there seems to be some advantages of treadmill tests, as they provide the possibility of determining inaccuracy at different walking speeds, durations, cadences and distances.

Step counters seem to underestimate the steps taken when walking slowly (74), and the accuracy of step counters in chronic disease populations is lacking; thus, validation studies in these populations are needed to justify their use in clinical trials and clinical settings (62).

Fitbit step counters have received considerable attention (58,69,71–73,75–78). The counter used in Teledi@log was the Zip step counter. The Fitbit Zip is a wireless battery-driven step counter capable of displaying steps, distance, calories burned and active minutes. Activity is visible on the Zip´s display and on a computer/smart phone. To support accurate measurements, users upload personal data such as age, gender, weight and height to the Zip. The Zip uses a three axial accelerometer, and the raw acceleration signals are converted into indicators of physical activity (e.g., steps) using mathematical formulas unknown to the user. Tully et al. (76) recommended the Zip as a valid activity monitor in measuring free-living physical activity in healthy adults, and Ferguson et al. (77) found high step accuracy in 24-hour real-life studies on healthy subjects. On the other hand, Beevi et al. (73) showed a high step error rate of the Zip at slow speeds (1 - 3 km/h). However, no studies have examined the step accuracy of the Zip on treadmills at normal speed or as a real-life study among cardiac patients.

In addition to the need for step counter studies with a focus on increases or decreases in step activity (33,45,46,51), there is a lack of knowledge on patient experiences with step counter use as a source of motivation for physical activity. Indeed, the motivational aspects of how to motivate cardiac patients to initiate and maintain satisfactory levels of physical activity after a cardiac event are needed.

The Teledi@log trial used the SDT to develop support for these motivational aspects.

1.6. SUMMARY

In summary, cardiac patients may benefit from CR, but only a small proportion of the patients receive the intervention. Exercise plays a central role in CR by reducing risk factors and enabling positive behavioural outcomes. Despite those benefits, only half of cardiac patients participate in regular exercise up to 18 months after a cardiac event. By using telerehabilitation technologies, Teledi@log intended to increase both attendance to CR and long-term adherence to recommendations. In addition, Teledi@log aimed to offer individualised rehabilitation that took place in patients' homes and in their natural environment. As walking has the potential to play an important role in secondary prevention of cardiovascular disease, the step counter Zip was implemented as a self-monitoring technology in Teledi@log using the SDT as the theoretical framework for motivation.

Research suggests that the Zip is an appropriate technology to use in clinical settings and in research. However, its accuracy needs to be determined at normal speeds on treadmills and in real life among cardiac patients. There is a lack of consensus on how many steps cardiac patients take during the period up to one year after a cardiac event; therefore, critical knowledge for suggesting realistic and appropriate goals for patients' daily steps in CTR is lacking. Moreover, no studies have explored patients' and health professionals' experiences with self-determined motivation for walking when using the step counter Zip in a CTR programme. Therefore, this doctoral research provided new knowledge on step counter accuracy, cardiac patients' walking activity and self-determined motivation for walking in CTR.

1.7. PURPOSE OF THE RESEARCH

The overall aim of the research presented in this thesis was to determine the accuracy of the step counter used in the Teledi@log (Study 1) and to create new knowledge on cardiac patients' walking activity after a cardiac event (Study 2). Furthermore, the aim was to explore self-determined motivation for walking as experienced by cardiac patients and health professionals when using a step counter as a part of a CTR programme (Study 3).

Study 1

The purpose of study 1 was two-fold:

a) To investigate the accuracy of the step counter Zip in measuring steps taken by healthy adults during treadmill walking (treadmill study). It was hypothesised that a Zip step counter would have a step-count error of ≤ 3%, compared to a gold standard, when tested by healthy adults on a treadmill.
b) To use the same motion measurement equipment to investigate the accuracy of the Zip in measuring steps taken by cardiac patients both at the hospital and in the patient's home (real-life study).

Study 2

The purpose of Study 2 was to explore cardiac patients' walking activity. The walking activity was analysed in relation to the numbers of steps taken and the duration of step counter use to determine the correlations between walking activity, demographics, and medical and rehabilitation data.

Study 3

The purpose of study 3 was to explore step counter use and self-determined motivation for walking during a CTR programme from the patients' and health professionals' experiences.

CHAPTER 2. RESEARCH METHODOLOGY

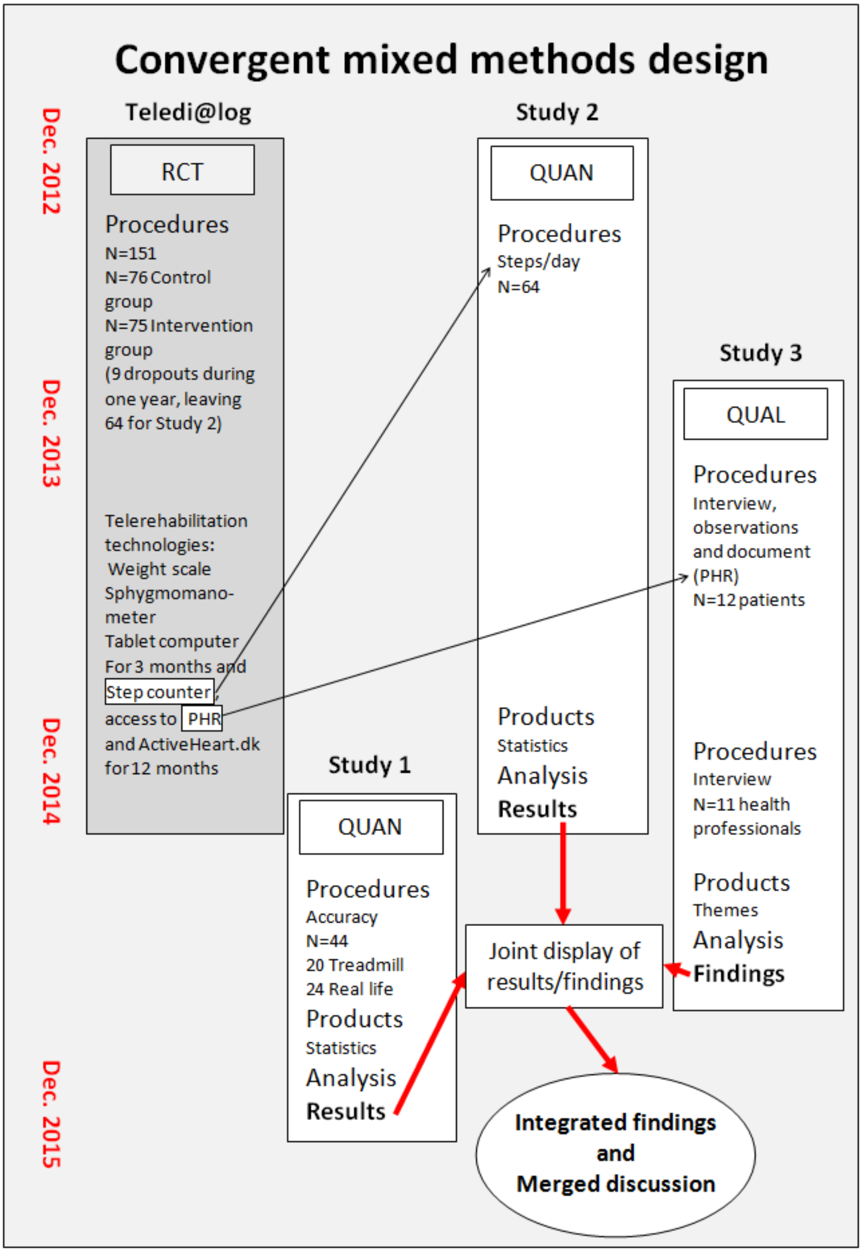
In this section, the research methodology is described followed by the description of the material and methods of the three studies. The motivational theory of SDT is presented as the theoretical framework for study 3.

2.1. MIXED METHODS

This research used a mixed methods approach. Using both quantitative and qualitative methods in the same study made it possible to provide a more comprehensive understanding of the accuracy of the step counter, cardiac patients' walking activity and participants' personal experiences with step counter use than with either method alone (79–82). The mixed methods approach was inspired by a convergent mixed methods design (79,81). Thus, the collection and analysis of both quantitative and qualitative data were performed separately. The quantitative results and qualitative findings were first presented separately and then merged into a joint display with the aim of discovering integrated findings from the three studies. These integrated findings framed the structure of the merged discussion (79,81). A joint display is a technique used to integrate and identify new insights beyond the information gained from the separate quantitative results and qualitative findings (82). In this research, the integrated findings led to a more comprehensive understanding.

The main part of this PhD study was performed concurrent with the Teledi@log study, as some of the data were derived directly from the intervention group in Teledi@log. Studies 1 and 2 were quantitative (QUAN) and study 3 was qualitative (QUAL). The mixed methods design is displayed in Figure 8.

Figure 8. Mixed methods design.



Convergent mixed methods design. The black arrows show the data from Teledi@log that were directly used in study 2 or 3. The red arrows show the results that created the joint display followed by a merged discussion. RCT: Randomised Controlled Study, QUAN: quantitative study, QUAL: Qualitative study, PHR: Personal Health Record.

Study 1 validated the Zip's accuracy and was originally planned to be conducted first. However, the design of a separate study protocol and the application to The North Denmark Region Committee on Health Research Ethics delayed the study. As such, study 1 was conducted last. Mixed method researchers recommend the use of the same participants in the different studies (79,83). This did not occur in Study 1, as the participants did not participate in Teledi@log because including an accuracy study during the intervention period might have biased the outcomes of the Teledi@log trial by placing an uneven emphasis on step counters compared to the other telerehabilitation technologies. Furthermore, healthy volunteers were needed for the treadmill part of Study 1.

Study 2 used baseline data (age, gender, body mass index (BMI) primary diagnose/treatment) and step data from the patients in the Teledi@log intervention group. Thus Teledi@log framed the timeline for Study 2.

For Study 3, a selected group of patients from the intervention group in Teledi@log and notes from their PHRs were chosen in addition to a selected group of health professionals involved in Teledi@log. The time frame was divided in two because the data collection of patients was conducted *during* the Teledi@log trial and the data collection of health professionals was conducted *after* the termination of the intervention period of Teledi@log. This time frame was chosen because it was expected that the patients would provide rich descriptions if they participated approximately one month after the three-month telerehabilitation period. Health professionals were considered to have been the most experienced in motivating patients to use step counters in CTR after the Teledi@log trial had been terminated. Thus, they participated in Study 3 at that time.

The mixed methods convergent design used in this research allowed the results of the accuracy study (Study 1) to be combined with the results from the study of walking activity (Study 2) in an attempt to provide a comprehensive understanding of cardiac patients' walking activity determined by a (more or less accurate) Zip. Furthermore, the design allowed for patients' and health professionals' experiences with the step counter (Study 3) to be displayed and discussed jointly with the results of both the accuracy study and the study of walking activity.

2.2. MATERIAL AND METHODS

2.2.1. STUDY 1

Participants

The sample size calculation was based on a significance level of 0.05 with a 90% power to identify a mean difference of 3% between the treadmill study and the real-life study. Furthermore, a standard deviation (±SD) calculated from an accuracy study by Park et al. was used (78). Thus, 19 participants were targeted to be included, both in the treadmill study and the real-life study.

Treadmill study

From November 2014 to January 2015, a sample of 20 healthy participants, recruited among voluntary employees at the Aalborg University Hospital, were included. The inclusion criteria were: an age ≥18 years, a self-judged general good health status, ability to walk and run on a treadmill, and the ability to understand verbal and written information. Persons who required a walking aid, were pregnant and/or breastfeeding were excluded.

Real-life study

From February to August 2015, a sample of 24 cardiac patients participated (11 patients from the Department of Cardiothoracic Surgery and 13 from the Department of Cardiology at Aalborg University Hospital, Denmark). The inclusion and exclusion criteria were the same as in the Teledi@log trial (Table 1) to achieve a similar group of participants as in Studies 2 and 3. Thirty-nine potential participants were approached, and 33 agreed to participate. Of these, eight withdrew their consent after the first 24-hour test due to a lack of interest in completing the study. One was discharged from the hospital before completing the test; thus, 24 patients completed the study.

Procedure

Treadmill study

All 20 participants carried four Zips in elastic belts, two Zips at heart level on the upper body and two at the waist, and a Shimmer fastened on an elastic belt on the lower left leg (Figure 9). The Shimmer 3 (Shimmer), a wireless integrated multisensory system (Shimmer Research, Dublin, Ireland), was used as the criterion standard for the measurement of steps (84,85). It contained a tri-axial gyroscope and accelerometer.

Figure 9. Placement of the Zips and Shimmer during the treadmill test.

Picture 1: Placement of the four Zips. Picture 2: Shimmer3 with gyroscope range displayed in x, y and z directions (86). Picture 3: The Shimmer was placed in an elastic band on the ankle with the orientation of the gyro Z-axis perpendicular to the sagittal plane on the participant's left ankle. Picture 4: Placement of the Shimmer during treadmill walking.

All participants walked for three minutes at ten different speeds, increasing from an expected speed of 1.5 km/h to 6 km/h (an increase of 0.5 km/h between each test). A speed test of the treadmill revealed a difference between the expected treadmill speed (visible on the treadmill display) and the precise speed (measured by recording the running treadmill during the tests); thus, the precise speeds were from 1.7 km/h to 6.1 km/h.

Real-life study

Twenty-four hospitalised patients were asked to wear the Shimmer on their ankle (as in the treadmill study) together with a Zip placed at their waist (left or right side depending on their own choice). Placement of the Zip at the waist and not the upper body was chosen because it was expected to be easier for the participant; the treadmill revealed similar accurate step recordings between the waist and the upper body. The patients wore the Zip and the Shimmer for a time period of 24 hours (TP24h) except for when bathing and swimming. The study took place at a mean of 4.3 [range 1-10] days after admission/surgery. This study was repeated in the patients' homes four weeks after the hospital test (mean: 28.2 days [range 26-31]).

Before the treadmill and real-life tests, participants' weight, height, age and sex were uploaded to each of the Zips.

Time periods of three minutes (TP3min) with evident walking activity were selected for each patient for every 24-hour measurement to directly compare step accuracy between the real-life study and the treadmill test.

Methods

Descriptive statistics were expressed as the mean ± SD. The accuracy of the step counter was determined as relative error scores. For the treadmill test, two relative error scores were measured for each participant at each speed, one for the upper body step counters and one for the waist step counters, using the following formula: E_{rel}: $\frac{\left(\frac{Fitbit1+Fitbit2}{2}\right)-Shimmer}{Shimmer} \times 100$, an Intraclass Correlation Coefficient (ICC) to assess the level of agreement between Shimmer and the Zips.

To compare the TP3min directly with the treadmill study, the walking speed of the TP3min was needed. To measure walking speed (numbers of steps × step length (km)/time(h)) in the TP3min, a determination of each patients' step length was made using the following formula: 0.228 – 0.002 × age + 0.370 × height – 0.043 × gender (87).

2.2.2. STUDY 2

Participants

A total of 151 cardiac patients participated in Teledi@log. Of these, 72 composed the intervention group. Eight of the patients in the intervention group dropped out in the following year (four died, one had a severe progression of illness, one was unreachable at follow-up, and two could not cope with or answer the questionnaire in the project), leaving 64 patients in the step counter study (Figure 5).

For the statistical analysis, each patient's step data were downloaded onto a secure database at intervals of one minute for 365 days from the day of inclusion.

Procedure

All 64 patients from the Teledi@log intervention group were provided with a Zip step counter. They were asked to wear the Zip for all waking hours (except for bathing and swimming) for at least three months after hospital discharge and up to one year. Furthermore, the patients were encouraged to wear the Zip in their breast pocket or at their waist, in accordance with the manufacturer's suggestions (88).

Before use, the Zip was programmed with the patient's date of birth, gender, weight and height to ensure accuracy of the step counts obtained.

The Zip had the potential to display steps, distance, calories burned and active minutes. In Teledi@log, only the steps were visible on the Zip's display, and in the patients PHR, both steps and calories burned were displayed. These variables were selected to enhance the focus on the steps walked.

Methods

Means ± SD are presented for continuous variables, and proportions (%) for categorical variables.

Steps per day were measured as the grand mean for every patient and a weekly mean at week 1 (around day 7), week 4 (around day 30), week 12 (around day 90), week 24 (around day 180), week 36 (around day 270) and week 52 (around day 365) after the starting day. The graduated step index presented by Bäck et al. (41) (Figure 6) was used to categorise patients into groups of low, medium and high activity.

The duration of step counter use was measured as *total days*, counted from the starting day to the final day of step counter use. The final day was determined as the last day of ≥ four consecutive *active days*. Active days were defined as days with more than 100 steps/day.

The associations between the groups and baseline characteristics were tested using one-way ANOVA for continuous data and Fisher's exact test for categorical data. In the case of a significant difference, a post hoc Bonferroni test was performed. For non-normally distributed continuous data, a Kruskal-Wallis test was conducted (days and total days), and a *t*-test was performed for the gender-sorted grand mean of steps walked. To test for an association between the mean number of steps walked and the termination of step counter use, a repeated measures logistic regression analysis was carried out. All tests were considered statistically significant at $P<.05$.

For both Study 1 and 2, MATLAB release 2014b (MathWorks, Natick, MA, USA) and STATA version 13.1 (StataCorp, College Station, TX, USA) were used for the statistical analyses.

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2.2.3. STUDY 3

Participants

Study 3 was a qualitative study that consisted of participant observations, individual interviews of patients and health professionals and documents from the patients' PHR (89–94).

The participants consisted of 12 patients from the Teledi@log trial, 11 health professionals, six physiotherapists and five registered nurses (RN) responsible for the CTR in the Teledi@log trial. Patients were observed twice, focusing on their usage of the step counters, and they were interviewed once to investigate how they experienced their use of the step counter during and after the monitoring period.

The patients were consecutively selected from the Teledi@log trial from June until September 2013.

The health professionals were purposefully selected for being the most experienced in promoting motivation using a step counter and included all health professionals participating in the Teledi@log trial. The interview was performed after the termination of the Teledi@log trial (August - September 2014) to understand their experiences with using a step counter as a motivation tool for patients' walking activity (93,94).

The documents consisted of written digitalised communication between the patients and the health professionals that was derived from the PHR (91,92), focusing on communication concerning the step counter and the patients' physical activity.

Procedure

Patients

The first participant observation period took place two weeks after discharge, and the second observation period occurred three months later. The observations focused on the patient's mnemonic strategies for using the step counter, the step counter's placement on the body, and the patient's ability to view walking activity on the step counter display and in the PHR. The time span between the two observation periods made it possible to focus on the patients' achieved routines for step counter use at the second observation. The observations lasted from 30 to 45 minutes. They were digitally recorded immediately after each observation and transcribed verbatim before conducting the patient interviews.

The interviews took place at the patient's home one month after the second observation period, as this time frame was considered appropriate for investigating the patients' experiences using the step counter during and after the monitoring period (91,93). The interviews were based on a semi-structured guide (Appendix C) that was inspired by the SDT (93,95), events from the observations and notes from the PHR (91,92). The interviews lasted between 45 and 75 minutes. The analysis of the transcribed interviews demonstrated that a satisfactory level of saturation had been reached (96), and no further interviews were conducted.

Health professionals

The interviews focused on health professionals' experiences using a step counter as a motivational tool for activity. The interviews were based on a semi-structured guide (Appendix D) inspired by the SDT [(93,95) and notes from the PHR (91,92). The interviews lasted approximately 20-35 minutes and were digitally recorded and transcribed verbatim.

Documents

Notes from the PHR were used as data for the independent analyses and as preparation prior to the interviews of both patients and health professionals

Methods

Data were analysed using deductive content analysis (90) with the SDT as the framework for analysis. In addition to the deductive approach, data were sought for spontaneous issues raised by the participants. The units of analysis (data) were transcribed text from the observations and interviews and notes from the PHR (documents) (89,90).

All data were organized using the software package Nvivo10 (Nvivo qualitative data analysis software; QSR International Pty Ltd. Version 10, 2014).

2.2.4. SELF-DETERMINATION THEORY

The SDT was the theoretical framework for motivation in the Teledi@log project. Behavioural change is needed for sedentary people to increase their levels of physical activity, and for that reason, motivation seems essential (97,98). In the physical activity literature, SDT has received much attention because it provides a theoretical framework of long-term motivation for behaviour change in exercise and physical activity (47,99–101). Physical activity recommendations, grounded in the SDT, have increasingly been implemented in research and in real life (47,100–104).

The Self-Determination theory is a meta-theory consisting of sub-theories that include individual differences, contextual relationships and interpersonal perspectives in human behaviour and motivation.

A central sub-theory in the SDT is the organismic integration theory that describes how individuals integrate behaviours and incorporate them into their repertoire of conducts and their personal behaviour system (101).

Fundamental to the organismic integration theory is the distinction between self-determined or *autonomous* forms of behaviour relative to non-self-determined or *controlling* forms of behaviour (101). Motivation lies along a continuum composed of varying degrees of self-determination including amotivation and extrinsic- and intrinsic motivation (102,105,106), as displayed in figure 10.

Figure 10. The self-determination continuum

Behaviour	Nonself-determined					Self-determined
Type of Motivation	**Amotivation**	**Extrinsic Motivation**				**Intrinsic Motivation**
Type of Regulation	Non-regulation	External Regulation	Introjected Regulation	Identified Regulation	Integrated Regulation	Intrinsic Regulation
Locus of Causality	Impersonal	External	Somewhat External	Somewhat Internal	Internal	Internal

The self-determination continuum, showing the motivational, self-regulatory, and perceived locus of causality bases of behaviour that vary in the degree to which they are self-determined. From Deci and Ryan: “The ‘What’ and ‘Why’ of Goal Pursuit. Human Needs and the self-Determination of Behaviour” page 237 (106).

The self-determination continuum, also known as the perceived locus of causality, includes one autonomous form of motivation (*intrinsic*) and two relatively autonomous forms (*integrated* and *identified*). On the other side of the continuum, two relatively controlling forms of motivation are presented (*introjected* and *external*) along with *amotivation* at the non-self-determined end of the continuum (101,106).

Amotivated individuals will engage in a behaviour without feeling any motivation, or they will show no interest in performing a behaviour (102,105). At the less self-determined end of the motivational continuum are the external and introjected regulations. External regulation refers to the desire to obtain external rewards, avoid punishments or fulfil the expectations of others (95), and introjected regulation is caused by a wish for intrapersonal rewards (e.g., pride) or by avoiding self-inflicted punishments (e.g., guilt or shame) (95).

At the more self-determined end of the motivational continuum is identified regulation, which refers to the individual's recognition of the importance of the changed behaviour (behaviour is accepted as personally important, i.e., acknowledging health benefits), and integrated behaviour, in which behaviour is fully assimilated and included in the person's self. Completely autonomous is the intrinsic motivation that involves motivation derived from the pleasure and satisfaction of performing the behaviour itself (101). Motivation at the most intrinsic end of the continuum seems to form more sustained behaviour (95,105,106). Internalisation is the process of gradually transforming external motivation into more intrinsic motivation performed with a feeling of autonomy and self-determination (102)

Another central sub-theory in the SDT is the basic needs theory (101), in which an individual's autonomous motivation is described as depending on the fulfilment of three basic psychological needs: a*utonomy* (choice, volition and freedom), *competence* (confidence in being able to perform a behaviour and achieve a desired goal) and *relatedness* to other humans (positive, warm relations) (95,105). These needs are fundamental and shape human behaviour (98,101). The three needs are complementary, meaning that fully integrated behaviour can only appear if all three psychological needs are supported (101).

A systematic review by Teixeira et al. (47) provided evidence for the use of the SDT in understanding and promoting exercise behaviour. Across a range of samples and settings, the review showed that all forms of autonomous regulation predicted exercise participation and sustained exercise behaviours over time (47). Furthermore, exercise participation with others (relatedness), such as social engagement and challenges, seemed to be associated with greater exercise participation, and a person's feeling of increased perceived competence for exercise was also positively predictive of more adaptive exercise behavioural outcomes (47). It seems that the SDT has the potential to explain thus far unrevealed aspects of motivation in relation to step counter-based walking activity in cardiac patients in a telerehabilitation programme.

2.3. ETHICAL CONSIDERATIONS

The Teledi@log project was approved by The North Denmark Region Committee on Health Research Ethics (N-20120051) and was registered at ClinicalTrial.gov: NCT01752192.

Study 1 was independently presented to The North Denmark Region Committee on Health Research Ethics on the 14th of August 2014. The committee responded by stating that the study seemed outside the ethical committee's area of concern and did not require approval.

All three studies followed the principles as outlined in the Declaration of Helsinki. As such, the nature of the studies was explained in writing and orally to the participants, and all participants signed a written informed consent. Furthermore, all participants were ensured of their anonymity and confidentiality. The participants were advised that participation was voluntary and that they could withdraw consent at any time.

All step data and interview text were stored in password-protected databases either at Aalborg University Hospital (baseline data and observation/interview text from Study 3) or Aalborg University (baseline data and step data from Zip/Shimmer in Study 1 and 2). Only persons from the Teledi@log research team had access to the databases. Identifiable information (names, addresses, social security numbers, illnesses, etc.) was removed from the data for the analysis.

In the presentation of the interview text, all participants' names are replaced by pseudonyms (Appendix 5).

It was considered ethical, liable and without any predictable technical risk to participate in Study 1 because the Zip and the Shimmer3 were CE approved. The treadmill study was also considered without any risk to the participants as the treadmill (Daum Eletronic Ergo_run Premium8) was CE approved and used on a daily basis in the physiotherapist department at Aalborg University Hospital. During treadmill walking, all participants were coached and observed by a researcher at all times, and therefore it was possible to terminate the study if any inconvenience or unexpected events had occurred.

CHAPTER 3. RESULTS/FINDINGS

In the following, the results and findings of the three studies are presented separately. These sections are followed by a joint display that merges the results into four integrated findings that frame the discussion.

3.1. ACCURACY OF FITBIT ZIP (STUDY 1)

The purpose of Study 1 was to investigate the accuracy of the step counter Zip in measuring steps taken by healthy adults while walking on a treadmill (treadmill study) and to use the same motion measurement equipment to investigate the accuracy of the Zip in measuring the steps taken by cardiac patients both at the hospital and in their homes (real-life study).

3.1.1. RESULTS

Displayed in Tables 3 and 4 are the descriptive characteristics of the participants in the treadmill study and the real-life study.

Table 3. Descriptive characteristics of participants in the treadmill study.

Variable	Total (n = 20)	Men (n = 10)	Women (n = 10)
Age (years) mean(±SD)	39 (13.79)	34 (12.5)	44 (13.95)
Height (cm) mean(±SD)	184 (25.19)	195 (31,53)	172 (6.57)
Weight (kg) mean(±SD)	82 (15,4)	88 (14.6)	76 (14.25)
BMI ($kg/m^{2)}$) mean(±SD)	**26 (6)**	**27 (7.2)**	**26 (4.85)**

BMI: Body Mass Index

Table 4. Descriptive characteristics for patients in the real life study

Variable	Total (= 24)	Surgical (n = 11)	Medical (n = 13)
Age (years) mean(±SD)	67 (10.03)	66 (10.9)	67 (9.7)
Height (cm) mean(±SD)	173 (6.46)	172 (7.31)	174 (5.85)
Weight (kg) mean(±SD)	83 (10.23)	81 (10.85)	85 (9.74)
BMI ($kg/m^{2)}$) mean(±SD)	**28 (2.69)**	**27 (2.81)**	**28 (2.65)**

BMI: Body Mass Index. Surgical: surgical treatment. Medical: medical treatment.

The results from the treadmill study are shown in Table 5. The mean percent relative error (±SD) at 3.2 km/h for step counters placed on the upper body was 1.26 (5.06) and was 1.92 (12.49) for the waist step counters.

The mean error was <3%, but the standard deviation showed an unacceptably high deviation, and the ICC was 0.8746 (upper body) and 0.9114 (waist). At 3.6 km/h and at higher speeds, the mean percent relative error was < 3% with a high ICC (all > 0.9950).

Table 5. Results from the treadmill study at different speeds.

Speed	**Zip Upper body**			**Zip Waist**		
(km/h)	E_{rel}	*±SD*	*ICC*	E_{rel}	*±SD*	*ICC*
1.7	-74.74	29.18	.0839	-62.89	34.10	.0930
2.2	-31.59	44.91	.1032	-22.63	35.89	.1595
2.7	-4.54	18.62	.4331	-3.93	13.01	.8983
3.2	1.26	5.06	.8746	-1.92	12.49	.9114
3.6	-0.05	0.63	.9963	0.00	0.54	.9973
4.1	-0.17	0.44	.9977	-0.12	0.41	.9981
4.6	-0.21	0.58	.9951	-0.17	0.39	.9976
5.1	0.03	0.26	.9989	0.03	0.26	.9990
5.6	0.08	0.40	.9974	0.01	0.42	.9973
6.1	0.11	0.44	.9967	0.07	0.43	.9967

E_{rel}: Percent relative error. SD: Standard Deviation. ICC: Intraclass Correlation Coefficient. Zip Upper body: Zip placed on the upper body. Zip Waist: Zip placed at the waist

Real-life study

The results of the real-life study are shown in Table 6. The percent relative error (±SD) of the TP24h at the hospital was -47.15 (24.11) (ICC: 0.60). For the TP24h at home, it was -27.51 (28.78) (ICC: 0.87). The percent relative error of the TP3min at the hospital was -24.63 (29.95) (ICC: 0.79), and at home, it was -11.43 (15.51) (ICC: 0.96).

The real-life study indicated a high degree of inaccuracy, yet for the TP3min, the measurements were slightly more accurate.

Table 6. Results from the real-life study.

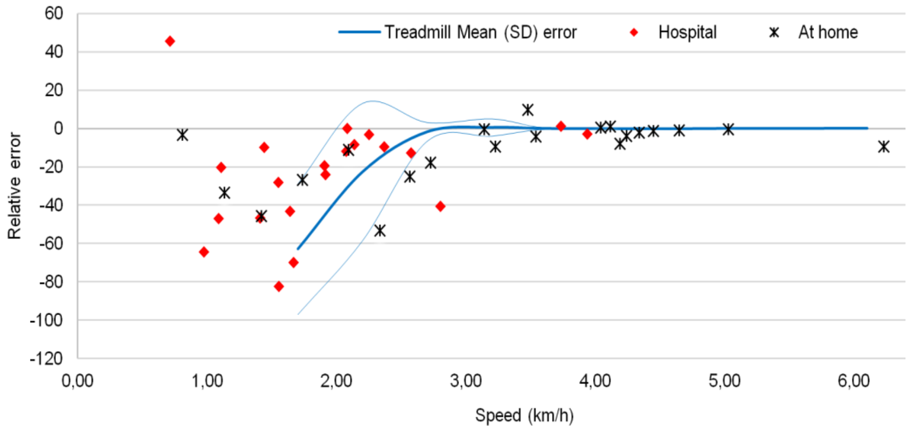
	Hospital			Home			All		
	E_{rel}	±SD	ICC	E_{rel}	±SD	ICC	E_{rel}	±SD	ICC
TP24h	-47.15	24.11	.60	-27.51	28.78	.87	-37.33	28.08	.86
TP3min	-24.63	29.95	.79	-11.43	15.51	.96	-18.03	24.52	.93

E_{rel}: Percent relative error. SD: Standard Deviation. ICC: Intraclass Correlation Coefficient. Hospital: The Zip worn by patients at the hospital. Home: The Zip worn by patients at home.

For both the treadmill and the real-life study, inaccuracy was mainly due to an underestimation by the Zip.

The treadmill study found that the inaccuracies were directly related to slow speed and that accuracy increased with increasing walking speed. The inaccuracies of the waist step counters in the treadmill study are displayed in Figure 11 together with the inaccuracy of the TP3min.

Figure 11. Relative errors of the Zip Waist on the treadmill and in TP3min in real life.



This indicates that the step accuracy in real life is most evident at high speeds. Similar to the treadmill study, at 3.6 km/h and faster, the average percent relative error was acceptable (< 3% error).

3.2. HOW MANY STEPS DO CARDIAC PATIENTS TAKE? (STUDY 2)

The purpose of Study 2 was to explore cardiac patients' walking activity. The walking activity was analysed in relation to the numbers of steps taken and the duration of step counter use and was conducted to determine the correlations between walking activity, demographics, and medical and rehabilitation data.

3.2.1. RESULTS

Patient characteristics

The patients' baseline characteristics are shown in Table 7. Twenty-two percent (14 out of 64) of the patients were classified as in the low activity group, with a mean of < 3000 steps/day, and 14% (9 out of 64) were highly active, walking ≥ 10,000 steps/day. The remaining 41 patients (64%) were medium active, walking between 3000 – 9999 steps/day.

The mean age of the entire sample was 62.8 years (range: 35 – 88 years). There was a significant difference in age between the activity groups (*P*=.01). Patients in the low activity group were significantly older than the patients in both the medium activity group (*P*=.03) and the high activity group (*P*=.02). The mean ages of the three groups of low, medium and high activity were 70.7, 61.1 and 58.2 years, respectively.

Males represented 51 of 64 (80%) of the participants. Although the less active patients' BMI was higher, this was not significant. Almost half (48%) of the patients had a primary diagnosis of ACS, and 21 patients (33%) had been treated with surgery (CABG, valve surgery or a combination of CABG and valve surgery). Eight patients (11%) had heart failure, and 8% (5 out of 64) had both heart failure and ACS.

Forty-five percent (29 patients) chose the CTR-Healthcare Centre, and 36% (23 patients) chose the CTR-Hospital. The remaining 19% (12 patients) chose the CTR-Call Centre.

Table 7. Descriptive characteristics of patients

Characteristic	All patients	Activity level (steps/day) Low <2999	Medium 3000-9999	High ≥10,000	P^b
Demographic variables					
Participants, n (%)	64 (100)	14 (22)	41 (64)	9 (14)	
Age (years), mean (SD)	62.8 (11.5)	70.7 (10.7)	61.1 (11.4)	58.2 (8.3)	.01[c]
Sex, n (%)					.29
Male	51 (80)	13 (20)	30 (47)	8 (13)	
Female	13 (20)	1 (2)	11 (17)	1 (2)	
BMI(kg/m^2), mean (SD)	28 (5.1)	29.7 (5.1)	27.7 (5.4)	27.0 (4.2)	.38
Primary diagnosis or treatment, n (%)					
ACS[a]	33 (48)	6 (9)	20 (31)	7 (11)	
Surgery[d]	18 (33)	6 (9)	12 (19)	0 (0)	
Heart failure	8 (11)	1 (2)	5 (8)	2 (3)	
ACS & heart failure	5 (8)	1 (2)	4 (6)	0 (0)	
Cardiac telerehabilitation, n (%)					.08
Health care center	29 (45)	7 (11)	20 (31)	2 (3)	
Hospital	23 (36)	3 (5)	17 (27)	3 (5)	
Call center	12 (19)	4 (6)	4 (6)	4 (6)	

[a] ACS: acute coronary syndrome; BMI: body mass index.
[b] *P* value for comparison of all three activity groups (low, medium, and high).
[c] Post hoc Bonferroni corrected values: low versus medium activity groups (*P*=.03), low versus high activity groups (*P*=.02), and medium versus high activity groups (*P*<.99).
[d] Surgery includes valve replacement, mitral valve repair, and coronary artery bypass grafting

Duration of step counter use

Two patients used the step counter for a total of 365 days each, and the overall mean (±SD) of total days of duration was 160 (100) [range: 26 – 365 days]). There was a significant difference between the low and high activity groups (*P*=.01) in total days of Zip use.

Active days comprised 139 (93%) of the 160 (87%) total days. There was a significant difference between both the low and medium activity groups (*P*=.01) and the low and high activity groups (*P*=.003) in active days of step counter use (Table 8).

Table 8. Duration of step counter use and number of daily steps displayed as the mean (±SD).

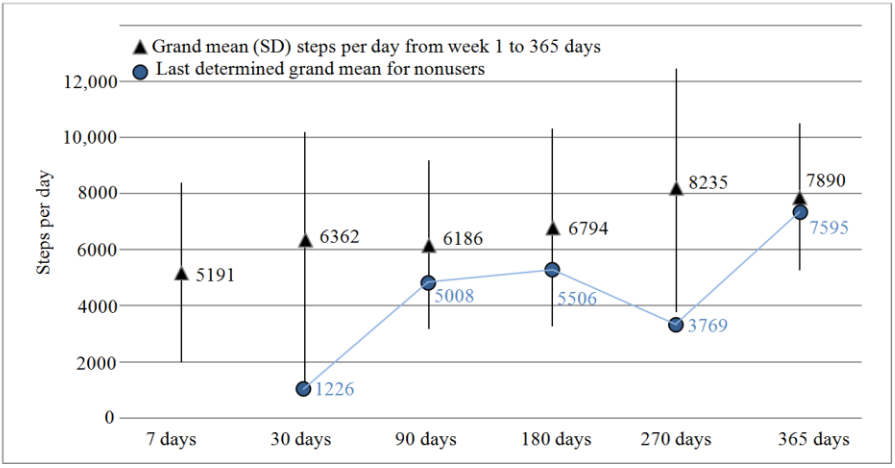
		Activity level (steps/day)			
Step counter use	**All patients**	**Low <2999**	**Medium 3000-9999**	**High ≥10,000**	***P***
Duration of use					
Total days, mean(SD)	160 (100)	109 (56)	168 (103)	208 (112)	.04[a,b]
Active days, mean(SD)	139 (93)	79 (26)	148 (97)	189 (102)	.01[a,c]
Active/total days	87 %	72 %	88 %	91 %	
Walking activity (steps/day), mean (SD)					
Grand mean	5899 (3151)	1996 (716)	6016 (1784)	11,439 (440)	
Gender					.82[a]
Male	5853 (3274)	2064 (696)	6008 (1785)	11,430 (469)	
Female	6078 (2725)	1105 (0)	6037 (1869)	11,501 (0)	
Week					.004[d]
Week 1 (day 7)	5191 (3198)	1578 (500)	5366 (2306)	9611 (2995)	
Week 4 (day 30)	6362 (3834)	1807 (780)	6305 (2536)	12,697 (1678)	
Week 12 (day 90)	6186 (3013)	2304(1189)	6073 (2271)	10,637 (1095)	
Week 24 (day 180)	6794 (3518)	808 (0)	6506 (3569)	9011 (884)	
Week 36 (day 270)	8235 (4220)	0 (0)	5960 (2461)	12,784 (3127)	
Week 52 (day 365)	7890 (2629)	0 (0)	7426 (2730)	9050 (2811)	
Primary diagnose or treatment					.12[a]
ACS[e]	6549 (3149)	2194 (712)	6127 (1558)	11,588 (354)	
Surgery[f]	4781 (3023)	1879 (653)	6058 (845)	0 (0)	
HF	7340 (3190)	2636 (0)	5949 (2605)	10,916 (306)	
ACS & HF	4505 (163)	865 (0)	5415 (845)	0 (0)	
Cardiac telerehabilitation					.34[a]
CTR Healthcare Cent	5324 (2579)	2197 (585)	5779 (1243)	11,737 (333)	
CTR Hospital	6128 (3084)	2082 (980)	5950(2242)	11,187 (518)	
CTR Call Centre	6847 (4353)	1578 (751)	7485 (1608)	11,478 (418)	

[a] *P* value for comparison of all three activity groups (low, medium, and high).
[b] Post hoc 2-sample Wilcoxon rank-sum test values: low versus medium activity groups (*P*=.05), low versus high activity groups (*P*=.01), and medium versus high activity groups (*P*=.22).
[c] Post hoc 2-sample Wilcoxon rank-sum values: low versus medium activity groups (*P*=.01), low versus high activity groups (*P*=.003), and medium versus high activity groups (*P*=.21).
[d] *P* value for correlation between termination of step counter use and mean steps walked at the specified days.
[e] ACS: acute coronary syndrome.
[f] Surgery includes valve replacement, mitral valve repair, and coronary artery bypass grafting

Step measurement

The grand mean (±SD) of all patients' active days was 5899 (3151) steps/day. The week mean steps/day at each of the time points were the following: day 7 (mean 5191 (3198)), day 30 (mean 6362 (3834)), day 90 (mean 6186 (3013)), day 180 (mean 6794 (3518)), day 270 (mean 8235 (4220)), and day 365 (mean 7890 (2629)) steps per day (Table 8). This indicated an increase in walking activity over time. As the increase in walking activity could have been the result of the low activity patients' termination of step counter use, the week mean of non-users (the last determined) was calculated and is displayed in Figure 12 together with the increase in patients' grand mean. In addition, a linear regression revealed a significant relationship between termination of step counter use and low week mean steps at the different weeks (*P*=.004) (Table 8). Despite the slight increase in non-users' weekly means, it cannot be ruled out that the increase in steps per week over one year might have been due to the loss of those patients with low walking activity.

Figure 12. Grand mean (SD/length of whiskers) steps per day at different days for both users and non-users.



Patients who chose the CTR-Call Centre had the highest mean steps/day (6847 (4353)), and patients using the CTR Healthcare Centre had the lowest (5324 (2579) steps/day). There was no significant relationship between choice of rehabilitation setting and mean steps/day (*P*=.34) (Table 8).

3.3. EXPERIENCE WITH STEP COUNTER USE (STUDY 3)

The purpose of study 3 was to explore step counter use and self-determined motivation for walking during a CR programme from patients' and health professionals' perspectives.

3.3.1. FINDINGS

The included patients were eight men and four women with a median age of 62 years (range: 36-85 years). One female died during the study period, leaving 11 patients available for the interviews. Five nurses and six physiotherapists were included. All participants and their characteristics are displayed in tables 9 and 10.

Table 9. Descriptive characteristics of patients.

ID	Sex	Age (years)	Treatment
1	Male	67	Surgery: CABG
2	Male	75	Surgery: CABG
3	Female	36	Surgery: Valve surgery
4	Female	55	Medical: ACS
5	Male	60	Medical: HF
6	Female	50	Medical: ACS
7	Male	82	Surgery: Valve surgery
8	Male	69	Medical: ACS & HF
9	Female	85	Medical: HF (diseased)
10	Male	66	Medical: ACS
11	Male	51	Surgery: CABG
12	Male	49	Surgery: CABG
Mean and range		62 (36 – 85)	

Table 10. Workplace and gender of the included health professionals

Workplace	**Physiotherapists**	**RN**
University Hospital	1 (Male)	
Regional Hospital	1 (Female)	1 (Female)
Healthcare Centre 1	1 (Female)	1 (Female)
Healthcare Centre 2	1 (Male)	1 (Female)
Healthcare Centre 3	1 (Female)	1 (Female)
Healthcare Centre 4	1 (Female)	1 (Female)

RN: Registered Nurse

The analysis revealed themes and subthemes according to each of the three psychological needs in the SDT. The themes and subthemes are displayed in table 11.

Tabel 11. Themes and subthemes from the content analysis

Psychological needs from SDT	Themes from analysis	Subthemes from analysis
Autonomy	Independence from standardised rehabilitation	Individual choice and decision for walking activity
		Tailor walking activity
Competence	Conscious awareness of walking activity	Feedback on walking activity
		Knowledge leading to awareness of walking
Relatedness	Interaction whit others in relation to walking activity	Feeling of being under surveillance, yet supported
		Support from next of kin

The analysis and the resulting themes are provided in an additional file (Appendix 5). In the following, the themes and subthemes are discussed in detail.

Autonomy as independence from standardised rehabilitation

The step counter supported the choice and decision to individualise walking activity and made it possible to tailor activity.

The patients gained insight into their own activity because their steps could be visualized, and they felt an opportunity to *decide* for themselves what type of activity they wanted to perform. As such, the goals for steps became flexible. It seemed that the step counter provided independence by enabling the patients to *choose* to exercise by themselves without attending traditional rehabilitation. Because the visible steps disclosed individual activity, this led to increased independence from standardised rehabilitation that created space for *individual choice and decision*.

The patients used the step counters to monitor their steps across different activities. They chose activities that were suitable to their lifestyle and developed strategies to achieve their step goals through these activities. This made them independent of standardised programmes. The step counter became a tool that made it possible for them to *individually tailor their activity*. Similarly, the health professionals expressed that monitoring a patient’s steps made it possible to assist in tailoring each patient’s individual training program, and *individual* strategies for walking activity became obtainable.

Competence as conscious awareness of walking activity

The visibility of the steps provided feedback on walking activity and knowledge about the health benefits of walking led to an awareness of walking

The visibility of the steps on the step counter and in the PHR provided the patients with immediate feedback on the number of steps they had walked. Guided by the health professionals, the patients set realistic and clear walking goals, and they were goals that the patients wanted to achieve because it gave them satisfaction. The *immediate feedback on walking activity supported* the patients' competence in walking because it made both the patients and the health professionals consciously aware of the patients' achieved steps.

Health professionals and patients both expressed that *awareness of the health benefits* of walking made the patients walk with intent. Walking became more than an everyday activity to get around; it became a *conscious activity* supporting health. This knowledge supported the feeling of being competent in performing physical activity.

Relatedness as interaction with others in relation to walking activity

Feedback from health professionals on walking activity led to a feeling of being under surveillance yet supported, and next of kin were supportive walking partners.

The patients seemed aware that their step activity was being monitored by health professionals, and they did not want to "lose face" or to disappoint the health professionals as a result of their inactivity. The patients were motivated to walk more because they were *under surveillance* by the health professionals. In addition, the health professionals used the PHR to support patients' motivation by giving positive feedback on their activity. Thus, the relationship between patients and health professionals involved *supportive surveillance*, and the patients strived to achieve and document sufficient walking activity.

Patients expressed that *relatives and friends may be supportive* for walking motivation. Similarly, a physiotherapist noticed a friendly competition between a man and his wife. It seemed that relatives and friends may have supported the patients' motivation to walk.

3.4. JOINT DISPLAY AND INTEGRATED FINDINGS

In accordance with the convergent mixed methods design, the results/findings from the three studies were integrated as findings in joint displays to generate more comprehensive insights that went beyond the information gained from the individual qualitative and quantitative results (82). In the following, these displays are presented (Table 12).

Table 12. Joint display of the results/findings leading to integrated findings.

Study 1	Study 2	Study 3
Accuracy of Zip is ≤ 3% at 3.6 km/h and higher during treadmill walking and in real life. Accuracy increases as walking speed raises. For both the treadmill and the real-life study, the inaccuracy was mainly due to an underestimation of the Zip. Low accuracy in the 24-hour measurements. ↓	Cardiac patients walked a mean (±SD) of 5899 (3151) steps/day. Patients in the low activity group were significant older than patients in either the medium active group (*P* = .02) or the highly active group (*P* = .01). There was a relationship between low activity and high BMI[2] ↓	No participants addressed inaccuracy as a concern during the interview[1] ↓
Integrated finding: *Accuracy of the Zip increased as walking speed was raised, yet no participants expressed concerns regarding inaccuracy.*		
	Patients who chose the CTR-Call Centre had the highest mean (±SD) steps/day (6847 (4353)) compared to the other CTR settings[2]. Only 12 out of 64 (19%) of the patients chose the CTR-Call Centre. ↓	The Zip offered autonomy as independence from standardised rehabilitation because the step counters provided opportunities to tailor activities with respect to daily life. The step goals became flexible and incorporated into the patients' natural environment. ↓
Integrated finding: *The Zip supported autonomy as independence from standardised rehabilitation, and patients in the CTR-Call Centre had the highest mean steps/day.*		
	The majority of the patients showed low to medium activity; as such, 55 patients out of 64 (86%) walked less than the recommended 10,000 steps per day. There was a significant association between long-	Competence was supported as the step counter made it possible to set realistic and individual step goals. The participants became conscious of the fact that walking may result in health benefits.

Study 1	Study 2	Study 3
	term use of the Zip and high step activity; yet the duration of Zip use was a mean (±SD) of 160 (100) days. The grand mean (±SD) steps/day increased from 5191 (3198) to 7890 (2629) over the year[3], which is relatively low step activity compared to the recommended 10,000 steps/day. ↓	Patients felt satisfied when they reached their step goals. ↓
Integrated finding: *The Zip supported participants' competence and feelings of satisfaction regardless of their relatively low activity. High step activity was related to long time use.*		
	The majority of the patients chose to receive CTR at either the Healthcare Centre or the Hospital (52 out of 64 (81%)), in which the patients followed group sessions such as group exercise with other patients. Patients in the CTR Healthcare Centre group (29 out of 64 (45%)) walked a mean (±SD) of 5324 (2579) steps/day, and patients in the CTR Hospital group (23 out of 64 (26%)) walked a mean (±SD) of 6128 (3084) steps/day[2]. ↓	The Zip offered relatedness as the patients felt observed yet supported by the health professionals and helped by their next of kin. The group exercise at the CTR-Healthcare Centre and Hospital was not mentioned by the patients when they were asked about 'relatedness' (as a psychological need for motivation). ↓
Integrated finding: *The Zip supported relatedness as support despite surveillance, but having other patients in group exercise sessions was not mentioned as a component of relatedness.*		

[1] Concerns regarding the accuracy of the Zips was not a direct question in the semi-structured interview guide; still, all units of analysis were sought for spontaneous issues raised.
[2] This difference was not significant.
[3] It cannot be ruled out that the increase in steps per week over one year might have been due to the loss of patients with low walking activity.

CHAPTER 4. DISCUSSION

This discussion is based on the merged results/findings of the three studies. The structure of the discussion follows the integrated findings presented in the joint displays (Table 12). The presentation was inspired by ‘presentation through weaving,’ in which both qualitative and quantitative research findings weave back and forth around the four themes (82).

The integrated findings will be discussed in relation to previously published research. In addition, a discussion of the design and methods are presented, followed by the conclusion, limitations and perspectives for the future of telerehabilitation of cardiac patients.

4.1. DISCUSSION OF THE RESULTS/FINDINGS

The overall aim of the research presented in this PhD thesis was to determine the accuracy of the Zip when walking on a treadmill and in real life (Study 1) and to create new knowledge on cardiac patients’ walking activity after a cardiac event (Study 2). Finally, the aim was to explore self-determined motivation for walking as experienced by cardiac patients and health professionals when a step counter is used as part of a CTR programme (Study 3).

4.1.1. ACCURACY OF THE ZIP INCREASED AS WALKING SPEED WAS RAISED, YET NO PARTICIPANTS EXPRESSED CONCERNS REGARDING INACCURACY

The Zip was valid at speeds of 3.6 km/h and higher (E_{rel} < 3%) both on a treadmill and in real life when examining periods of evident walking (TP3min) (Study 1). The same high accuracy has previously been found in other Fitbit step counters (69,74).

The patients in Study 2 walked a mean (±SD) of 5899 (3151) steps/day. Despite the results from Study 1, it was not possible to determine how accurate these numbers of daily steps were, as the patients’ walking speeds were unknown. Study 1 determined a direct correlation between low walking speeds and high inaccuracy of step measurement with the Zip. There is reason to believe that the number of steps determined in Study 2 may have been inaccurate because older individuals have a low habitual mean walking speed between 1.7 - 2.4 km/h (107), and patients with cardiac disease walk more slowly than healthy adults (108–110). In particular, the step accuracy of the low activity group could be questioned, as patients in the low activity group had a significantly higher mean (±SD) age (70.7 years (10.7)) than patients in both the medium active group (61.1 years (11.4)) and the highly active group (58.2 years (8.3)) (Study 2).

Consistent with other studies (62,111), Study 1 revealed that the inaccuracy was mainly due to underestimation. Thus, if users compare their walking activity to external benchmarks (e.g., 10,000 steps per day), the underestimation is likely to be a source of frustration (77).

In addition to the deductive analysis in Study 3, all units of analysis were sought for spontaneously raised issues. None of the participants mentioned inaccuracy of the Zip at any point (Study 3), which suggests that the motivational aspect of using a step counter to support physical activity did not seem to be influenced by concerns of inaccuracy.

In Study 1, the real-life test showed a high step inaccuracy in the 24-hour measurements. This seemed unavoidable, as 24-hour measurements will always record activities other than walking, and thus the accuracy may have been limited (112). In Study 1, all of the real-life test patients wore the Zip at their waist, and in Study 2, the Zip was placed either in their breast pocket or at their waist. A wrist-worn or hip-worn step counter does not necessarily capture common activities such as cycling, resistance and static exercise, and load carrying (67), which might explain the inaccuracy.

It is hypothesised that activity recommendations in the future will involve not only activity but also rest and sleep, as a healthy lifestyle depends on adequate exercise, healthy sleep habits and limited sedentary behaviour (112). Furthermore, activity monitors are continuously being developed, and new integrated multisensory systems are promising for measuring 24-hour activity. They can monitor steps, active/sedentary minutes, distance travelled, intensity of activity, energy expenditure, hours of sleep, heart rate, skin temperature, inclination, GPS position and other activities at the same time. These types of integrated multisensory systems are appealing for monitoring 24-hours of daily life (60,112). In particular, monitoring heart rate in addition to activity is expected to provide valuable information because heart rate indicates the intensity of an activity (112). However, when using heart rate as a parameter, it is necessary to keep in mind that the heart beats of some cardiac patients might be irregular and/or regulated by medication.

In summary, the accuracy of Zip depended on the walking speed. Speeds of 3.6 km/h and higher provided a step inaccuracy of less than 3%. However, 24-hour measurements provided a high inaccuracy in step readings. Nevertheless, participants did not pay spontaneous attention to inaccuracy when using the Zip.

4.1.2. THE ZIP SUPPORTED AUTONOMY AS INDEPENDENCE FROM STANDARDISED REHABILITATION, AND PATIENTS IN THE CTR-CALL CENTRE HAD THE HIGHEST MEAN STEPS/DAY

Study 3 revealed that the step counters offered autonomy as independence from standardised rehabilitation because step counters provided opportunities to tailor activities with respect to patients' daily lives. The step goals became flexible and incorporated into the patients' natural environment. In other words, Study 3 revealed that the visualisation of the steps offered the patients a tool to choose and decide on their own activity, taking their own interests and values into account. Studies on motivation for lifestyle changes have noted that tailoring interventions is essential for behavioural change (113–116). In addition, step counters as a part of home-based rehabilitation exercise may improve walking activity and may have longer-lasting effects than hospital-based rehabilitation, as they can result in more of a lifestyle change than treatment (60,117).

As for physical activity, the choice of CTR setting that represented the most independence seemed to be the CTR-Call Centre because patients who chose the CTR-Call Centre did not attend group sessions (e.g., group exercise) as part of their CR. Study 2 revealed that patients in the CTR-Call Centre had the highest mean (±SD) steps/day (6847 (4353)) compared to both CTR-Healthcare Centre and CTR-Hospital patients (though the difference was not significant). This indicates that CTR through a Call Centre may support walking activity as effectively as CTR at hospitals and healthcare centres.

Other studies have shown an increase in walking activity when using step counters (45,53,59,61). It was impossible to determine whether the patients in the Teledi@log intervention group walked more than the patients in the control group, as the step activity of the control group was unknown. Insight into a control group's walking activity is desirable yet challenging. Other researchers have provided participants in a control group with blinded step counters to determine their walking activity (46). However, it is uncertain whether a blinded step counter may encourage the user to walk more, thereby creating an unrealistic picture of a control group.

Only 12 out of 64 (19%) of the patients chose the CTR-Call Centre, and the reason for choosing one CRT over another CTR setting was not revealed in this research.

In summary, the step counter supported autonomy as independence from standardised rehabilitation, and patients in the CTR-Call Centre group had the highest mean steps/day; however, only a minor proportion of the patients chose the CTR-Call Centre.

4.1.3. THE ZIP SUPPORTED PARTICIPANTS' COMPETENCE AND FEELINGS OF SATISFACTION REGARDLESS OF THEIR RELATIVELY LOW ACTIVITY. HIGH STEP ACTIVITY WAS RELATED TO LONG-TERM USE.

Study 2 revealed that 41 out of 64 patients (64%) were classified as medium active and walked between 3000 – 9999 steps/day, and 14 out of 64 (22%) walked less than that. As such, 55 patients out of 64 (86%) walked less than the recommended 10,000 steps per day. The recommendation of 10,000 daily steps to achieve health benefits appears to be a reasonable estimate of daily activity for healthy adults, but this goal may be too ambitious for people with cardiac disease (46,118,119).

Research suggests that a target of approximately 7000 (41) to 7500 (46) daily steps might reduce waist circumference, body mass index and cardiovascular disease risk factors in patients with coronary artery disease (41,46).

Bearing in mind the dose-response relationship between physical activity and health status (25,26,119), 7500 daily steps may not be sufficient to reach an optimal health status in cardiac patients (46), yet it could be the starting point to improving their physical activity levels. However, experts do not agree on the number of steps needed per day for cardiac patients to achieve better health in secondary prevention of cardiac disease.

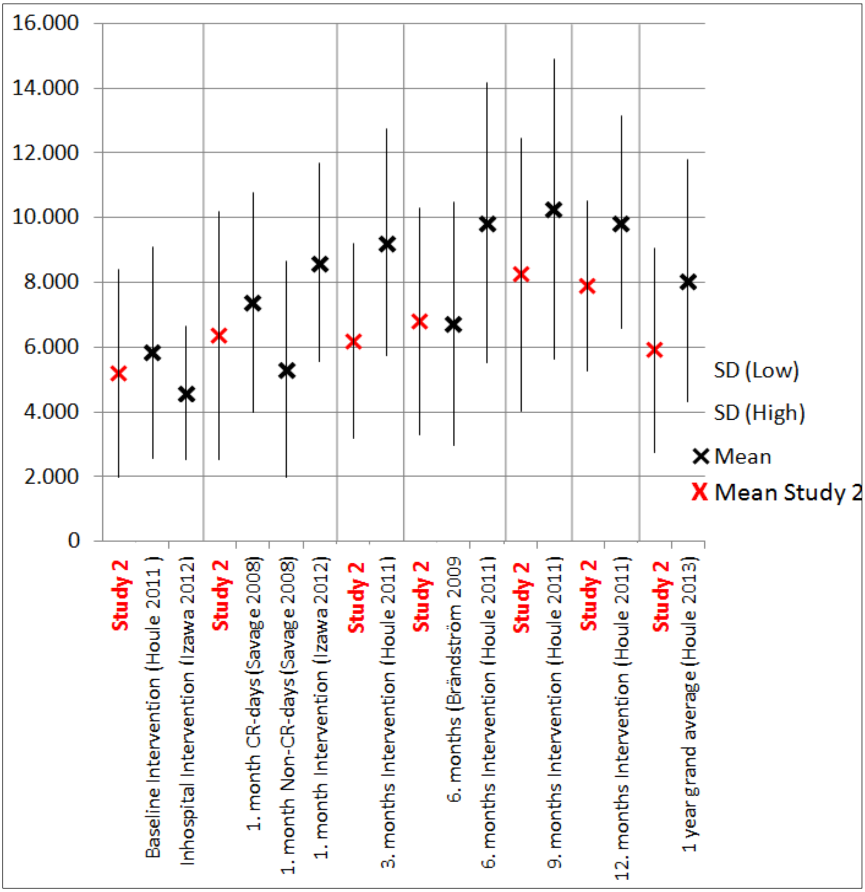
Study 2 showed that the mean steps/day for one year was 7890, which is close to the target of 7500 steps/day found in research. Still, only a few patients continued to use the step counter throughout the whole year. Study 2 also showed that the grand mean (±SD) steps/day at specific time points were the following: day 7 (mean 5191 (3198)), day 30 (mean 6362 (3834)), day 90 (mean 6186 (3013)), day 180 (mean 6794 (3518)), day 270 (mean 8235 (4220)), and day 365 (mean 7890 (2629)).

When comparing these results with other studies on cardiac patients, it seems that the patients in Study 2 were less active throughout the year after a cardiac event.

The mean in this study was as much as 25% steps/day less than that of cardiac patients in comparable studies (33,41,45,51,52,120,121) (Figure 13).

There is a major difference in the research methods of the other studies and this study. In all studies except for this one, the step counter was given to the patient for the first month or for one week prior to the time of measurement (1, 3, 6, 9 or 12 months), while patients in our study retained the step counter for up to 365 days. The continuous monitoring in our study is likely to have provided a more accurate picture of the realities of activity than that provided by the short periods of testing (122).

Figure 13. Cardiac patients walking activity (from literature) mean (±SD) steps/day, displayed jointly with results from Study 2



Joint display of the mean (±SD) steps/day for present study (Study 2) and comparable studies at different times over one year. Baseline (or inhospital) and at one, three, six, nine and 12 months. Houle 2013 only measured the mean for the whole year.

Despite the fact that the patients in this study walked less than the recommended 10,000 steps/day and less than patients in comparable studies, Study 3 revealed that the step counter became a tool to set clear and individual goals for walking and to make the patients aware of their own levels of activity. According to Bravata et al. (60), step counter users who were given daily step goals significantly increased their physical activity, whereas step counter users without step goals did not increase their physical activity. According to the SDT, competence is formed by the person's beliefs of being able to perform the desired behaviour change, e.g., by setting realistic goals (33,48,51). This could provide an explanation of why there was a significant association between long-term use of the Zip and high step activity (P=.04), as the patients who actually did achieve high goals for walking were motivated to use the Zip over a longer period of time. However, the patients were given the opportunity to wear the Zip for up to 365 days after the cardiac event, and the mean total days (±SD) of use were 160 (100). It was not possible to determine the reason for termination of step counter use. A few lost the step counter or reported it had broken, but why the other patients stopped is unknown. The patient interviews in Study 3 were conducted four months after their inclusion and the start of step counter use. All patients, except one, were still using the Zip at the time of the interview. The non-user had lost it and expressed no need for a new counter as the three months had provided him with sufficient knowledge of his own activity. This indicates the emergence of a feeling of independence after a period of step counter use. The other patients' reasons for stopping may have been a lack of motivation for walking or for using the Zip or they may have been trying to avoid confronting the fact that they were inactive.

Study 3 revealed that patients walked because they expected health benefits. From a SDT perspective this may be viewed as extrinsic motivation because the motivation was not the act itself (walking) but the expected achievements of the act (the health benefits); however, the motivation seemed integrated because it was well-internalised (106). Studies on sustained motivation for behavioural change fail to show the long-term effects when motivation is extrinsic, but the short-term effects are evident (95,105).

As reported in Study 2, the grand mean (±SD) steps/day increased slightly from 5191 (3198) steps/day in the first week to 7890 (2629) steps/day after one year. Nevertheless, the increase in steps per week over one year may have been due to the loss of patients with a low walking activity.

Study 3 showed that the Zip made patients feel satisfied when they reached their step goals. Each patient had individual step goals that changed over time alongside changes in their walking capacity and wellbeing. Still, Study 2 did not reveal to what extent each patient reached their own step goals. It may be argued that it would be more appropriate to determine to what degree one's own goals were fulfilled than to look at the fulfilment of the goal of 10,000 steps/day. This might also explain why the patients felt satisfied with their achieved walking activity despite the relatively low levels of walking (Figure 12) (Study 3). This is consistent with Normansell et al. (116), who found that participants felt that they benefited from step counter use regardless of their change in number of steps walked.

In summary, the Zip seemed to support competence and thereby self-determined motivation to walk, and a slight increase in walking activity over time was observed. There was a significant relationship between long-term use and high step activity. Nevertheless, the patients walked less than recommended and less than patients in comparable studies.

4.1.4. THE ZIP SUPPORTED RELATEDNESS AS SUPPORT DESPITE SURVEILLANCE, BUT HAVING OTHER PATIENTS IN GROUP EXERCISE SESSIONS WAS NOT MENTIONED AS A MOTIVATING FACTOR.

As found in Study 3, the step counter supported interaction with others in relation to walking activity. *Relatedness* was expressed as surveillance and support, as the patients felt observed yet supported by health professionals and helped by their next of kin. The next of kin supported the patients' walking activity by friendly competition and by being walking partners.

Surveillance from the health professionals put pressure on the patients, which motivated them to walk. In addition, the health professionals maintained a supportive role as they gave positive feedback by writing supportive comments in the PHR. According to the SDT, this can be considered an integrated extrinsic motivation that supports motivation for walking, despite the fact that the SDT considers surveillance and feedback (e.g., text messages) as failing to provide long-term motivational change because the desired behaviour stops when the surveillance and feedback stops (95,105). Despite that, Study 3 revealed that the patients felt motivated, supported and safe while being observed. This is in line with other telerehabilitation studies, in which surveillance and observation were found to support motivation for behaviour change (113,114).

In the SDT, relatedness occurs if significant others demonstrate understanding and involvement; these significant others may be friends, relatives, and family but also health professionals (95). This is interesting because based on the results from

Study 2, the majority of the patients chose CTR at a healthcare centre or hospital. However, these patients walked less than patients in the CTR-Call Centre group (not a significant difference). Patients who chose CTR at the healthcare centre or hospital participated in group exercise, and it has been hypothesised that group exercise can support relatedness (a psychological need for motivation) (123). During the patient interviews in Study 3, no patients addressed group exercise sessions when asked questions concerning relatedness; instead, they only talked about health care professionals and relatives. The group exercise sessions (at the healthcare centre and hospital) were placed in already existing rehabilitation settings and were conducted together with patients who were not participating in Teledi@log, meaning that only a minor proportion of the patients were part of Teledi@log or had a step counter. That might explain why these group sessions did not support relatedness e.g., through friendly competition between the patients or interest in each other's step activity with the step counter.

In summary, the Zip supported relatedness regarding health professionals and the patients' next of kin, but having other patients in the group exercise sessions was not mentioned as a motivating factor.

4.2. DISCUSSION OF THE DESIGN AND METHODS

In the following the design and methods will be discussed

4.2.1. DISCUSSION OF THE DESIGN

A mixed methods research design was chosen, and through the joint display of the results and findings, new integrated findings were revealed. This led to a more comprehensive understanding of how accuracy of the Zip may have influenced cardiac patients' walking activity and their experiences with walking. As such, this research benefited from using mixed methods.

A disadvantage of the mixed methods approach is that it requires skills in qualitative, quantitative and mixed methods research. It may be more complex than conducting single method studies, and the advantage of a more comprehensive understanding may be lost in the missing depth (81). As such, a broader qualitative study on patients' motivation for using a step counter might have explained aspects that were not revealed in this research (e.g., why the patients chose to stop using the step counter). On the other hand, mixing the methods revealed that the patients felt motivated to walk despite their relatively low walking activity. Neither the qualitative nor the quantitative study alone would have revealed this divergent finding. In addition, it might be difficult for a single researcher to conduct both qualitative and quantitative research at the same time. In this PhD thesis, it was important that the supervisors comprised different research competencies and were thus able to provide assistance when needed in both quantitative and qualitative research methodologies.

Furthermore, it is important to address concerns regarding paradigms when using mixed methods. Traditionally, methodological purists have argued that one should always work within either a qualitative or a quantitative paradigm and that mixed methods are not possible due to the difference in their underlying paradigms (124). The research presented in this thesis was based on both quantitative and qualitative methods because different methods were needed to answer the research questions. The quantitative and qualitative methods were regarded as necessary approaches to answer the research questions in the most comprehensive way. Thus, the outlook of the research presented in this thesis was inspired by pragmatism. A pragmatist outlook has often been applied in studies with the use of a mixed methods design (81,125,126). Pragmatism provides a set of assumptions that legitimises a mixture of paradigms and allows researchers to include both qualitative and quantitative research questions and data in the same research (81,125–128).

4.2.2. DISCUSSION OF METHODS

As this research was part of a larger CTR trial that used multiple telerehabilitation technologies, there is a risk that the patients' activity might have been influenced by factors other than the Zip, e.g., the group exercise sessions for patients in the CTR-Healthcare Centre and Hospital or the information provided in the digital toolbox (Activeheart.dk). For Study 2, a statistical isolation of the Zip data would have required additional statistical analyses that would have been difficult with a sample size of 64 patients; furthermore, it would have been too extensive for this PhD thesis.

Similarly, the participants in Study 3 found it difficult to focus solely on the Zip during the interview and not on the whole Teledi@log rehabilitation packet. This was managed with sensitivity from the interviewer during the interview and by guiding the informants to maintain their focus on the Zip.

Study 1

The treadmill test was performed with healthy adults and not cardiac patients, which might limit its transferability to real-life studies. In a study by Jehn et al. (108,109), heart failure patients performed both a treadmill and a real life test. They found a satisfactory step accuracy even for slow walking during treadmill tests (108,109). Treadmill walking is not representative of normal walking, and it is hypothesised that test persons on a treadmill will produce non-natural rigid walking regardless of health condition or age (which might improve accuracy). This means that the test person’s health condition is of less significance during treadmill walking.

Despite the fact that the results from treadmill studies cannot be directly transferred to real life settings, they are still important because they can isolate the step accuracy at different speeds and because it is possible to control the environment (speed, placement of devices, time spent walking and so on).

If Study 1 had been conducted first (as initially planned), the results might have provided the opportunity to choose another step counter for the Teledi@log project, as the Zip showed inaccuracy in 24-hour measurements and at slow speeds. Still, to our knowledge, there are no other comparable step counters (comparable in price and user-friendliness) that provide more accurate step counts. As such, the Zip still seemed to be an appropriate choice.

The manufacturer recommended a number of placements for the use of the Zip (breast pocket, bra, pants pockets or belt) (88). Study 1 only validated Zips placed at the waist and the upper body in the treadmill study and the waist in the real-life study. The reliability of the Zip when placed in other areas is still unknown.

In the real-life study, the patients were instructed on how to fasten the devices during the 24-hour test. However, there is reason to believe that the Shimmer devices can sometimes slide from one side to another. None of the participants reported (verbally or in the diary) any misplacement of the devices, but a few times, the gyroscope readings showed reverse data halfway through the test (as though the Shimmer had been turned upside down). This, of course, complicated the data readings in Study 1 but not the validity of the data.

Study 2

In Study 2, the results must be viewed with caution due to the small number of participants. In addition, when dividing the participants into smaller groups (low, medium and high activity), the results must be viewed with even more caution. The findings could be explored advantageously in a larger sample.

Another limitation was that the study sample from Teledi@log was limited to two communities in the northern region of Denmark. There might be differences in the exercise levels of different populations throughout Denmark. Potential regional differences were not revealed in this study.

Blinding the step counters used in a control group was discussed in section 4.1.2. Still, it would have been valuable to determine the difference in walking activity between patients with and without the Zip. Furthermore, it would have been interesting to determine to what degree the patients fulfilled their own step goals and not solely discuss walking activity in light of comparable studies and recommendations. Comparison of each patients' individual step goals would have been complicated as their goals changed alongside patients' health and physical recovery. It would have been interesting to standardise the expectations of each patient's step goals and compare them with the achieved steps. A standardisation method could have been the expectation of a 10% increase based on the achieved steps at certain times during the research. On the other hand, standardisation would have compromised the idea of individualisation (as in Teledi@log).

Study 3

To ensure trustworthiness when conducting qualitative content analysis, there is a need for self-criticism and good analysis skills. Trustworthiness should be clear from the preparation phase to the reporting via reflections on the data collection, sampling strategy, selection of the units of analysis, interpretation and reporting of findings and the analysis process (94).

The choice to use observation, text and interview data revealed a suitable unit for analysis. The consecutive sampling of participating patients provided a sufficient sample. On the other hand, a more purposive sampling (129), e.g., by selecting patients equally distributed between the three activity groups, might have provided new insight into the motivation for step counter use and for low, medium and high activity. However, that would have postponed the conducting of the patient interviews until after the termination of Teledi@log, which would have been difficult to accomplish during the duration of a PhD.

Using deductive content analysis narrowed the analysis to within the SDT. This might have resulted in a less rich description, despite searching for spontaneous issues that emerged. However, a more in-depth and detailed analysis on the psychological needs for motivation was revealed. Moreover, content analysis makes sense of what occurs when people are examined through the lens of a theory (94). De-contextualisation of the text might have occurred when using Nvivo10, but critical reading and discussion with supervisors was performed to prevent this.

In qualitative research, the investigator is the primary instrument for gathering and analysing data (93). Therefore, the interaction between the researchers and the participants is crucial. As all patients were interviewed in their own homes, it was important for the researcher to not intrude and to act as a guest in their homes with respect for the participants and their surroundings during the visit. Still, the patients' homes were considered the most appropriate place for the interview because the overall framing of the Teledi@log trial was rehabilitation in the patients' homes. Moreover, the patients did not have to manage transportation time for the interview, and the home surroundings might have provided a more relaxed situation for the participant.

Additional considerations are warranted when recruiting colleagues in research projects. In study 3, the health professionals were my colleagues in the Teledi@log trial. The benefits of being familiar with the participants and the trial are that the pre-existing knowledge and understanding of the culture might strengthen the interview, thus resulting in rich information from the participants. On the other hand, the familiarity may lead to truisms because the researcher might take some things for granted without questioning.

Future research

The results from the accuracy study revealed concerns regarding the inaccuracy of step readings at slow speeds in particular. Future research in activity tracking should focus on the development of activity monitors capable of measuring activity accurately, even at slow speeds. Furthermore, the development and testing of activity monitors capable of measuring 24-hour real-life activity are needed, as healthy living is based on both activity and rest/sleep (112); this is recommended as it could reveal more substantial knowledge on patient activity (and rest/sleep) during the rehabilitation period.

Regarding treadmill tests, future research would benefit from conducting a speed test of the treadmill, as performed in Study 1. Study 1 revealed inaccuracy, although minor; however, none of the comparable studies were found to have conducted the same type of speed test. This means that there is a risk that the speed in their studies was incorrect, making comparisons slightly less certain.

As for cardiac patients' walking activity in the rehabilitation period, a larger sample of cardiac patients would have been desirable. A larger sample would have also enabled comparisons of walking activity in relation to other health parameters (e.g., medication, comorbidity, and duration of hospital stay).

Determining the relationship between patients' walking activity during hospitalisation and their walking activity in the rehabilitation period might also provide valuable information. Namely, it might be possible to predict which patients are at risk of inactivity after discharge from the hospital.

Furthermore, research on the fulfilment of one's own step goals in relation to different motivational aspects is needed, as it could reveal new knowledge on the motivation of patients who meet or fail to meet their activity goals. Additionally, research on the reasons why patients stop using a step counter might lead to insight into the differences between people who feel motivated by step counters and those who do not.

Questionnaires to determine the degrees of self-determination have been developed and tested in relation to physical activity (102). These should be used in future research on walking activity and the use of step counters in CTR.

CHAPTER 5. CONCLUSION

The overall aim of the research presented in this PhD thesis was to determine the accuracy of the Zip step counter used (Study 1) and to create new knowledge on cardiac patients' walking activity after a cardiac event (Study 2). Furthermore, the aim was to explore self-determined motivation for walking as experienced by cardiac patients and health professionals when a step counter was used as part of a CTR programme (Study 3). Finally, by using mixed methods, a more comprehensive understanding of the research questions was reached through integrated findings.

In conclusion

- The accuracy of the Zip depended on the walking speed. Speeds of 3.6 km/h and higher provided a step inaccuracy less than 3%. However, 24-hour measurements provided a high inaccuracy in step readings. Nevertheless, participants did not pay spontaneous attention to inaccuracy when using the Zip.

- The Zip supported autonomy by providing independence from the standardised rehabilitation, and patients in the CTR-Call Centre group had the highest mean steps/day; still, only a small proportion of the patients chose the CTR-Call Centre.

- The Zip seemed to support competence and thereby self-determined motivation to walk, and a slight increase in walking activity over time was observed. Furthermore, there was a significant relationship between long-term use and high step activity. Nevertheless, the patients walked less than recommended and less than patients in comparable studies.

- The Zip supported relatedness in relation to health professionals and the patients' next of kin, but having other patients in group exercise sessions was not mentioned as a motivational factor.

To summarise, the step counter supported a feeling of self-determined motivation for walking, when used in a CTR programme. However, the patients walked less than recommended and, less than patients in comparable studies. Furthermore the step counter was inaccurate in 24-hours measurements and in slow speed; still, participants did not pay spontaneous attention to inaccuracy.

CHAPTER 6. PERSPECTIVE

Physical activity interventions have been implemented in CTR, but they still require attention in the future. When developing, designing, and implementing future activity interventions for CTR programmes, the research presented in this thesis can be a source of ideas and recommendations.

Step counters are important for future CTR because they support autonomy from standardised rehabilitation, and rehabilitation can be performed in the participants' natural environment. This type of individualisation seems to be effective in increasing both attendance rates and long-term adherence to rehabilitation recommendations in CTR (8). Furthermore, step counters support competence and self-determined walking and provide relatedness to health professionals and relatives. Bearing that in mind, step counters should be a part of future CTR efforts.

It would be beneficial to consider step counters more broadly as activity monitors that include integrated multisensory systems, and accurate activity monitors that are capable of recording 24-hour activity are desired, as health professionals (in particular) expect the collected data to be valid.

Furthermore, it is important to develop future CTR as being more in the hands of each individual patient and in a way that provides the patient with access to his or her own data, rehabilitation plans, and information and with the ability to contact health professionals in a format that suits the patient's individual needs.

Currently, the Quantified Self trend has increased as self-monitoring and self-logging have been increasingly used by the public. People are more engaged in health monitoring as devices, applications and other technologies make data collection easy and inexpensive (130). Almost all smarts phones have the capacity to log activity such as distance travelled, active minutes and steps walked. Furthermore, it is possible to add mood, food intake and weight and share data on activity websites (such as Endomondo). As such, monitoring may be integrated into daily human lives in the form of tracking, monitoring, recording, and transferring data related to health (55). According to Appelboom et al. (57), patients self-quantification via wireless mobile health applications and monitoring systems makes them better equipped to follow and understand recommendations from health professionals, to have more personalized and preventive care, and to make more informed choices regarding wellness and health care (130).

Therefore, health professionals should support this evolving trend by adding monitoring of health data or by extracting data from already existing devices. However, the accuracy and reliability of the devices must be determined.

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APPENDICES

Appendix A.

Cardiac disease and (number of patients)	Intervention	Type of pedometer or accelerometer and Measurement method	Steps per day (average ±SD if available)	Source
Percutaneous intervention (n=40), Coronary Artery Bypass Surgery (n=34), Myocardial Infarction (n=25), and other (n=8) Total: n=107.	Cardiac rehabilitation	Walk4Life pedometer on 7 consecutive days. Primary outcome was total steps taken, with CR and non-CR days analyzed separately.	**At 1-moths** CR-days 7387±3387 Non CR-days 5315±3336	Savage et al 2008 (33).
Acute Myocardial Infarction (n=89)	Participated in a longitudinal follow-up study on re-adjustment 1 week and 4 months after Myocardial infarction.	Type of pedometer not mentioned. Wearing of a pedometer for 7 consecutive days from morning to bedtime.	**At 6-months** 6719±3771	Bränd-ström et al., 2009. (51).
Acute Coronary Syndrome (n=65)	Intervention: socio-cognitive intervention and pedometer use every day since discharge Control group: usual care	Yamax Digiwalker NL-2000, Lees Summit, USA. Blinded pedometers used during 7 consecutive days from morning to bedtime.	**At baseline** Intervention 5845 ± 3246 Control: 6097 ± 3055. **At 3-monts** Intervention: 9234 ± 3502 Control: 7972 ± 3828 **At 6-monts** Intervention: 9856 ± 4325 Control:6980 ± 3147 **At 9-monts** Intervention: 10261 ± 4625 Control: 7591 ± 3669 **At 12-month**: Intervention: 9850 ± 3282 Control: 7970 ± 3433	Houle et al., 2011. (45).
Heart failure, Valve Surgery, Myocardial Infarction or Coronary Artery Bypass Grafting	Intervention group; self-monitoring with a pedometer (n=63)	Kenz Lifecorder EXa 1-axial accelerometer was used for 8 days, and the final 7 days were used to calculate the average and standard deviation.	**At baseline** Intervention: 4588.0 ± 2056.3 Control: 5155.2 ± 2424.5 **At 1-month** Intervention: 8609.6 ±	Izawa, et al., 2012. (53)

Cardiac disease and (number of patients)	Intervention	Type of pedometer or accelerometer and Measurement method	Steps per day (average ±SD if available)	Source
(N=125)	Control group (n=63).		3064.5 Control: 5512.9 ± 2571.8	
Coronary Artery Disease (n=332)	None	Keep walking LS 2000 pedometer for seven consecutive days.	**At 6-months** *Median* (25th–75th percentile): 7027 (4553–9356)	Bäck et al., 2013. (41)
Acute Coronary Syndrome (n=41)	None	(NL-2000) A blinded pedometer with a 7-day memory was used at baseline, 3, 6, 9, and 12 months following hospitalization.	**Grand average over 12-months** mean ± StandardErrorMean 8051 ± 3735.	Houle et al., 2013. (46)

Appendix B. (In Danish)

Nøjagtighed af skridttæller Fitbit Zip

på hjertepatienter under daglig brug

Målgruppen for forsøget er hjertepatienter

Undersøgelsen er en del af forskningsprojektet: Accuracy of the pedometer Fitbit Zip, during treadmille walking and in real life on cardiac patients (Nøjagtighed af skridttæller Fitbit Zip på løbebånd samt på hjertepatienter under daglig brug).

Undersøgelsen foregår over to døgn. Det første døgn vil være mens du stadig er indlagt og det andet døgn vil være ca. en måned efter udskrivelsen. Du vil blive bedt om at gå med en skridttæller samt en bevægelses sensor (Shimmer3). Du vil bære skridttælleren omkring livet, og bevægelsessensoren vil sidde i en stof-rem, der sættes omkring din venstre ankel.

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Aalborg Universitetshospital

Indledning

For at undersøge om skridttælleren Fitbit Zip måler skridt nøjagtigt, vil jeg spørge om du vil deltage i dette videnskabelige forsøg. Det er frivilligt at deltage, og du kan på ethvert tidspunkt trække dit samtykke tilbage og udtræde af forsøget, dermed vil alt materiale, som kan henføres til dig blive slettet. Udtrædelse kræver ingen begrundelse, men det vil være til gavn for forskningen at kende til årsagen.

I denne deltagerinformation kan du læse mere om, hvad forsøget går ud på og hvad du skal gøre, hvis du siger ja.

Formål

Forsøget har til formål, at undersøge nøjagtigheden af skridttælleren Fitbit Zip under daglig brug, mens du er indlagt og en måned efter indlæggelsen. I alt vil 20 hjertepatienter indgå i forsøget

Du vil blive bedt om at bære en skridttæller samt en bevægelsessensor på to forskellige dage, dog ikke når du går i bad. Du vil ligeledes blive bedt om at sove med apparaterne. Remmene de sidder i er lavet af et behageligt materiale, som formodes ikke at være til gene.

Du vil blive instrueret i, hvordan du skal bære skridttællerne og bevægelsessensoren.

Det første døgn hvor du bærer skridttællerne og bevægelsessensoren, vil foregå mens du stadig er indlagt på sygehuset. Du vil blive bedt om at udfylde en aktivitetsdagbog.

Undersøgelsen bliver gentaget en måned efter udskrivelsen. Den forskningsansvarlige vil besøge dig i dit hjem og gentage instrukserne om brugen af skridttælleren og bevægelsessensoren. Derefter vil du bære skridttællere og bevægelsessensoren over et døgn, mens du udfører dagligdags aktiviteter. Du vil igen blive bedt om at skrive en aktivitetsdagbog.

Skridt data og bevægelsesdata vil trådløst blive overført til en database, hvor forskere efterfølgende kan analysere dem. Det vil blive undersøgt, om skridttælleren måler skridt lige så nøjagtigt som bevægelsessensoren. Dermed kan det vurderes om skridttælleren er troværdig.

Du vil blive vejet og din højde vil blive målt. Disse data skal bruges for at skridttælleren kan udregne skridtlængde og dermed gangdistance. Fakta vedrørende din hjertesygdom, årsag til indlæggelse, behandling under indlæggelsen samt hvor længe du har været indlagt vil blive hentet fra din journal.

Alle disse fakta vil blive behandlet fortroligt, og kun den forskningsansvarlige, samt personer med relation til testen, har adgang til fakta.

I forbindelse med deltagelse vil vi bede dig om at afgive skriftligt samtykke (se vedlagte).

Nytte ved forsøget

Brugen af en skridttæller har vist sig at være motiverende i forhold til at være fysisk aktiv, derfor vil en undersøgelse af hvor nøjagtigt Fitbit Zip måler skridt, være særdeles interessant for en fremtidig brug af denne skridttæller. Der er ikke fundet hverken bivirkninger, risici, komplikationer eller ulemper ved brugen af skridttæller ej heller ved brugen af Shimmer3. Dermed betragtes det som risikofrit at deltage i projektet.

Adgang til forskningsresultater

Det forventes at resultaterne af forsøget vil blive offentliggjort i midten af 2015. Som forsøgsdeltager vil du, hvis du ønsker det, få besked om forskningens resultat.

Kontaktperson

Med denne information håber jeg, at du har fået tilstrækkeligt indblik i, hvad det vil sige at deltage i forsøget, og at du føler dig rustet til at tage beslutningen om din eventuelle deltagelse.

Har du spørgsmål eller vil vide noget mere, er du meget velkommen til at kontakte Charlotte Brun Thorup

Med venlig hilsen

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Dagbog

Kære deltager
Det er vigtigt, at du i store træk beskriver, hvilket aktiviteter du har udført i løbet af de 24 timer du laver undersøgelsen på sygehuset og i hjemmet. Derfor har vi lavet denne aktivitetsdagbog, som kan lette beskrivelsen.

Vi vil meget gerne, at du for hver eller hver anden time husker tilbage og markerer hvilke aktiviteter du har haft. Tidspunkterne bliver selvfølgelig cirka tidspunkter, men vi vil bede dig om at være så præcis som mulig.

Herunder finder du et eksempel på en udfyldt aktivitetsdagbog.

Det er specielt vigtigt at du noterer hvornår du sætter udstyret på og tager det af, også hvis det sker i løbet af dagen (f.eks. mens du er i bad/svømmehal)

Eksempler på aktiviteter:

Går/står: Normal aktivitet der **ikke** foregår siddende eller liggende

Sidder: Hviler, læser og andet siddende

Ligger/sover: Hviler og sover

Aktiviteter: Til røntgen undersøgelse eller lignende

Træning: Træning med fysioterapeut/motions cykel

Måltid: Morgen-, middag og aftensmad samt mellemmåltider

Uden udstyr: Bad, svømmehal og anden aktivitet uden skridttæller

	Går /står	Sidder	Ligger/sover	Aktiviteter	Træning	Måltid	Uden udstyr
09.45			↓				
10.00							
10.15		↓					
10.30		↓					
10.45							
11.00					↓		
11.15					↓		
11.30							
11.45						↓	
12.00						↓	
12.15							
12.30			↓				
12.45			↓				
13.00			↓				
13.15							
13.30		↓					
13.45							

Nøjagtighed af skridttæller Fitbit Zip

Løbebåndstest af en skridttællers nøjagtighed

Målgruppen for forsøget er raske forsøgspersoner.

Undersøgelsen er en del af forskningsprojektet: Accuracy of the pedometer Fitbit Zip, during treadmille walking and in real life on cardiac patients (Nøjagtighed af skridttæller Fitbit Zip på løbebånd samt på hjertepatienter under daglig brug)

Forsøget vil foregå på løbebånd, og vil blive udført på Aalborg Universitetshospital, Hobrovej 18-22. 9000 Aalborg.

Forskningsansvarlig er:

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Indledning

For at undersøge om skridttælleren Fitbit Zip måler skridt nøjagtigt, vil jeg spørge om du vil deltage i dette videnskabelige forsøg på løbebånd. Det er frivilligt at deltage, og du kan på ethvert tidspunkt trække dit samtykke tilbage og udtræde af forsøget. Udtrædelse kræver ingen begrundelse, men det vil være til gavn for forskningen at kende til årsagen.

I denne deltagerinformation kan du læse mere om, hvad forsøget går ud på, hvad der vil ske med dig, hvis du siger ja.

Formål

Forsøget har til formål, at undersøge nøjagtigheden af skridttælleren Fitbit Zip på løbebånd. I alt vil 20 raske forsøgspersoner indgå i forsøget

Du vil blive bedt om at bære fire Fitbit Zip´s samt en bevægelsessensor (Shimmer3). Du vil bære to Fitbit Zip´s på overkroppen (fastgjort til et elastikbælte) og to i et elastikbælte omkring livet. Bevægelsessensoren vil sidde i en rem, der sættes omkring din højre ankel.

På løbebåndet vil du blive bedt om at gå i 3 minutter ved forskellige hastigheder, startende fra 1 km/t til 6 km/timen. Hastigheden 6 km/timen kan betragtes som let løb. Der vil være en hvilepause mellem hver periode, hvor den forskningsansvarlige vil notere data fra skridttællerne.

Du vil blive vejet og din højde vil blive målt. Disse data skal bruges for at skridttælleren kan udregne skridtlængde og dermed gangdistance. Du vil endvidere blive bedt om at opgive din alder. Alle disse data vil blive behandlet fortroligt, og kun undersøger samt personer med relation til testen har adgang til data.

Derudover vil du blive bedt om at skrive under på at dit selvvurderede fysiske helbred er i så god stand at du uden risiko kan gennemføre gangtesten ved de angivne hastigheder.

Nytte ved forsøget

Brugen af en skridttæller har vist sig at være motiverende i forhold til at være fysisk aktiv, derfor vil en undersøgelse af hvor nøjagtigt Fitbit Zip måler skridt være særdeles interessant for en fremtidig brug af denne skridttæller. Der er ikke fundet hverken bivirkninger, risici, komplikationer eller ulemper ved forsøget brugen af skridttæller ej heller ved brugen af Shimmer3. Dermed betragtes det som risikofrit at deltage i projektet.

Plan for forsøget

Tidspunktet for løbebåndstesten vil blive hverdage efter kl. 15.00 og undersøgelsen vil vare ca. 2 timer. Andet tidspunkt kan aftales hvis det er mere hensigtsmæssigt. I forbindelse med deltagelse vil du blive bedt om at afgive skriftligt samtykke.

Adgang til forskningsresultater

Det forventes at resultaterne af forsøget vil blive offentliggjort i midten af 2015. Som forsøgsdeltager vil du, hvis du ønsker det, få besked om forskningens resultat.

Kontaktperson

Med denne information håber jeg, at du har fået tilstrækkeligt indblik i, hvad det vil sige at deltage i forsøget, og at du føler dig rustet til at tage beslutningen om din eventuelle deltagelse.

Har du spørgsmål eller vil vide noget mere, er du meget velkommen til at kontakte Charlotte Brun Thorup

Med venlig hilsen

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DET VIDENSKABSETISKE KOMITÉSYSTEM

Informeret samtykke til deltagelse i et sundhedsvidenskabeligt forskningsprojekt.

Forskningsprojektets titel: *Test af en skridttællers nøjagtighed på hjertepatienter under daglig brug* og *løbebåndstest af en skridttællers nøjagtighed*

Erklæring fra forsøgspersonen:

Jeg har fået skriftlig og mundtlig information og jeg ved nok om formål, metode, fordele og ulemper til at sige ja til at deltage.

Jeg ved, at det er frivilligt at deltage, og at jeg altid kan trække mit samtykke tilbage uden at miste mine nuværende eller fremtidige rettigheder til behandling.

Jeg giver samtykke til, at deltage i forskningsprojektet, og har fået en kopi af dette samtykkeark samt en kopi af den skriftlige information om projektet til eget brug.

Forsøgspersonens navn:
____

Dato: _______________ Underskrift

Ønsker du at blive informeret om forskningsprojektets resultat samt eventuelle konsekvenser for dig?

Ja _____ (sæt x) Nej _____ (sæt x)

Erklæring fra den, der afgiver information:

Jeg erklærer, at forsøgspersonen har modtaget mundtlig og skriftlig information om forsøget.

Efter min overbevisning er der givet tilstrækkelig information til, at der kan træffes beslutning om deltagelse i forsøget.

Navnet på den, der har afgivet information: *Charlotte Brun Thorup*

Dato: _______________ Underskrift

Appendix C.

Opening question	
Who, time and place	Would you please introduce yourself briefly by sharing your name, age and your illness?
Research questions	***Interview questions***
Covering the following areas • Importance of physical activity • Autonomy • Competence • Relatedness • The use of the step counter	What does physical activity mean to you (what is important)? What do you expect from being physical active? In relation to physical activity, what do you expect to achieve during the next year? If others described your way of being physically active, what would they say? What are your advantages in relation to physical activity? What is most challenging for you in relation to physical activity? In relation to physical activity, what would you like to learn more about? What behaviour would you like to change in relation to physical activity? Who influences you to change your level of activity (increase or decrease)? Who supports you in relation to physical activity?
Step counter	What do you think about the step counter? What does the step counter mean to you? What do you think the step counter is going to mean to you in the future?
Closing questions Makes it possible for the interviewees to raise spontaneous issues inspired by the previous questions	Is there anything else you would like to tell me about?
Exploratory questions Makes the interviewees feel important. These questions are used when appropriate throughout the interview	That sounds interesting, please tell me more. Can you give me a more detailed description? Please provide examples.

Appendix D.

Opening question	
Who, time and place	Would you please introduce yourself briefly by sharing your name, profession and the place of your employment? (Healthcare centre or hospital)
Research questions	**_Interview questions_**
The health professionals experienced of using the pedometer in the interaction with the patients concerning physical activity	Tell me about the step counter What was your experience with using the step counter as a working tool to support patients' physical activity? What do you think the step counter means to the patients? Tell me about the patient's relatives' involvement in the patients' use of the step counter
Step counter – own experiences	Have you used the step counter yourself? What do you think about the step counter? (as a working tool) What does the step counter mean to you? Does it influence your interaction with the patient if you have a step counter yourself?
Closing questions Makes it possible for the interviewees to raise spontaneous issues inspired by the previous questions	Is there anything else you would like to tell me about?
Exploratory questions Makes the interviewees feel important. These questions are used when appropriate throughout the interview	That sounds interesting, please tell me more. Can you give me a more detailed description? Please provide examples.

Appendix E.

Units of analysis			Sub-themes	Themes
Interview: patients	**Interview: health profession-nals**	**Observations and Documents (notes from the PHR).**		
Autonomy				
"Well, I don't do it for the sake of others, only for my own sake. It´s the same about the goal of 10,000 steps, which I might not get to every single day, but then I get more another day" (ID5). "When the weather was nice, I could easily walk the 10,000 steps. But, I would not have walked 10,000 steps on a rainy day [laughs]. I want to decide myself" (ID12). "When the lawn needs mowing, then you feel motivated, not to be active, but to make the lawn look good" (ID8). "I don't need the pedometer anymore. I now know how many steps the normal working day provide, or my favourite walking trip. If I have been inactive, then I just walk 18 holes at the golf club" (ID5). "The alternative was to exercise at the Healthcare centre, but I am not driving all that way for half an hour of exercise. You could just take a walk in the nature. It's basically the pedometer that supports your exercise" (ID11).	You have to accept the patient's choice At the same time you have to make sure that the patient understands the health related problems of their choice, and that the choice are made on the basis of knowledge (Nurse at Healthcare Centre 3).	"In the middle of the living room there was a rowing machine, and during the first observation the patient expressed a wish for a more detailed personal plan for exercises improving strength beside her pedometer goals. She explained that this was because she wanted to exercise on her own" (Field note ID3). "Morten, you are close to the 5000 steps per day, good ☺, are you ready to increase the amount of steps?" (PHRpatientID12).	Individua l choice and decision for walking activity	Iindependence from standardised rehabilitation

"When you have a pedometer, you look at it, how many steps have I walked now? Then we've gone for an evening walk. If you can't see the results of what you do, that is, measuring the steps, then you have no opportunity to adjust" (ID10). "Before [the pedometer] I wasn´t given any marker on how many steps to walk a day. I was just told to walk; now I walk longer distances about 7,000 steps 8,000 steps on one trip" (ID2).	"After all we use it a lot, I preach; you must reach those 10,000 steps a day, but we do have some citizens that … if they reach 5,000 then I think it's very well done, considering their physical level" (Physiotherapist at Healthcare Centre1). "In worst case scenarios they only walked 2,000 steps in a day. You have to be aware of their starting point when you plan their individual activity level" (Physiotherapist at Healthcare Centre4).	"I can see you are getting close to your goal of steps, should we try and raise the number of steps to 10,000?" (PHRpatientID2). "Thanks for a nice talk on the phone today; I am pleased that you are feeling OK. The heart failure makes you 'short of breath' and I suggest that you take shorter but more frequent walks (PHRpatientID7). "John experiences leg pain when walking [just a short distance]. We agreed to measure how far he can walk (numbers of steps). After that we will determine goals for daily steps" (PHRpatientID1). "Thomas wants to loos weight by increasing physical activity through indoor bike riding and 5000 daily steps. Suggested that Thomas divides the walking trip into two. In a month's time we will evaluate the achieved physical activity PHRpatientID11).	Tailoring walking activity	

Units of analysis			Sub-themes	Themes
Interview: patients	**Interview: health profession-nals**	**Observations and Documents (notes from the PHR).**		
Competence				
"Unfortunately I forgot the pedometer this morning, and I went for a long walk, which unfortunately didn't get registered" (ID2). "I forgot my pedometer today, but I went for a shopping trip in Aalborg, and I think I walked about 7000 steps all together. I tell you: I was so tiered after that, I slept all evening" (PHR ID1). It´s nice to see that I did actually walk many steps today." ID1)	"Previously it seemed blurred, whereas now, with this [the pedometer], it is easier to keep track on their activity" (RN at Healthcare Centre3).	Hi Mette [nurse at the hospital], the pedometer is really motivating. I wore it at the gym, I went there with my wife, and it gave me 2 – 3.000 steps at the cross trainer" (PHRpatientID12).	Feedback on walking activity	Conscious awareness of walking activity
"Especially when I think about it, in a way, I've got my life back so, if I just sat back, I wouldn't have understood 'the message'" (ID3). "Purely for medical reasons, it is all about your health. It is all about health. I try to keep as healthy as possible, and it appears that, exercise makes a difference" (ID10). "Walking is my work. I want to be in a good shape, because it's good for me" (ID2). "It´s form my own sake, and if some clever people tells me that 10000 steps per day is good for my, the it won't be any good if I just walk 500 steps (ID 5)	Some of the patients don't consider walking as a health related issue; they just consider walking as an act to get from one place to another. The pedometer changed that. (Nurse at Healthcare Centre 1)	"Three months has passed by, and you have to live without telerehabilitation technologies. You have reached all your goals; you have lost 13 centimetres around your waist, and walk a lot of steps. You have said no to any additional rehabilitation sessions at the health care centre" (PHRpatientID11). "A patient had the pedometer placed visibly at the shirt, expressing that it is an appropriate place for him, because it reminds him to walk and makes him aware of activity" (Field note ID11).	Knowledge leading to awareness of walking	

		"Hi, Helle. It´s nice to see that you really focus on exercise and activity, and that you set yourself personal goals. Regarding strength exercise, I have some suggestions, but it is very important to listen to the signs from your body, like pain. You can make sit ups and by doing … etc. etc. If you have any questions don't hesitate to contact me again. Yours sincerely, Peter Hansen, Physiotherapist, Aalborg University Hospital" (PHRpatientID3)		

Units of analysis			Sub-themes	Themes
Interview: patients	**Interview: health profession-nals**	**Observations and Documents (notes from the PHR).**		
Relatedness				
"You lose face if the pedometer shows too few steps. I mean, you lose face if you don't do what they [the health professionals] told you to do" (ID4). It may not show too few steps … it would be embarrassing to wear a pedometer that only shows 200 steps. It has to be more, maybe not in one walk … but if you continue to walk, then the victory comes to you (ID4). Of cause you listen to people [health professionals] who knows what they are talking about (ID1)	"For the patients, it´s the immediate result each evening. It's like a close surveillance of activity, like a: 'well done today, Peter'" (Physiotherapist at Healthcare Centre2).	Hi Ib. How are you? Are you using the pedometer every day? There aren't many steps uploaded to the PHR (PHRpatientID4). Hi Hans. I can see that you have been really active, that's good☺. Enjoy the lovely weather today, maybe you feel like a long walk on the beach? (PHRpatientID5) Hallo Mette [nurse at the hospital]. As you can see, I don't walk much. I am extremely affected by the new drug. Immediately after intake, my pulse and blood pressure drops and I need to lie down. (PHRpatientID4) It´s a safe feeling, that the nurse follows your rehabilitation status in the PHR. I haven't reach my goals yet, but I am determined that I will (PHRpatientID9)	Feelings of being under surveillance, yet supported	Interaction whit others in relation to walking activity
It´s my kids, my kids they are also active, and I want to be active together with them. They have been walking with me; they helped me to get started. And when you have the pedometer, then you look at it, 'how many steps have I been walking?', then we have been out for an evening walk. (ID3). I just call my friend and ask her; 'don't you need	His wife bought a pedometer herself, they compared, and talked about how many steps they had reached. I think that it was motivating for them, to see that the spouse	I offered the patient rehabilitation gym at the healthcare centre, but he chose continues to exercise with his wife (PHRpatientID11).	Support from next of kin	

some fresh air?' It´s like; 'two for the price of one' because then we talk and talk, and suddenly, whiteout noticing, we have been walking a long trip (ID6).	feeling good. (Physiotherapist at Healthcare Centre3)			

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