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A multicomponent intervention to decrease sedentary time during hospitalization: a quasi-experimental pilot study

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Abstract

Objective: The aim of this study was to evaluate the feasibility and preliminary effects of a multicomponent intervention to decrease sedentary time during and shortly after hospitalization.

Design: This is a quasi-experimental pilot study comparing outcomes in patients admitted before and after the implementation of the intervention.

Setting: The study was conducted in a university hospital.

Subjects: Participants were adult patients undergoing elective organ transplantation or vascular surgery.

Interventions: In the control phase, patients received usual care, whereas in the intervention phase, patients also received a multicomponent intervention to decrease sedentary time. The intervention comprised eight elements: paper and digital information, an exercise movie, an activity planner, a pedometer and Fitbit Flex™, a personal activity coach and an individualized digital training program.

Measures: Measures of feasiblity were the self-reported use of the intervention components (yes/no) and satisfaction (low–high = 0–10). Main outcome measure was the median % of sedentary time measured by an accelerometer worn during hospitalization and 7–14 days thereafter.

Results: A total of 42 controls (mean age = 59 years, 62% male) and 52 intervention patients (58 years, 52%) were included. The exercise movie, paper information and Fitbit Flex were the three most frequently used components, with highest satisfaction scores for the fitbit, paper information, exercise movie and digital training. Median sedentary time decreased from 99.6% to 95.7% and 99.3% to 91.0% between Days 1 and 6 in patients admitted in the control and intervention phases, respectively. The difference at

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Day 6 reached statistical significance (difference = 41 min/day, $P = 0.01$). No differences were seen after discharge.

Conclusion: Implementing a multicomponent intervention to reduce sedentary time appeared feasible and may be effective during but not directly after hospitalization.

Keywords

Physical therapy, exercise, sedentary behavior, telemedicine, hospitalization

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Introduction

In many patients, hospitalization is associated with physical inactivity and more time spent sedentary, in some leading to a longer length of stay and functional decline during and after hospitalization.[1–7] In the last 10 years, several randomized controlled trials (RCTs) studied the effect of physical activity interventions during and after hospitalization. A recent systematic review, concluding that the effect of physical activity interventions on physical performance in older patients during hospitalization was uncertain, included 15 trials.[8] The interventions used in those trials varied considerably and comprised (supervised) physical exercise program(s) with mobility, flexibility, strength, balance, walking and functional exercises,[9–19] proprioceptive neuromuscular facilitation,[20] electrical stimulation,[21] vibration training[22] and horse riding stimulation.[23]

Four RCTs published afterwards[24–27] investigated one or more (supervised) physical exercise program(s) including mobility, flexibility, strength, balance, walking and functional exercises. These RCTs showed contradictive evidence for the effect of physical interventions during and after hospitalization, with two studies showing a positive effect, one on physical activity[27] and the other on physical performance,[24] and two studies demonstrating no effect on physical performance measures.[25,26]

The interventions in some of the aforementioned studies were delivered by means of eHealth.[18,19,23] eHealth is defined as the use of information and communication technologies to support or improve health and health care.[28] eHealth has a broad area of application to facilitate physical activity in patients such as mobile (exercise) applications to facilitate physical activity in particular, by means of, for example, the provision of digitial information, mobile (exercise) application activity trackers (measuring physical activity).[18,19,23,29–31]

In the literature, including the aforementioned studies on physical activity interventions in hospitals that were using eHealth, eHealth applications are mainly studied as single interventions. It is, however, advocated to combine them with face-to-face contacts, including individual or group education.[32,33] This advice is based on observations that adherence rates of eHealth interventions are in general disappointing,[33] whereas personal contacts with health professionals can increase their uptake.[34] Such a combination of eHealth and therapeutic guidance is called "blended care" or "technology supported care."[35] A multicomponent intervention may also help to tailor the intervention to patients' personal needs, as a recent study among 336 hospitalized patients showed that individual preferences regarding the promotion of physical activity may vary considerably.[5] However, to our knowledge, there are no studies investigating the effectiveness of a blended physical therapy intervention during hospitalization. A missed opportunity since hospitalized patients are often more sedentary than strictly necessary.[1]

Thus, to our knowledge, there are no studies investigating the effectiveness of a blended physical therapy intervention during hospitalization. The aim of this study was, therefore, to evaluate the feasibility and preliminary effectiveness of a multicomponent physical therapy intervention comprising both eHealth and non-eHealth elements to decrease sedentary time of patients hospitalized for vascular or transplantation surgery.

Methods

This study was conducted at the vascular and transplantation surgery wards of the Leiden University Medical Center (LUMC) in the Netherlands between July 2015 and March 2016. The study protocol complied with the Declaration of Helsinki and was approved by the Medical Ethics Review Committee of the LUMC (protocol no. P15.026) and registered in the Netherlands Trial Register (no. NL7820).

As shown in Figure 1, a quasi-experimental design was used, with three phases—(1) a control phase (four months): patients included in this phase received care as usual; (2) a one-month implementation phase: in this phase, physical therapists (PTs) were trained and nurses/physicians were informed about a multicomponent intervention to decrease sedentary time, and the recruitment of patients paused during this phase; and (3) an intervention phase (four months): patients included in this phase (recruitment restarted) received the multicomponent intervention, alongside usual care.

During both the control and the intervention phases, all consecutive adult patients who were scheduled for elective (scheduled in advance) surgery at the transplantation surgery ward (e.g. kidney transplant, pancreas transplant) or the vascular surgery ward (e.g. aneurysm surgery, femoral-tibial bypass) and with a planned hospital stay of at least three days were invited to participate in the study. The inclusion criteria were as follows: living independently before admission, ability to understand Dutch and having sufficient mental and physical abilities to undergo the intervention and to complete a pen-and-paper questionnaire. In close consultation with the treating physician, patients with a poor prognosis for recovery were excluded from the study.

The screening for eligibility for the study was done prior to surgery by the PT and the treating physician based on the study criteria. All eligible patients were informed about the study and were invited to participate by means of an information letter sent by postal mail, followed by a phone call from one of the researchers (D.C. or L.F. (PT)). If a patient met the criteria and agreed to participate, written informed consent was obtained and the baseline questionnaire was completed before surgery. Participating patients who were readmitted to the hospital during the study period were not invited to participate in the study for a second time. During the control phase (CG), all patients received regular PT based on their individual needs if necessary, and by referral by the treating physician. Regular PT was conducted by hospital PTs who were working exclusively at the transplantation and vascular surgery wards.

Patients included during the intervention phase received a multicomponent intervention during hospitalization and the first month after discharge in addition to regular physical therapy (physical therapy by indication). This multicomponent intervention comprised eight eHealth and non-eHealth elements (see Supplemental Appendix 1): (1) paper information about the importance of physical activity before, during and after discharge; (2) digital web-based information about the importance of physical activity before, during and after discharge; (3) an exercise movie comprising strength or mobility exercises (available on hospital television, mobile phone, laptop or tablet); (4) an activity planner (only used during hospitalization) consisting of a board with icons attached to the headend of the patient's bed, informing the patient, clinicians and family about the functional mobility of the patient; (5) a pedometer for patients to monitor their own physical activity; (6) a wearable activity tracker (Fitbit Flex™) to monitor their own physical activity; (7) personal activity coaching, consisting of the opportunity for patients to contact a physiotherapist by email or phone for support or to ask questions, available both from admission until one month after discharge; and (8) access to Physitrack™, which is an app-based digital exercise program, tailored by a PT for every individual patient.

The multicomponent intervention started on the first day after surgery, or in case of a post-surgery intensive care (IC) period, on the day of transfer from the intensive care unit (ICU) to the clinical ward; it was delivered on all weekdays by two PTs (D.C. and L.F.), except for the digital exercise program Physitrack which was delivered by the PT of the transplantation surgery ward or of the vascular surgery ward if necessary. Assessments (Figure 1) were done at admission (baseline), during hospitalization, at discharge from hospitalization, one

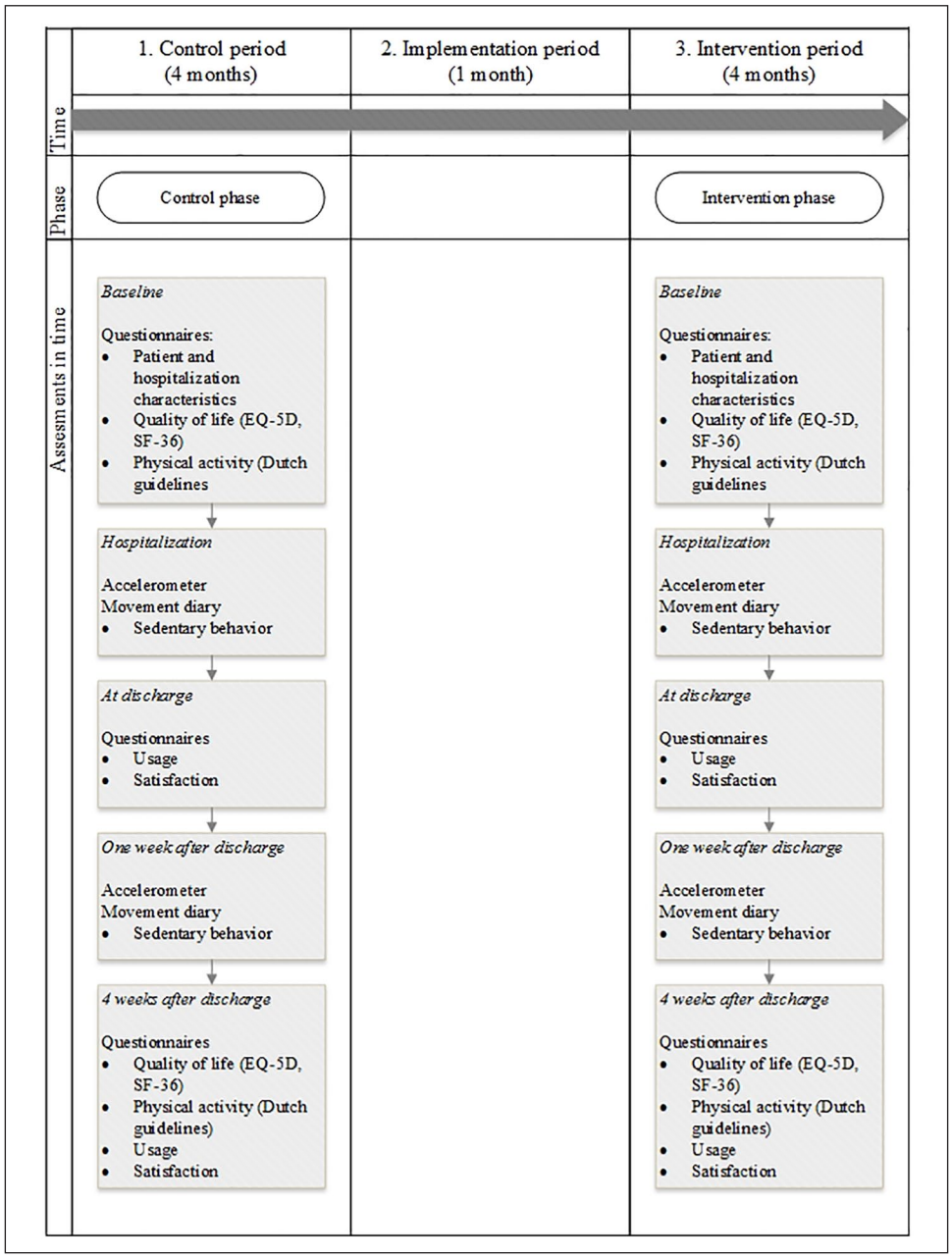

Figure 1. Assessments at the different time points in the study.

and four weeks thereafter (by D.C. and L.F). Assessments consisted of questionnaires (baseline, discharge from hospitalization, four weeks after discharge), a three-axis accelerometer to assess physical activity behavior (during hospitalization and one week after discharge) and a diary for physical activities (during hospitalization and one week after discharge).

The following patient and hospitalization characteristics were extracted from the patients' medical files: date of birth, sex, date and reason for hospital admission, date of surgery and date of discharge. The following personal and sociodemographic data were collected by means of a questionnaire: weight (kg) and length (cm) to compute the body mass index (BMI: kg/m^2); living status (living alone, with partner or family, living in a nursing home, other status); educational level (low: up to and including lower technical and vocational training, medium: up to and including secondary technical and vocational training, high: up to and including higher technical and vocational training and university); profession (studying, working, volunteer, unfit for work, housewife or houseman, unemployed or retired); sick leave (yes/no); unfit for work (yes/no); smoking (yes/no, I quit/no, I never smoked); receiving physical therapy before admission (yes/no); in possession of a smartphone, computer, tablet and television (yes/no); using the smartphone, computer, tablet or television for health purposes (yes/no).

The feasibility (use and satisfaction) of the various elements of the multicomponent intervention was evaluated only among patients included in the intervention phase at discharge from hospitalization and one month after discharge by means of a self-developed questionnaire. For each of the eight elements (i.e. eHealth and non-eHealth elements), patients were asked to rate the frequency of use in the past period using a four-point Likert-type scale (often, regularly, occasionally or never) and give a grade for their overall satisfaction (low–high = 0–10).

The main aim of the intervention was to reduce sedentary time by offering patients various options to perform activities and be more physically active. Sedentary time was considered the primary outcome in this study, since patients tend to spend relatively much time lying or sitting following surgery. For this purpose, the daily percentage of sedentary time was measured with an accelerometer (Activ8™ Professional Activity Monitor)[36] and a physical activity diary. For each patient, accelerometery data were collected twice: during hospitalization (excluding IC period) and one week after discharge for one week. The Activ8 is a tri-axial accelerometer worn on the leg that is sensitive to high accelerations in the human activity spectrum. The accelerometer contains a battery, a clock and data storage and is able to convert raw signals into postures and motions. Automated analysis of the angular position of the Activ8 converts raw samples into physical activity classes. The Activ8 is able to distinguish whether a patient is lying, sitting, standing, walking, cycling or running.

During hospitalization, when the patient arrived at the ward, patients were instructed to attach the Activ8 with water-resistant adhesive fixation material on the frontside of the upper leg, 10 cm above the basis of the patella. Patients were informed that the Activ8 should be worn all days and nights during the hospitalization period, and there were no restrictions in daily activities, including taking a shower or bath.

At discharge, patients were instructed to wear the accelerometer for seven days, starting one week after discharge from the hospital, according to the same rules and instructions as the previous period. After wearing the accelerometer for one week, day and night, at home, patients returned the Activ8 by postal mail in a pre-stamped envelope. If a patient was not able to attach the accelerometer to the leg, nurses assisted (during hospitalization) or family members were instructed to do so (after discharge).

The information from the accelerometer was downloaded by the researchers (D.C. and L.F.). Sedentary time was defined as any data from the accelerometer designated by the instrument as either lying or sitting and between 7:30 a.m. and 22:00 p.m. This time frame was chosen since most patients would have been awake. Accelerometer data from the day of discharge were not taken into account, since the sedentary time during that day is not typical for a day spent fully in hospital. If patients had worn the accelerometer at home for more than seven days, only the first seven days were taken into account. The proportion of sedentary time was calculated as the total time spent on sitting or lying divided by 12.5 hours (7:30 a.m. to 22:00 p.m.). If any non-wear time was registered during the 12.5-hour period, the time spent on lying or sitting was divided by the actual time the accelerometer was worn within the time frame between 7:30 a.m. and

22:00 p.m. If any irregularities, unclarities or non-wear time in the accelerometer data occurred, the movement diary was used to check the interpretation of the accelerometer data and discussed among the researchers. On average, the analysis of the data from a single patient of either the hospital period or period after discharge took one hour.

Secondary outcomes concerned measures of health-related quality of life (HRQoL) and physical activity administered at inclusion and four weeks after discharge. HRQoL was measured using the EuroQol 5D (EQ-5D) and the Medical Outcomes Study 36-Item Short Form Health Survey (SF-36). The EQ-5D is a generic measurement of the valuation of HRQoL (utility) in five dimensions: mobility, self-care, usual activities, pain and mood.[37,38] The five three-point Likert-type scale results in a total score (no health to full health = −0.329 to 1.0).

The SF-36 contains 36 questions divided into eight subscales: physical functioning, physical functioning and mental role, social functioning, mental functioning, vitality, pain and perceived health.[39,40] From these subscales, physical and mental component summary scores for HRQoL can be calculated ranging from 0 to 100 (worst to best HRQoL). Physical activity over the past month, summer and winter was measured, using a validated questionnaire to determine whether or not the Dutch recommendations of health-enhancing physical activity (30 minutes of at least moderate intensity physical activity on at least five days of the week or heavy intensive active for at least 20 minutes three times a week) were met (yes/ no).[41]

Statistical analyses comprised the following. The distribution of the data was checked for normality by means of the Shapiro–Wilk test ($P > 0.05$ normal distribution). Baseline characteristics of the patients in the control and intervention groups were presented as means with standard deviation (SD), median with interquartile range (IQR) or number (%) and were compared by means of the unpaired student's *t*-test, Mann–Whitney's *U*-test or chi-square test, where appropriate.

Descriptive statistics were used to describe usage (*n* (%)) and satisfaction (median (IQR)) regarding the elements of the intervention at both baseline and four weeks after discharge. Furthermore, satisfaction was compared (Wilcoxon signed rank test) between baseline and four weeks after discharge to analyze whether there was a difference in feasibility for the elements inside or outside the hospital. Mann–Whitney's *U*-test was used for the comparison of the proportion of time spent on sedentary time for each consecutive post-surgery day between the control group and the intervention groups both during hospitalization and the measurement period after discharge.

In addition, a linear mixed-models (LMM) analysis was used to compare the individual patterns of daily sedentary time during hospitalization between the control group and the intervention group. Main effects and interaction term for group and days were used, with age, gender, BMI and type of surgery (transplantation/vascular) being entered as covariates in the analysis. We first fitted the model with time × group interaction and evaluated the corresponding significance test. Subsequently, the model was refitted after exclusion of the interaction effect, with only main effects for all variables. Models were fit with random effect for both intercept and time effect, based on optimality of Schwarz's Bayesian information criterion (BIC). The same analysis was done to compare the patterns of daily sedentary time during the first week after discharge between the control group and the intervention group with age, gender, BMI, type of surgery (transplantation/vascular) and length of stay being entered as covariates in the analysis.

HRQoL (median (IQR)) and physical activity (*n* (%)) of the intervention and control groups four weeks after discharge and changes over time (four weeks after discharge-baseline) were compared by means of Mann–Whitney's *U*-test or chi-square test. Since this was a pilot study, no sample size calculations were made. All analyses were performed with IBM SPSS, Statistics Data Editor 24. *P*-values less than 0.05 are considered statistically significant.

Results

A total of 187 patients were considered eligible to participate in this study (85 in the control phase

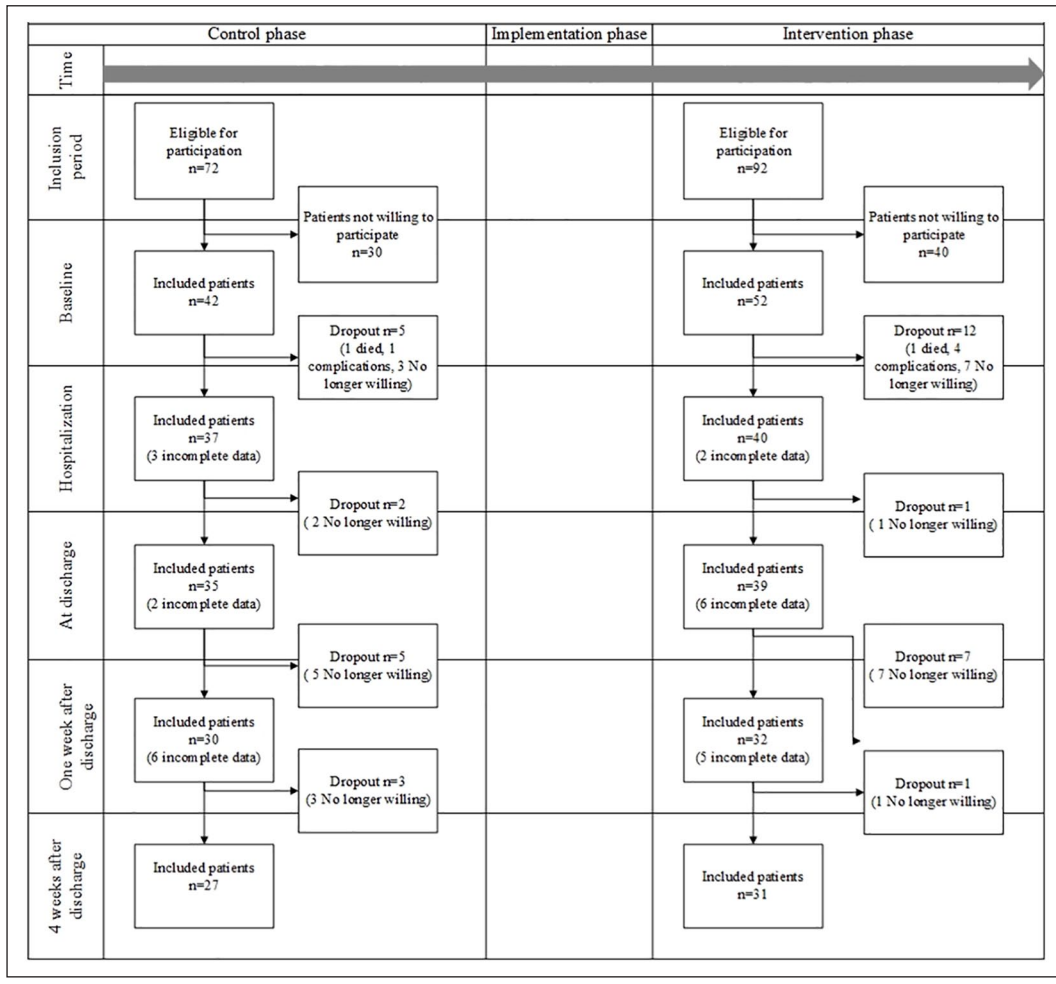

Figure 2. Flowchart of the patients who were eligible for participation in the study.

and 102 in the intervention phase; see Figure 2). Due to logistic issues (e.g. weekend admission or a too short time frame before surgery), 72 and 92 patients were actually invited to participate, of whom 42 (58%) and 52 (57%) agreed to participate and were included in the control and intervention groups, respectively. Patients who dropped out during the study or remained in the study but did not complete all assessements are shown in the flowchart (Figure 2).

Table 1 shows that there were no significant differences in characteristics between the control and the intervention groups, except for a lower use of pre-admission physical therapy and more use of computer/laptop for health purposes in the control group.

Moreover, the average duration of hospitalization and length of stay on the ICU were significantly shorter in the intervention phase than in the control phase (ICU not shown in table: mean = 0.60 days (SD = 0.87) vs 2.3 (SD =7.7); $P = 0.02$).

Table 2 shows the usage and satisfaction of the patients in the intervention group regarding the various elements in the intervention. During hospitalization, the exercise movie, paper information and the wearable activity tracker were used by the

Table 1. Characteristics of patients hospitalized for at least three days at the transplantation or vascular surgery wards of a university hospital during a control and intervention phase.

	Control group (*N* = 42)	*n*	Intervention group (*N* = 52)	*n*	*P*-value
Age in years, mean (SD)	59.1 (13.0)		57.7 (15.0)		0.63
Age categories (years)					
⩽50	12 (29)		14 (27)		
51–64	14 (33)		19 (37)		
⩾65	16 (38)		19 (37)		
Male gender	26 (62)		27 (52)		0.45[b]
Body mass index, mean (SD)	26.2 (4.5)	40	26.2 (4.1)	51	0.98
Transplantation surgery	23 (55)		36 (69)		
Vascular surgery	19 (45)		16 (31)		
Living status		41			0.94[b]
Living alone	13 (32)		15 (29)		
Living with partner/family/other	28 (68)		37 (71)		
Educational level		41		51	0.39
Low	14 (34)		22 (43)		
Middle	13 (32)		10 (20)		
High	14 (34)		19 (37)		
Paid work	13 (31)		21 (40)		0.47[b]
Unfit for work	8 (19)		5 (10)	51	0.33[b]
Sick leave	6 (15)	40	11 (21)		0.63[b]
Smoking		40		51	0.66[b]
Currently smoking	7 (18)		12 (24)		
Previously smoking	33 (83)		39 (77)		
Physical therapy before admission	6 (15)	40	19 (38)	50	0.03[b]*
In possession of device				51	
Smartphone	26 (62)		32 (63)		1.00[b]
Computer/laptop	31 (74)		37 (73)		1.00[b]
Tablet	26 (62)		23 (45)		0.16[b]
Television	42 (100)		47 (92)		0.18[a]
Using device for health purposes				51	
Smartphone	15 (36)		12 (24)		0.29[b]
Computer/laptop	11 (26)		4 (8)		0.04[b]*
Tablet	9 (21)		4 (8)		0.11[b]
Television	17 (41)		15 (29)		0.37[b]

Characteristics are described as *n* (%) unless otherwise stated.
[a]No chi-square test was executed because expected count was below 5.
[b]Chi-square test with Yates' correction continuity.
*$P < 0.05$.

largest proportions of patients, while at home the proportions of patients were highest for paper information, pedometer and the wearable activity tracker used by the largest proportion. More than half of the patients used three or more elements of the multicomponent intervention during hospitalization as well as at home.

Satisfaction with the individual elements during hospital versus at home was highest for the wearable activity tracker, digital training program, the paper

Table 2. Patients' use of and satisfaction with elements of a multicomponent intervention aiming to decrease sedentary time (intervention group only).

	At discharge ($N = 33$)	One month after discharge ($N = 33$)	
How often did you use each of the following elements? *n* (%)			
Paper information			
Used	21 (66)	17 (53)	
Never used	11 (34)	15 (47)	
Website information			
Used	7 (22)	10 (31)	
Never used	25 (78)	22 (69)	
Exercise movie			
Used	22 (69)	13 (41)	
Never used	10 (31)	19 (59)	
Activity planner			
Used	10 (32)		
Never used	21 (68)	Was not used at home	
Pedometer			
Used	9 (30)	14 (47)	
Never used	21 (70)	16 (53)	
Wearable activity tracker			
Used	12 (41)	14 (44)	
Never used	17 (59)	18 (56)	
Activity coach			
Used	5 (16)	1 (3)	
Never used	27 (84)	30 (97)	
Digital training program			
Used	10 (31)	9 (29)	
Never used	22 (69)	22 (71)	
No. of elements used at the same time, *n* (%)			
One	2 (7)	6 (22)	
Two	9 (31)	5 (19)	
Three	7 (24)	7 (26)	
Four	3 (10)	6 (22)	
Five	5 (17)	1 (4)	
Six	3 (10)	2 (7)	
Satisfaction (grades) of the element, mean (SD/maximum–minimum)			
Paper information	7.5 (1.0/5–10)	6.5 (1.3/4–8)	0.03*
Website information	5.5 (2.2/2–7)	5.6 (1.8/2–7)	0.41
Exercise movie	7.4 (1.5/4–10)	6.0 (1.7/2–8)	0.50
Activity planner	7.1 (1.4/5–10)	Was not used at home	
Pedometer	6.0 (2.6/1–9)	5.5 (2.5/0–8)	0.28
Wearable activity tracker	7.9 (1.6/4–10)	6.9 (2.2/1–9)	0.69
Activity coach	6.8 (1.9/4–8)	6.0 (1.4/4–7)	[a]
Digital training program	7.6 1.6/5–10)	6.3 (1.4/3–8)	0.11

[a]Not enough valid cases to perform the Wilcoxon test.
*$P < 0.05$.

Table 3. Percentage of sedentary time during the day of patients admitted for transplantation or vascular surgery.

	n	Control group	*n*	Intervention group	Difference	*P*-value[a]	Difference in time (minutes)[b]
During hospitalization							
Percentage per day on the clinical wards, median (IQR)							
Day 1	34	99.6 (95.7–100.0)	38	99.3 (93.6–100.0)	0.3	0.36	3
Day 2	31	97.8 (94.1–99.7)	34	96.6 (91.0–99.1)	1.2	0.25	10
Day 3	30	96.9 (92.8–99.0)	30	94.2 (87.0–98.4)	2.7	0.18	24
Day 4	25	96.6 (91.2–98.3)	25	93.5 (90.5–96.3)	3.1	0.09	27
Day 5	22	96.1 (91.3–98.6)	17	93.3 (88.4–95.4)	2.8	0.07	24
Day 6	18	95.7 (92.7–98.0)	12	91.0 (87.3–93.2)	4.7	0.01*	41
Percentage per person Days 1–3, median (IQR)	29	97.7 (93.7–99.4)	30	97.3 (93.2–98.5)	0.4	0.26	4
At home							
Percentage per day one week after discharge, median (IQR)							
Day 1	24	84.8 (69.0–91.6)	26	78.1 (68.6–86.3)	6.7	0.28	58
Day 2	24	81.8 (72.6–90.4)	27	79.2 (70.6–86.7)	2.6	0.55	23
Day 3	24	79.4 (70.8–88.5)	26	75.9 (71.7–84.6)	3.5	0.47	31
Day 4	24	77.9 (65.4–85.4)	26	76.4 (67.8–85.5)	1.5	0.80	13
Day 5	24	79.6 (73.4–89.6)	26	77.2 (67.1–88.3)	2.4	0.15	21
Day 6	23	80.2 (71.4–89.9)	26	79.0 (74.4–83.5)	1.2	0.70	10
Percentage per person Days 1–6, median (IQR)	23	80.2 (69.3–88.1)	25	76.7 (70.6–82.3)	3.5	0.48	30

IQR: interquartile range.
[a]Mann–Whitney's *U*-test.
[b]Calculation based on measured timeframe.
*$P < 0.05$.

information and the exercise movie. Satisfaction with the elements was in general lower at home as compared to in hospital, in particular for the paper information.

Table 3 shows the course of the average proportion of sedentary time per day (median % of time spent) on the first six days of hospitalization. Sedentary time decreased between Days 1 and 6 from 99.6% (IQR = 95.7–100.0) to 95.7% (IQR = 92.7–98.0) and from 99.3% (IQR = 93.6–100.0) to 91.0% (IQR = 87.3–93.2) in the control and intervention groups, respectively. On Day 6, sedentary time was statistically significantly lower in the intervention group compared to the control group. This difference in proportion of sedentary time equals 41 minutes of sedentary time in favor of the intervention group.

To take into account all days of hospitalization, an LMM analysis during hospitalization, including interaction between the between-subject and within-subject factors (control/intervention group × time (days) interaction), provided no evidence in favor of this interaction effect on sedentary time ($P=0.11$, 95% CI = (–1.57, 0.17)). After removing the interaction term and re-fitting the model, we found no evidence of the main effect for the between-subject factor (the main effect for control vs intervention group; $P=0.60$, 95% CI = (–1.79, 3.08)) during hospitalization over time for sedentary time.

One week after discharge, the median % of time spent on sedentary activities did not differ groups on any measurement day. Taking into account all measurement days, the LMM including interaction (control/intervention group × time (days) interaction) provided no evidence in favor of this interaction effect ($P=0.76$, 95% CI = (–1.36, 1.00)) in sedentary time. After removing the interaction term and re-fitting the model, we again found no evidence of

the main effect between phases (control vs intervention group; $P=0.64$, 95% CI = (–6.23, 3.86)) one week after discharge in sedentary time.

Table 4 shows the comparisons of the SF-36, EQ-5D and proportions of patients meeting the Dutch recommendations of health-enhancing physical activity. There were no significant differences, neither after discharge, nor regarding the change scores.

Discussion

This quasi-experimental pilot study evaluated the feasibility and preliminary effectiveness of a multicomponent intervention to decrease sedentary time during and directly following hospitalization of patients undergoing organ transplantation or vascular surgery. It was found that patients admitted in the intervention phase used on average three or more of the eight components of the intervention, with the paper information, the exercise movie, the wearable activity tracker and the individual digital training program being the most frequently used and best appreciated elements. In comparison with the control phase, patients admitted in the intervention phase tended to spend less time sedentary during hospitalization, but not after discharge. Results have to be interpreted with caution, due to methodological issues, such as the relatively high dropout rate in both the intervention phase and the control phase.

Our results regarding the feasibility of the multicomponent intervention are promising, but the usage of the individual components varied. Approximately 60% of the patients who reported the usage of the elements used three or more components of the intervention during hospitalization and at home. This may not be seen as disappointing, as a broader range of elements was offered so that patients could select those that best fitted their interests and capabilities. This variety of modalities was based on the observation that preferences regarding the promotion of physical activity of patients who are hospitalized may vary considerably.[5] Nevertheless, there was a relatively high dropout rate from the study, and although this occurred in both phases and is thus not likely to be related to the intervention, it cannot be ruled out that the usage and satisfaction outcomes are biased.

The results from our study are difficult to compare with other studies on physical activity interventions during hospitalization,[8,24–27] because these did not investigate multicomponent interventions including various eHealth elements/non-eHealth elements at the same time. However, studies that specifically evaluated the feasibility of single eHealth interventions, such as the study by Laver et al.[19] on an interactive gaming program, showed that their use in a hospital setting was feasible. Our study also found a decreased usage between hospitalization and the first month at home. A similar observation was done in a study by Oesch et al.,[18] where the adherence, rating, enjoyment and motivation regarding exergames during inpatient rehabilitation faded over time, in comparison with conventional exercise therapy. That finding could probably be explained by the "Law of Attrition" describing the exponential decrease within eHealth elements in adherence.[18] Although many solutions to reduce this effect and to maximize patient engagements are possible within eHealth interventions,[18] the challenge of long-term adherence remains. It should be considered, however, that with time, the need for the intervention may decrease because the patients' health status improves.

Our results regarding the preliminary effects of the multicomponent intervention are similar to other studies evaluating physical eHealth interventions' effects on physical performance by Layer et al.[19] and Kim et al.[23] These studies described significant improvements on capacity tests (e.g. the Functional Reach Test, Timed Up and Go Test and Timed 10-meter walk test) of the elderly patients in a (geriatric) hospital who received a physical eHealth intervention compared to patients who received conventional care or ball therapy. Although these outcome measures differ from accelerometry, both describe the functional status of a patient. In the absence of other studies investigating the effect of blended care on physical activity, our study shows similar results as the study of Wanigatunga et al.[27] Wanigatunga's study found that accelerometry-based physical activity increased in older patients

Table 4. Health-related quality of life and physical activity of patients before and after transplantation or vascular surgery.

	Baseline			One month after discharge			Difference Baseline to one month after discharge		
	Control group	Intervention group	*P*-value	Control group	Intervention group	*P*-value	Control group	Intervention group	*P*-value
HRQoL									
SF-36 PCS	*n* = 40	*n* = 47		*n* = 26	*n* = 27		*n* = 26	*n* = 27	
Median	35.3	44.5 (47)	0.14[a]	35.0 (26)	36.9 (27)	0.59[a]	−1.5 (26)	−7.0 (27)	0.11[a]
IQR	27.8 to 47.9	32.1 to 51.1		26.4 to 43.2	29.5 to 42.6		−8.2 to 7.0	−16.0 to 0.5	
SF-36 MCS	*n* = 40	*n* = 47		*n* = 26	*n* = 27		*n* = 26	*n* = 27	
Median	51.6	51.6	0.84[a]	49.6	50.9	0.94[a]	−1.0	−0.7	0.96[a]
IQR	35.0 to 55.0	40.4 to 55.4		41.2 to 58.0	42.8 to 55.0		−6.0 to 7.8	−6.8 to 6.8	
EQ-5D	*n* = 39	*n* = 45		*n* = 27	*n* = 29		*n* = 26	*n* = 25	
Median	0.81	0.81	0.48[a]	0.81	0.81	0.85[a]	0.00	0.00	0.19[a]
IQR	0.65 to 0.84	0.69 to 0.85		0.78 to 0.89	0.71 to 0.86		−0.01 to 0.17	−0.14 to 0.04	
Physical activity									
Dutch recommendations, *n* (%)	13 (31)	32 (62)	0.08[b]	12 (29)	17 (33)	0.51[b]			

EQ-5D: EuroQol 5D (low–high = 0–1); HRQoL: health-related quality of life, IQR: interquartile range; SF-36 PCS: 36-Item Short Form Health Survey–Physical component score (low–high = 0–100); SF-36 MCS = 36-Item Short Form Health Survey–Mental component score (low–high = 0–100).

[a]Mann–Whitney's *U*-test.

[b]Chi-square test with Yates' correction continuity.

receiving center-based exercise sessions combined with home exercise sessions after hospitalization for one year. In addition, Wanigatunga et al. also found similar findings on the long-term effects between groups and no interaction between group and the time, using a LMM analysis. However, our study especially contributes to modern care by evaluating physical activity of patients receiving this multicomponent intervention, including evaluating the feasibility of the multicomponent intervention.

Our study had several limitations. First, we included at the patient level, so in the intervention phase there was a mix of patients who were participating in the study and patients who were not included in the study. If all patients at one specific ward had been included in the study, instead of a sub-selection based on pre-defined inclusion criteria, there might have been more mutual solidarity to be physically active, so the effect of the multicomponent intervention could have been larger. Second, the dropout rate was considerable and may have led to attrition bias. Nevertheless, we tried to reduce the impact of attrition bias using the intention to treat analysis. As the dropout rate was similar in both phases (36% control, 39% intervention), it is not likely to be associated with the intervention. Third, at baseline we found that the intervention group had received more physical therapy before admission. As a consequence, patients in the intervention group could have been more susceptible to reduce sedentary time after the surgery. Fourth, the study was conducted in two wards of one university hospital in the Netherlands, which limits the generalizability of the results to other hospitals and countries where the contents of the conventional (physical) therapy or occupational therapy may differ. Fifth, some of the assessments applied were subjective by nature. We used patients' self-reported data to collect data about height and weight, whereas more objective data from the anaesthesiologist's record could have been used. Moreover, the use of the various components of the intervention was recorded subjectively, by means of patient report. For some elements, such as the usage of data of the digital training program, data are actually collected in the application itself, yet retrieving that data in a valid manner is very time consuming and not feasible within the available resources. In addition, despite the obvious advantages of accelerometery to monitor physical activity time, it cannot be ruled out that the accelerometer was worn by another person than the actual patient. And finally, this study could not be blinded, as patients, PTs, physicians and nurses were aware of the study phase (control or intervention).

Thus, the findings of this pilot study with a quasi-experimental design suggest that the implementation of a multicomponent intervention to decrease sedentary time during and directly following hospitalization may be effective during hospitalization, but not after discharge. The results must be interpreted with caution, however, due to the aforementioned limitations. First of all, confirmation of the results in a larger study with a randomized design would be necessary. Since the current study did not show a sustained positive effect after discharge, the need for more support for patients in the home setting should be investigated, including patients' preferences for the most appropriate modalities. In addition, further research is needed regarding the characteristics of patients who remain largely sedentary after discharge, so that the interventions can be further personalized. In general, more studies into which components are appropriate for which patients are needed, in order to provide tailored care.

Clinical Message

In patients admitted to hospital for organ transplantation or vascular surgery sedentary time during hospitalization could probably be decreased by means of a multicomponent intervention including eHealth aiming to decrease sedentary time.

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Supplemental material

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