Exercise-based real-time telerehabilitation for older patients recently discharged after transcatheter aortic valve implantation, a mixed-method feasibility study

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Submitted to: JMIR Rehabilitation and Assistive Technologies
on: November 10, 2021

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Abstract

Background: The use of telehealth technology to improve functional recovery following transcatheter aortic valve implantation (TAVI) has not previously been investigated

Objective: This study examined the feasibility of exercise-based cardiac telerehabilitation after TAVI.

Methods: Single-center, prospective, non-randomized study using a mixed methods approach. Data collection included testing, researchers' observations, logbooks, and individual patient interviews, which were analyzed using a content analysis approach. The intervention lasted for three weeks and consisted of home-based online exercise training, an activity tracker, a TAVI-information website, and one online session with a nurse

Results: Thirteen patients were included; median age of 83 (range 74-87) years. Five patients (three males and two females) completed the study and were interviewed. Easy access to supervised exercise training at home with real-time feedback and use of the activity tracker to count daily steps were emphasized by the patients who completed the intervention. Reasons for patients not completing the program included poor data coverage, participants´ limited IT skills, and lack of functionality in the systems used. No adverse events occurred.

Conclusions: Exercise-based telerehabilitation for older people after TAVI does not seem feasible in its present form, as 70% of the included patients did not complete the study. Those completing the intervention highly appreciated the real-time feedback during the online training sessions. Aspects that support retainment rates and enhance patients´ IT skills should be addressed in future studies.

(JMIR Preprints 10/11/2021:34819)
DOI: https://doi.org/10.2196/preprints.34819

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Introduction

Aortic valve stenosis (AS) affects approximately 3% of people aged ≥75 years. Untreated, AS leads to symptoms such as dizziness, fainting, dyspnoea, chest pain, heart failure, and sudden cardiac death [1]. Transcatheter aortic valve implantation (TAVI) is increasingly being used as a procedure of choice for older patients with severe AS and high perioperative mortality risk [1,2]. The number of TAVI procedures is expected to rise over the coming years because of an ageing population [3] and the positive short and long-term results of the procedure [4]. Thus, TAVI has recently also been recommended in patients who are >65 years old and at low and intermediate risk from surgical aortic valve replacement [4].

To date, no major guidelines recommend cardiac rehabilitation (CR) after TAVI [5], although emerging evidence suggest that CR is safe and has the potential to reduce mortality, and to improve exercise capacity and quality of life [6–9]. Participation in CR soon after TAVI may be of particular importance, since sedentary behaviour in this often frail population with multiple comorbidities is related to a higher risk of mortality and functional decline one year after the procedure [10]. In Denmark, less than 20% of patients are referred to and participate in CR following TAVI [11]. Several factors hinder patients' participation in CR including old age [12], lack of availability of a municipality-based CR, lack of continuity between hospitals and local health centres where CR programs are performed, and lack of individualized rehabilitation [13].

Telerehabilitation is defined as the use of information and communication technologies to support rehabilitation [14,15]. Cardiac telerehabilitation (CTR) has proven to be as effective in decreasing morbidity and mortality as centre- and hospital-based CR programs [16,17]. CTR may enhance attendance rates and long-term adherence to rehabilitation recommendations since it is performed in the participants' own environment and can thereby be incorporated into their daily routines [18,19]. CTR often consists of digitally available cardiac- related patient information and the use of different devices (e.g. activity trackers, weight scales) that collect and transfer data to a personal health record or a digital platform [20,21], while others additionally provide supervised exercise training [16,22]. Considering that the participation of older patients in center-based cardiac rehabilitation programs is poor [12,23], CTR may resolve barriers that hinder CR utilization, and improve adherence and sustainability of effects [24].

The effectiveness of CTR following TAVI has not yet been investigated, probably due to the fact that the use of modern technology in the elderly population is still

limited [25,26]. Hence, we have developed a digital CTR program (TeleTAVI), based on four elements: 1) supervised home-based online exercise training, 2) an activity tracker, 3) a website containing disease-specific patient education and training videos, and 4) one online session with a nurse specialized in care of patients undergoing TAVI. The development process was based on a participatory design [27], including individual patient interviews, and workshops with patients, health professionals, researchers, and system developers [28] The purpose of this study was to investigate the feasibility and usability of a CTR program, named TeleTAVI, delivered via a tablet to an older population who had recently undergone TAVI surgery, with consideration given to the potential barriers in the use of technology for this particular population. We hypothesised that patients who undergo TAVI would be able to manage and use a tablet containing a TeleTAVI program at home and would be positive regarding the TeleTAVI content and approach.

Material and methods

A prospective non-randomized, single-center study using a mixed-methods approach was designed to investigate the feasibility of the TeleTAVI program and to evaluate patients´ experiences with the program. Additionally, the study was conducted to gather information about whether and how a future large-scale randomized controlled trial could be performed. The first author (BCB) was in charge of all procedures for recruitment and the running of the study, while the last author (CBT) performed the patient interviews. The study was reported in accordance with the CONSORT extension for feasibility and pilot studies [29]

Setting

Participants were recruited at the Department of Cardiology, Aalborg University Hospital, Denmark, between August 18 to September 22, 2020. The hospital performs 120 TAVI procedures annually. The Danish National Health Service provides tax-supported healthcare including general CR for all inhabitants, guaranteeing free access to family physicians and public hospitals.

Ethics

The Danish Data Protection Agency approved the study (registration 2020-054). The Regional Ethics Committee stated that no approval was required for the study. Informed

written consent was obtained from all participants before inclusion.

In- and exclusion criteria

Eligible participants were adults planned for elective TAVI and capable of reading and understanding Danish. Indications for TAVI in the present patient cohort were primarily high-risk, symptomatic AS and/or an age of >80 years. The exclusion criteria were physical deficits adversely influencing physical performance, decreased cognitive functioning, or TAVI performed as an acute- or subacute surgery.

Surgery and perioperative management

TAVI was performed with local anesthesia and conscious sedation, with insertion of a self - expandable aortic valve using a balloon catheter through a transfemoral incision. The choice of the heart valve used (Edwards Sapien Ultra (Edwards Lifesciences, Medtronic, USA) or Merill MyValve (Life Sciences Pvt. Ltd, India)) was made by the surgeon. After surgery, patients were transferred to the intensive care unit for observation and returned to the ward on the evening of the day of surgery or, at the latest, next morning. When stable, patients were mobilized to walk on the surgery day and discharged within two or three days postoperative.

Intervention

The technologies used for the pilot study are illustrated as supplementary material. The intervention lasted three weeks.

Technology and management

The technologies were introduced during a home visit, one week after hospital discharge. A booklet containing written user instructions for each element of the intervention and a schedule of rehabilitation activities was provided to each patient before hospital discharge. The booklet was continuously adjusted during the study period, according to the feedback from the patients.

For delivery of the video-training sessions at the hospital, we used a 49” TV monitor, a high definition sound bar, and a Bluetooth headset for enabling two-way communication during each session.

Tablet

All participants received a tablet (iPad, Apple, Cupertino, USA), provided with a SIM card for data coverage. For the online training sessions, we used an encrypted video conferencing system (Videosamtale) hosted by Aalborg University Hospital, that complies with the general data protection regulation (GDPR) for the European countries. During the home visit, patients were thoroughly introduced to how to connect to the online program and how to access the project website [30] for information and videos related to themes identified as important by patients who had previously undergone TAVI. For simplicity, the tablet setup only allowed the patients to use the TeleTAVI project´s website and an email program for assessing the link to the videoconferencing system.

Activity tracker

We used two different activity tracker models measuring step counts: the Fitbit Charge 3 (Fitbit LLC, San Francisco, USA) and the Beurer AS 87 (Beurer Germany, Swabia, Germany) to identify the most feasible activity tracker, for use in a later extension of the program. Patients filed the daily number of steps in their training diaries, and we uploaded the data stored in each activity tracker after collecting the equipment at patients' homes.

Interventions

Exercise training

The individualized online home-exercise training followed the national recommendations for cardiac rehabilitation with a combination of aerobic and strength training twice weekly, each session lasting 30-45 minutes [31]. The target intensity for the aerobic exercises was of either a heart rate of 80-100 beats per minute (patients wearing Fitbit) or a Borg CR10 dyspnoea 3–5 [32] (patients wearing Beurer). The number of online sessions was set to five. Patients were offered further sessions if able to attend. Additionally, patients were instructed to take a 30-minute walk daily with moderate intensity. Before hospital discharge, patients were instructed about three exercises to be performed on alternate days until the home visit took place (supplementary material).

Follow-up session with a nurse

The one online session with a project nurse was established as a follow-up after hospital discharge. The topics during the sessions were based on patients' perspectives on the development process of the TeleTAVI program [28]. Spouses participated in the sessions at

their own discretion.

Data collection and analysis

Eligible patients were approached for inclusion the day before their surgery.

Assessments

Demographic and perioperative data were collected from patients´ medical journals. The following assessments were performed the day before surgery to evaluate patients' preoperative functional status and to target the exercise training program: six-min walk test [33]; 30 seconds-sit-to-stand test to assess functional lower extremity muscle strength. [34]; four-meter walk test to assess gait speed. A gait speed <0.7 m/s is defined as frailty in TAVI [35]. Also assessed was dominant hand grip strength using the DHD-1 digital hand dynamometer [34] and Mini Mental Scale evaluation (MMSE) [36]. For health-related quality of life we used the HeartQol [37], which is a disease specific questionnaire validated for patients who have undergone cardiac valve replacement surgery [37,38]. For frailty we used the Tilburg Frailty Indicator (TFI), a validated self-administered instrument for assessing multidimensional frailty in older populations [39]. Number of steps were recorded and compared to those registered in the patients´ step diaries. Furthermore, we collected data on number of home visits for technical support and telephone calls regarding difficulties using the tablet and log-in procedure. Data were stored using REDcap electronic data capture tool (REDCap Consortium, Vanderbilt University Medical Centre, Nashville, US), hosted by the North Denmark Region.

Field notes and logbooks

Field notes consisted of field observations and log-book registrations for each patient regarding their participation in the CTR-program.

Patient interviews

Individual interviews with patients completing the CTR-program were performed to get insight into patients' experiences of being part of the TeleTAVI program and the usability of technologies and devices. The interviews were based on a semi-structured interview guide [40] (supplementary material) and lasted 30-90 minutes. All interviews took place in the patients' homes at the end of the intervention; partners were invited to participate. The

interviews were digitally recorded and transcribed verbatim by a research assistant.

Data analysis

Descriptive statistics were used to describe the study population, using SPSS statistical software, IBM Analytics, NY, USA. Data were presented as median, minimum, and maximum as well as numbers, frequencies, and percentage when appropriate. No formal sample size calculation was performed due to the explorative character of the study and because no efficacy testing was to be performed [41].

The first author read all observations and comments registered in the research diaries. Themes were identified according to the elements that comprised the intervention; findings were reviewed and discussed with the last author. The analysis of each individual interview was carried out as a deductive manifest content analysis, with the aim of creating a condensation of meaning [42]. After familiarization with the text, the interviews were coded and abstracted into categories and subcategories using the coding system NVivo [43]. Both authors reviewed the categories and analysed these according to the different elements of the intervention. The results are presented as a joint display [44], meaning that both quantitative and qualitative results are presented together, according to the source of data: patient citation from the interviews, logbook, or field notes.

Results

Twenty consecutive patients admitted to Aalborg University Hospital for elective TAVI were assessed for eligibility. Thirteen patients with a median age of 83 years (range: 74-87) agreed to participate and performed the baseline assessments. The median length of hospital stay was three days (range: 3-30 days). Five patients (three males and two females) completed the study. All had some experience with either the use of a computer or a tablet, or they could get help from their relatives to manage the technology. Frailty was detected in a single patient completing the study, while three patients in the drop-out group were categorized as frail (Table 1). Reasons for dropouts included tiredness post-surgery (n=2), hospital readmission (n=1) and poor mobile coverage (n=1) among others (Figure 1, study flow chart). The first three included patients were introduced to the technology on the first postoperative day and reported that they were tired and could not concentrate on the technology at that time. Thus, the introduction to the technology was scheduled one week after hospital discharge.

The results and findings are presented as a joint display (Table 3) and are summarized into the following categories: home based rehabilitation, online exercise training, activity tracker, online session with the nurse, website and technical issues. Each category is elaborated separately.

Table 1 Demographics and surgical characteristics of participants

Variables	Included N=13	Completed the study N= 5	Did not complete the study N= 8
Age, years	83 (74;87)	82 (74;84)	83 (75;87)
Gender, n (male %)	8 (63%)	3 (60%)	5 (63%)
BMI,kg/m^2	26 (23;30)	26 (23;27)	28 (24;30)
Co-morbidities, n (%)			
Hypertensio arterialis	8 (62%)	3 (60%)	5 (63%)
Ischaemic heart disease	4 (27%)	2 (40%)	2 (25%)
Previous stroke	2 (15%)	1 (20%)	1 (13%)
Atrial fibrillation	3 (23%)	2 (40%)	1 (13%)
Diabetes mellitus	4 (27%)	1 (20%)	3 (37%)
Left ventriculum ejection fraction	60 (40;60)	60 (40;60)	60 (45;60)
NYHA functional class II; III; n (%)	8 (62%); 5 (38%)	4 (80%); 1 (20%)	4 (50%); 4 (50%)
ASA 3; 4, n (%)	3 (23%); 10 (77%)	1 (20%); 4 (80%)	2 (25%); 6 (75%)
FEV1%	77 (52;132)	61 (52;132)	80 (52;125)
Aortic peak gradient	83 (50;140)	77 (50;140)	87 (55;105)
Hæmoglobin	8.2 (6.6;9.5)	8.5 (7.2;8.9)	8.2 (6.6;9.5)
Length of hospital stay *	3 (3;30)	3 (3;6)	3.5 (3;30)
Physical functioning			
Six-min walk test, meter	400 (136;543)	460 (299;543)	391 (136;499)
Walked distance % expected	97 (36;143)	104 (63;143)	97 (36;113)
Gait speed 4m	03.90 (02.98;10.20)	03.71 (03.15;04.26)	04.15 (02.98;10.20)
Sit-to-stand-test 30 sec	10 (6;16)	11 (8;15)	10 (6;16), n=7
Hand strength % expected	123 (82;162)	108 (84;162)	127 (82;160)
Mini Mental State Examination	30 (28;30)	30 (29;30)	30 (28;30)
HeartQol questionnaire	2.21 (.71; 2.86)	2.5 (0.86;2.86)	1.75 (0.71;2.64)
Sociodemographics, n (%)			
Living alone	3 (23%)	1 (20%)	2 (25%)
Educational level			
Public school/short education	8 (61%)	2 (40%)	6 (75%)
Medium education	3 (23%)	0 (0%)	3 (37%)
Long education	2 (15%)	1 (20%)	1 (12%)
IT skills, n (%)			
Novice	3 (23%)	0 (0%)	3 (37%)
Acquainted with tablet/PC **	10 (77%)	5 (100%)	5 (62%)
Tilburg Frailty Indicator, total score	3 (0;8)	2 (0;8)	1(0;8)
Not frail, n (%)	9 (69%)	4 (80%)	5 (63%)

Frail (≥ 5 points), n (%)	4 (31%)	1 (20%)	3 (38%)

Data are presented as median (min, max), unless otherwise stated
*Includes operative day; **Patient or next of kin
Abbreviations: BMI, body mass index; NYHA, New York Heart Associations functional classification; ASA, American Society of Anesthesiologists functional classification; FEV1%, Forced expiratory volume in the first second.

Table 2 Joint display of results and findings summarized into categories, according to the source of data

Categories	*Source of data*		
	Patient citation from the individual interviews	*Logbooks*	*Field notes*
1.Home-based rehabilitation	1. Well, my goodness, you have not only received a new heart valve, you have received such an embrace of what you [red. health professionals] have given, to be able to feel good afterwards and beyond. I just feel it´s been so good. One is shown the way forward (patient, female). 2.It´s a good thing too, because if people are debilitated, and are in doubt about whether you can hold to such a training trip. You can just be at home, and then jump on. So, I, that´s for sure. This is fine, Corona [red Covid-19] or not (patient, male).	Home visits for technology introduction: n= 8; lasted 1½-2 hours each. Additional home visits for technical support: n=6 Transportation between the hospital and patient´s homes varied from 20-80 km	Easier to establish a relationship during the home visit, when patients had met the health professional during hospital stay. Easier for patients to follow the instructions, when these were practical.
2.Online exercise training	3.I think it has been nice to have things shown. And I think it has been great to have the tablet to look at when we did the exercises. So, it was nice, (…) also like today where you could correct me if it was wrong or it was right, right? So, I think it´s been fine (patient, female). 4.We often said to each other ”There are some muscles we do not use”, we think ”you do not need to do”, but when we have finished [red. training], there were some muscles we have used, which we do not usually use, so just like the arms all the way up and like that, that´s not how we are used to (spouse, female). 5. It [red. training] was on certain days, so I had to get it over, then I could give myself to do something else. I could not go out in the fields or anything else before it was over (patient, male). 6.Well I can tell you. When we stand and do it [red. training], I feel, well you´re in here in the living room, you are standing and directing and your friends there, they are standing here. This is how I feel, we´re a small bunch of people (patient, female).	Numbers of training sessions per participant varied from 2 (n=1) to 7 (n=1) The number of participants per session varied from one to three The sessions lasted 30-40 minutes each The heart rate during the aerobic exercises varied from 70–90 beats per minute. For the CR10 dyspnea, the reported rating was 3-4.	Two spouses joined the training sessions. No adverse events occurred during the online training sessions. Giving individual guiding during online sessions was challenged, when more than two patients participated. An advantage to monitor the heart rate for targeting training intensity. Trying exercises and training equipment out during the home visit supported individualization of exercises for the online sessions.
3. Activity	7. Well, it was motivating because that, then I reach the 1.700 [steps]	Number of steps per day:	Three patients returned their training

tracker	here, you know, well, then I´ll take a walk up in the woods and reach 2.000 (patient, male). 8. It has not worked, just lying on the table there, with power on. I thought it was missing power, but then you said I should wear it in my wrist, and then the shit worked. Then I went on the big walk, to get many steps (patient, male).	1.868 to 17.280; distance varied from 1.457-7.840 meters Number of days the units were used: 7-28 days	diaries. There was concordance between patient registered data and the unit´s stored data. Only one user registered data for all days.
4. Online session with the nurse	9. Can well remember that we should get ready for the conversation. I think it gives a bit of reassurance, there is someone who is interested in you, right? (Spouse, female).	Five sessions took place, lasting from 20-45 minutes each. One session was as a telephone call	Virtual face-to-face meeting was a positive experience and the issues discussed were mostly of practical nature.
5. Website	10. Watched patient and relatives' videos, that is, the different ones telling about how they have experienced it. The videos were very, very good, mostly listened to the videos, not read that much (patient, female).	Log-in entry data was not collected.	The introduction to the use of the website took place as the last part of the home visit.
6. Technical issues	11. I am not used to using a tablet. I have a computer that I always use. So that way, I´m used to using technology, but I´ve never used a tablet before (patient). 12. I totally get [goose] bumps when I think about, no, you have to, can you, you cannot figure it out (patient, female). 13. If there were many [participants], then the pictures got small, and then you have to get closer. It would be better if there was a big picture of you [instructor], and small of the others (patient, male).	Telephone guidance to the log-in procedure given to four out of five users, often for the first session. One participant needed telephone guidance for all sessions	*External challenge*: Unstable or insufficient 4G net coverage; program/net outage. *User related challenge*: IT novice in the use of a touch screen or email program; guidance for session login was often necessary; impaired vision-or hearing. *Functionality:* *Tablet*: customization to each user; relatively small screen size, when more than two users are online at the same time; user forgets to charge the battery. *Equipment:* a 49" monitor facilitates viewing users logged in; a large screen enhances provision of individual guidance for the online training.

Home based rehabilitation

The home setting was practical, and patients felt privileged to participate. Meeting the same health professionals throughout the whole process facilitated continuity and was appreciated by the patients and the health professionals involved. Meanwhile, the introduction to the technologies and provision of technical support were time-consuming for the health care professionals.

Field notes showed that the practical tasks learned during the home visit supported most patients in using the technology and joining the online sessions.

The interviews revealed that patients completing the program were positive about the TeleTAVI program and felt cared for, instead of feeling left alone after hospital discharge (Table 3, citation 1). The home-based setting was perceived by the patients as practical and as an advantage, since no transportation to a community center was necessary. The home-based setting was also especially valued due to the restrictions on social interaction during the Covid-19 pandemic (Table 3, citation 2).

Online exercise training

The number of training sessions per participant ranged from two (n=1) to seven (n=1) and no adverse events occurred. The instruction on the exercises and training equipment during the home visit was helpful for later individualization of exercises and was also valued by the patients. Targeting the training intensity was feasible, regardless of the method used (heart rate or level of dyspnea). However, it was a challenge for the instructor to provide individual guidance when more than two patients were online in the same session.

Patients experienced exercise training online as motivating and “real”, and several factors contributed to that. Firstly, this was due to the use of known exercises (Table 3, citation 3). Secondly, patients could see the physiotherapist on the screen while receiving guidance as to the correct exercise performance and they were able to exercise the whole body (Table 3, citation 4). Thirdly, they felt committed to the online sessions, though such commitment could also be a barrier to performing usual daily activities (Table 3, citation 5). While a one-to-one online training seemed to be most efficient, voiced as “to see the instructor was the most important”, exercising in a group could also be motivating,

as it enhanced the feeling of not being alone (Table 3, citation 6).

Activity tracker

There was a large variation between patients regarding the number of steps taken per day, varying from 1,868 to 17,280. Wearing an activity tracker was perceived by the patients as a way to verify the usual number of daily steps taken. Expressions like "all steps count" often occurred throughout the interviews, when patients described positive experiences with wearing the device, which could be a motivation to increase the daily number of steps (Table 3, citation 7). Others did not wear the device throughout the intervention period, either because they were reassured that their usual daily steps exceeded the recommended or because they did not understand how to manage the device (Table 3, citation 8).

Online session with the nurse

Five online sessions were conducted. The issues discussed were mostly of practical nature, such as medication, pain, and sleeping. The project nurse experienced the virtual face-to-face conversation with the patients as positive, since their body language was visible, which was indicative of patients´ actual well-being. Patients and spouses appreciated the provision of the follow-up after hospital discharge (Table 3, citation 9), although most of them could not recall the specific issues discussed.

Website

Overall, the project website was only occasionally used by the patients, mostly because they forgot that they could access it. When it was used, patients, and eventually their spouses, appreciated watching the videos in which other patients talked about their own course of disease, treatment, and recovery (Table 3, citation 10). Patients were not interested in viewing the videos with information on self-training.

Technical issues

Challenges regarding the use of the technology were experienced by both patients and health care professionals. These were categorized into being of external, or user- or

functionality-related.

The main external challenge was unstable or insufficient 4G data coverage mostly in low populated areas, which could often be solved by connecting the tablet to the users' Wi-Fi when available. One dropout was due to unstable data coverage.

User-related challenges were associated with the lack of prior experience with virtual communication platforms, such as handling emails or dealing with a touch screen (Table 3, citation 11), and this lack often required IT support, which was provided by telephone. Customization of the tablet was provided when necessary; for instance, by adjusting the time period for the screen touch. Patients expressed different ways of managing challenges with the use of a tablet, ranging from confidence to lack of faith in their own ability (Table 3, citation 12). One patient expressed that he had no interest at all in the use of digital technology and left such issues to his spouse. Regardless of the individual approach taken, patients did manage to use the tablet to participate in the online training sessions.

Challenges concerning the functionality of the tablet were also detected. For the patients, the main challenge was related to the tablet's relatively small screen size and visual deficits, since it was important to be able to see the instructor's full body, so they could better follow the exercises (Table 3, citation 13). For the health professionals, instructing the patients in the TeleTAVI during the home visits took from 90 minutes to 120 minutes, meaning that it was a time-consuming task and, further, one that continued as they had to instruct and guide the patients afterwards, for log in to the training sessions. going forward.

Discussion

Exercise-based telerehabilitation for the elderly after TAVI does not seem feasible in the presented form, as 70% of the included patients did not complete the study. Barriers negatively influencing adherence to the program included poor data coverage, participants' limited IT skills, and the functionality of the systems used. Meanwhile, qualitative findings suggest that the TeleTAVI program supported a personalized, tailored, training intervention in patients completing the program. The home-based online delivery form of the exercise training sessions was appreciated by the patients, since there was no need for transportation, and they felt that they exercised their whole body while getting real-time

feedback. Still, the program was time-consuming for the health care professionals, since a great deal of time was used for transportation, home instruction, and IT support. No adverse events occurred. An overview of the key findings is presented in Figure 2 and include advantages, facilitators, barriers, and perspectives for future research. Aspects that support retainment rates and enhance patients' IT skills need to be further addressed, before the program can be used in a larger scale, such as a randomized controlled setting, as intended.

Advantages and facilitators

Findings from this first study on TAVI CTR are in line with the existing knowledge of the use of CTR in patients with other cardiac conditions. In particular, the easy access to exercise training with no need of transportation to a rehabilitation center is a well-described advantage that promotes patient engagement and adherence [23,45]. Exercise supervision is a key element in center-based CR in order to individualize the exercises and provide enough training load to achieve gain in cardiorespiratory fitness [31]. In the present study, we experienced that the virtual feedback allowed for individualization during the training sessions, while the provision of exercise equipment facilitated patients reaching a proper training load. This was facilitated by the face-to-face introduction to the exercises during the introductory home visit. These elements were also voiced as important by the participating patients and their spouses, possibly supporting adherence to the program. Furthermore, the use of adequate equipment for video-training delivery at the hospital facility was vital for enabling a two-way communication during each session.

Barriers

We were particularly challenged as many patients did not complete our study because they could not manage the technology or because of technical issues. Firstly, in the short study period, we experienced outage of both the broadband connection and the video conferencing app. A stable internet connection was a premise for the use of the videoconferencing system. Even though the tablet had a 4G SIM card, we still experienced unstable data coverage in both rural and urban areas, a reason for two patient withdrawals. If required and available, we connected the tablets to patients´ own Wi-Fi, to

ensure proper running of the videoconferencing system and to enhance program compliance. To date, many homes still do not have internet. In 2019, 10% of Danish citizens reported not having broadband at home, in particular seniors age 75-89, of whom 29% have never previously accessed the internet [46]. This may pose a challenge for future TR delivery, particularly for the elderly population. Secondly, according to the initial study protocol, we introduced patients to the technology during their hospital stay, which was probably not the best introduction time for new technology in this older population. Consequently, we adapted the protocol and introduced the technology at the home visit one week after hospital discharge, and then had no further patient withdrawals due to this reason. Finally, the set-up for the intervention was time consuming for the health care professionals, as a great deal of time was spent on introduction to the telerehabilitation packet, IT support, and transportation. This may also be a barrier for future implementation of CTR after TAVI.

Future perspectives

Findings from our feasibility study indicate that the use of telerehabilitation technology in older persons who have undergone TAVI, although challenging, is also promising, since many patients are acquainted with the use of smartphones and tablets, and patients completing the program appreciated the home-based online setting. Therefore, we recommend two major changes for future TAVI-CTR intervention. Firstly, an extension of the program to eight weeks post-TAVI, since a longer intervention period may facilitate patients to become more acquainted with the technology. Also, the provision of remote IT support may support patients in using the tablet properly. Secondly, we´ll use a wireless platform, for collection of data on daily steps, that complies with institutional GDPR regulations [21]. Devices with commercial applications and that automatically upload to a tablet, and store, patients´ data on daily number of steps may not comply with GDPR regulations for data safety and privacy in research [47].

With as few as 10-20 % of patients attending CR after TAVI [11,23], delivery models that are alternative to the established center-based CR still need to be developed and tested to enhance patient uptake to rehabilitation post-surgery, as well as contribute to establish evidence on the effect of CR following TAVI. However, it is also important to bear in mind that patients who undergo TAVI are often octogenarians and frail [6,48], which may

have influenced patient withdraws in our study.

Strengths and limitations

As a single-center trial with no control group, our study has a limited generalizability. Also, we included a small number of participants due to study´s proof- of concept nature with a limited inclusion period. However, it is a strength that we screened all patients who were scheduled for a TAVI procedure in our hospital and the recruitment rate was similar to the feasibility randomized study performed by Rogers et al. [8]. Apart from the walked distance, the age of the participants in our study and several clinical features such as the presence of comorbidities, ejection fraction, and NYHA classification, were similar to those in studies investigating the effect of CR following TAVI [8,48–51].

Conclusion

In conclusion, we found that exercise-based telerehabilitation in older patients after TAVI does not seem feasible, as 70% of the included patients did not complete the intervention. Conversely, we found several promising aspects favoring the online setting, since real-time feedback during home training was highly appreciated by those completing the intervention. Aspects that support retainment rates and enhance patient's IT skills need to be further addressed before the program can be used in a larger scale as intended, in the form of a randomized controlled trial.

Acknowledgements

We thank all the clinical personnel involved in the clinical management of the patients.

This study was funded by the Danish Heart Foundation (19-R136-A9035-22130), AP Møller Fund, North Denmark Region´s Research Fund, and North Denmark Region´s Innovation Fund.

Declaration of conflicts

The authors declare no conflict of interest

Abbreviations

AS: Aortic valve stenosis

CR: Cardiac rehabilitation

CTR: Cardiac telerehabilitation

GDPR: General data protection regulations

TAVI: Transcatheter aortic valve implantation

TFI: Tilburg frailty indicator

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Supplementary Files