In press Health Psychology

Using Animated Visualisation to Improve Postoperative Mobilisation: A Randomised Controlled Trial.

Annie S. K. Jones[1], Maria Kleinstäuber[1], Amelia Akroyd[1], Annelies Mittendorf[2], Penny Bognuda[3], Arend E. H. Merrie[2], Lois Eva[3], Justin Fernandez[4], & Keith J. Petrie[1]

Author Note

[1]Department of Psychological Medicine, Faculty of Medical and Health Sciences, University of Auckland, Auckland, New Zealand.

[2]General Surgical Service, Auckland District Health Board, Auckland, New Zealand.

[3]Gynaecological Oncology Department, National Women's Health, Auckland District Health Board, Auckland, New Zealand.

[4]Department of Engineering Science, Faculty of Engineering, University of Auckland, Auckland, New Zealand.

Correspondence:
Keith J. Petrie, Department of Psychological Medicine, Faculty of Medical and Health Sciences, University of Auckland, Private Bag 92019, Auckland, New Zealand.
Email: kj.petrie@auckland.ac.nz

Conflicts of Interest: The authors declare that they have no conflict of interest.

Abstract

Objective. Enhanced Recovery After Surgery (ERAS) programmes fast-track recovery for surgical procedures, including colorectal and gynaecological oncology surgery. Early mobilisation is a postoperative ERAS module that can be self-managed by patients, but poor adherence is common. Visualisation is increasingly being used to improve patient understanding of pathological and treatment processes, and adherence to health behaviours. This study tested whether an animated visualisation intervention could improve adherence to postoperative mobilisation. **Methods.** 100 colorectal and gynaecological oncology surgery patients were randomised to an intervention, active control, or standard care control group. Intervention participants saw an animated intervention on a computer tablet at day one post-surgery. All patients wore fitness trackers from day of discharge to seven days post-discharge, and completed psychological measures at baseline, day one post-surgery and seven days post-discharge. **Results.** Step count data was available for 57 participants who were all colorectal surgery patients. There was a main effect of group, whereby intervention participants had a significantly higher average daily step count from discharge across the following week (M_{adj}=2294.60, CI [1746.11, 2744.89]), compared to control participants (M_{adj}= 1347.25, CI [826.51, 1871.20], p= .05). At post-surgery, intervention participants reported significantly greater perceived quality of recovery, and less difficulty in being mobile compared to control participants. **Conclusion.** This brief intervention appears effective in improving perceptions of early mobilisation, and initial evidence suggests improvements in adherence to post-surgical mobilisation. This intervention has high clinical applicability and could be incorporated into postoperative standard care.

Key Words: Early mobilisation, adherence, visualisation, intervention, ERAS

TRIAL REGISTRATION: Australia New Zealand Clinical Trials Registry ID # ACTRN12617000288325

The surgical postoperative recovery period is vital in determining return to good health and functioning for patients. Delayed or problematic postoperative recovery not only increases medical care and burden, but can also indirectly negatively impact the patient and their wider support network emotionally and financially (Lee et al., 2014). Over the last decade, Enhanced Recovery After Surgery (ERAS) programmes have been introduced into hospitals worldwide for a number of surgical services, including colorectal and gynaecological surgery (Gustafsson et al., 2013). ERAS programmes encompass a multi-disciplinary care pathway preoperatively to postoperatively, to reduce surgical trauma and metabolic stress on the body, and to optimise patient outcomes and a faster recovery (Lee et al., 2014; Varadhan, Lobo, & Ljungqvist, 2010). The ERAS items cover biological and medical recommendations (e.g. preoperative fasting, anaesthesia, intraoperative technique, postoperative analgesia) to instructing pre-admission information, education and counselling, and postoperative nutrition and mobilisation (Gustafsson et al., 2013). ERAS programmes have been adopted as standard practise in hospitals worldwide and within New Zealand..

In comparison to standard care, ERAS patients are typically discharged faster with fewer illness-related complications, while experiencing no increased rates of hospital re-admission or mortality (Varadhan et al., 2010). However, optimal recovery is reliant upon adherence to the components of the ERAS pathway. Despite the widespread introduction of ERAS recommendations and guidelines worldwide, non-adherence to ERAS that cannot be explained by major surgical and medical complications is common (Smart et al., 2012).

One key postoperative ERAS module is early mobilisation. Combining early mobilisation with early oral nutrition can help prevent postoperative loss of muscle strength (Henriksen, Jensen, Hansen, Jespersen, & Hessov, 2002), as the improved blood circulation resulting from early mobilisation allows the nutrients received from oral nutrition to be transported more efficiently around the body. Despite this, adherence to early mobilisation remains poor (Bergman et al., 2014; Fiore et al., 2017). Failure to complete early mobilisation is a common reason for ERAS deviation and is associated with poorer recovery (Vlug et al., 2012) and increased hospital stay (Smart et al., 2012). Efforts directed at getting patients to mobilise early can conflict with lay beliefs about bed rest and limited activity being necessary for the body to recover following a major operation (Brieger, 1983). Indeed, the difficulties of attempting to change these perceptions have been highlighted by staff (Pearsall et al., 2015).

There is limited evidence regarding the optimal methods for enhancing postoperative mobilisation. Previous research with colorectal patients has found that staff-facilitated mobilisation (dedicated walking assistance) can improve step count during in-hospital recovery but this is not maintained once the patient leaves hospital (Fiore et al., 2017). A recent systematic review of studies examining the impact of early mobilisation on postoperative recovery all used similar one-on-one style training with patients (Castelino et al., 2016). These staff-facilitated interventions require considerable resources and the efficacy of these interventions in improving mobilisation is inconsistent (Castelino et al., 2016). Staff-directed interventions may force patients to mobilise in hospital, but may not promote self-directed behaviour from the patient once discharged. Finding ways to increase patient self-adherence to postoperative mobilisation could therefore improve patient outcomes, without increasing staff burden.

Enhancing patient understanding of the biological mechanisms and purpose of early mobilisation in improving recovery time could help reduce anxiety and increase adherence to this behaviour. Visual health information or active visualisation is increasingly being used as an intervention technique to improve understanding, motivation, and adherence to health behaviours (Jones, Ellis, Nash, Stanfield, & Broadbent, 2016; Jones, Fernandez, Grey, & Petrie, 2017; Jones & Petrie, 2017; Perera, Thomas, Moore, Faasse, & Petrie, 2014; Stephens et al., 2016). A recent active visualisation intervention for HIV patients failing on treatment in a resource poor area improved adherence as demonstrated by a reduction in the clinical outcome of viral load (Jones, Coetzee, et al., 2018). Visualisation can help patients to understand abstract and conceptual information about how treatments relate to illness by providing a concrete demonstration of processes occurring inside the body. Visualisation interventions are brief and portable, and have successfully been delivered to patients in hospital using technology (Jones et al., 2016).

Clinical staff provide patients with information regarding the importance of early mobilisation as part of preoperative care, and additionally encourage ERAS patients to be mobile postoperatively, however, adherence to that recommendation is largely determined by the patient. A visualisation intervention may therefore help patients to establish a concrete link between the purpose of early mobilisation and their recovery. This understanding may further drive maintenance outside the hospital environment and improve both patient adherence and recovery.

The current study aimed to assess whether a visualisation intervention explaining the purpose of early mobilisation could increase adherence to this behaviour postoperatively. Therefore, the primary outcome of this study was adherence to postoperative mobilisation, operationalised as step count from day of discharge to seven days post-discharge. Secondary outcome measures included changes in perceived quality of recovery from surgery and beliefs about ERAS recovery behaviours. This study also aimed to assess whether this visualisation intervention would be more effective than receiving the same information verbally. To assess this idea, an animated visualisation intervention was developed to deliver to ERAS patients following colorectal and gynaecological oncology surgeries.

Methods

Trial Design and Participants

This study was a parallel, 3-arm, randomised controlled intervention trial with blinded assessors. A sample of 100 ERAS patients undergoing colorectal surgery (n=74) or gynaecological oncology surgery (n=26) were recruited. A recent trial protocol to increase postoperative mobilisation in ERAS patients following visceral surgery, aimed to detect a large effect size, which was an estimated mean change of 250 steps per postoperative day (*SD*= 290 steps per day) (Wolk et al., 2017). A G*Power (Faul, Erdfelder, Lang, & Buchner, 2007) calculation revealed that 84 participants would be necessary to detect a more conservative medium to large effect size of 0.35, at $\alpha= 0.05$, with 80% power and three groups. A sample of at least 96 participants was needed to account for an estimated 15% attrition rate.

Colorectal and gynaecological oncology pre-admission patients at Greenlane Clinical Centre, Auckland District Health Board, were recruited from July 2017 to July 2018. These surgeries have similar operative procedures (within the lower abdominal/pelvic cavity) and ERAS elements (Abeles, Kwasnicki, & Darzi, 2017). Included participants were having elective gynaecological oncology or colorectal surgery at Auckland City Hospital, Auckland District Health Board, could read and understand English, and were over 18 years of age. Exclusion criteria included having known mobility issues pre-surgery. Reasons for patient dropout included feeling too unwell during hospitalisation and having surgery while admitted for other reasons as an inpatient (see Figure 1). This study was approved by the Health and Disability Ethics Committee (17/CEN/47/AM02) and Auckland District Health Board Research Review Committee (A+7552).

Procedure

At pre-admission clinic, specialist nurses from each service referred patients to the researcher (AJ). Study information was provided and written informed consent was received before participants completed the baseline questionnaire. Randomisation was revealed after participants had a date scheduled for their surgery, which always followed the completion of recruitment and the baseline assessment. Participants were randomly allocated in a 1:1:1 ratio into one of three study groups, a standard care control group, a visualisation group, or an active control group. Randomisation was created by someone independent of the study, using a random number generator and contained in opaque, sealed envelopes.

At day one post-surgery, participants were seen by one of two study researchers who delivered the active control and intervention presentations to the patient at their bedside (AJ & MK). A script was used to ensure consistency. Both the intervention and active control presentations took up to ten minutes to deliver. Following this, an independent research assistant (blinded to study group) provided participants with the post-surgery questionnaire, fitted the fitness tracker, and provided a pre-paid courier bag for returning the tracker. Control participants completed the post-surgery questionnaire and were fitted with the fitness tracker.

At approximately seven days post-discharge ($M= 8.61$, $SD= 3.67$), the blinded research assistant completed a five minute follow-up telephone questionnaire with all participants, and reminded them to return the fitness tracker. Participants were sent a $20 shopping voucher to thank them for their participation after the return of the tracker.

All participants in our study received standard care as part of the ERAS protocol of their respective service. As part of Auckland District Health Board services, there is an ERAS nurse specialist who the patient meets with as part of their pre-admission appointment. During this appointment, the ERAS nurse specialists provide patients with practical information regarding the surgery, including what to expect pre-surgery, during surgery, and postoperatively during recovery. This involves informing them about the behaviours that they will be expected to complete before they leave hospital, as part of the ERAS checklist for discharge. These behaviours include early oral nutrition and early mobilisation (which were used to form the basis of the instructions in the intervention outlined below). Patients are generally given a handbook to keep with them that includes this information. The ERAS nurse specialists also attempt to visit all patients in-hospital following their surgery, and nursing and other treating staff follow the ERAS protocols and encourage these behaviours. To meet discharge criteria, patients are expected to be mobilising near normal to how they were prior to surgery, although there is no strict guideline they must meet.

<<INSERT FIGURE 1 ABOUT HERE>>

Intervention

The intervention materials were created by the study authors (AJ, KP & JF) with guidance from clinical collaborators (AM & AM). The intervention described the purpose of early mobilisation, the importance of early oral nutrition, and the link between these two behaviours. The presentation included animations contrasting the internal bodily processes when resting versus when mobile, animations demonstrating digestive processes, as well as real life footage of patient actors (examples in Figure 2). Two versions were created using either a male or female patient actor, and participants saw their gender-match. The intervention was delivered to patients on a computer tablet at their bedside.

The intervention began by addressing common lay surgery beliefs about the need for extended bed rest following surgery, and challenged this by providing information about improved patient outcomes under ERAS. Next, a clip showed the patient actor lying in a hospital bed. The camera zooms in and transitions to an animation showing the resulting effects upon heart rate, blood circulation, and the lungs. These clips were contrasted with the patient sitting upright and walking, and animations showing increases in heart rate, improved blood circulation, and lung function. Following this, participants were given specific instructions about their exercise plan during recovery (from day one to discharge) taken from the ERAS booklet provided as part of standard care.

The intervention also explained the importance of early oral nutrition post-surgery. This information was included as both early oral nutrition and early mobilisation are linked behaviours in enhancing recovery. An animation showed the digestive process from ingestion to the extraction and absorption of nutrients into the bloodstream. This was then linked to early mobilisation and improved blood circulation to establish the importance of both behaviours in promoting recovery. Again, participants received specific instructions about their in-hospital nutrition plan. The final film clip showed the patient actors walking outside once home, and the researcher explained the importance of gentle exercise once discharged.

The intervention ended with an elaborative reasoning task to help participants contextualise how they could incorporate mobilisation into their recovery. Participants were asked to discuss specific examples of ways they could include exercise into their time in-hospital and their daily life once discharged. The active control group received the exact same verbal script as the visualisation group (including the elaborative reasoning task), but saw no animations. The control group received standard postoperative ERAS care as explained above.

<<INSERT FIGURE 2 ABOUT HERE>>

Measures

Demographic and clinical information. At baseline, participants self-reported gender, age, ethnicity, and highest level of education. Clinical information recorded from patient notes included date of surgery, primary surgical procedure, length of hospital stay (days), 30 day hospital re-admission for complications, and cancer diagnosis.

Step count. Postoperative mobility was assessed by step count using Jawbone Up Move fitness trackers. Jawbone trackers have been found to have high measurement precision due to the use of triaxial accelerometers (Balto, Kinnett-Hopkins, & Motl, 2016). Up Move trackers were chosen specifically to try and minimise effects upon activity, as these trackers do not display numerical step count. Each participant was instructed to wear the tracker at all times (except showering) until they were contacted seven days post-discharge. The tracker was placed on the participant's non-dominant wrist, except when not possible due to intravenous lines. Participants with larger wrists were given a clip attachment to wear the tracker on their belt or shirt.

Step count data was analysed from the day of discharge to the day before the follow-up phone call was completed (seven days in total), to prevent any inconsistencies in the time that the tracker was fitted and taken off. The Jawbone "UP" mobile application was used to retrieve data through Bluetooth connection. Unfortunately, Jawbone underwent liquidation and removed their application and online servers in May 2018, meaning fitness tracker data was only available if collected before this date (n= 57). This sample consisted entirely of colorectal surgery patients who were recruited prior to the gynaecological oncology sample.

Self-reported exercise. At baseline, self-reported exercise was answered in a single item with an open-response format in minutes per week. Participants self-reported how many minutes they had spent completing moderate exercise (e.g. going for a walk) during the past seven days. This item has been used in previous research to assess self-reported exercise in another intervention study with a patient sample (Jones et al., 2016).

Quality of recovery. The Quality of Recovery short form (QoR-15) was used to assess perceptions of surgical recovery both post-surgery and at follow-up (Stark, Myles, & Burke, 2013). The QoR-15 measures five dimensions of recovery including physical (pain, physical comfort, and physical independence) and mental well-being (psychological support and emotional state). Responses are given on an 11-point scale from 0 (none of the time) to 10 (all of the time). Items 11 to 15 assess physical and psychological symptoms and are reverse-coded. Items are summed to create total scores. The post-surgery questionnaire excluded item 8 ("Able to return to work or usual home activities") and the follow-up questionnaire excluded item 7 ("Getting support from hospital doctors and nurses"). For this reason, total scores at each time point were analysed separately. This QoR-15 demonstrated good internal reliability at both post-surgery (α= .84) and follow-up (α= .89).

Perceptions of surgery and recovery. Items from the Brief Illness Perception Questionnaire (Broadbent, Petrie, Main, & Weinman, 2006) were adapted to assess perceptions of surgery and recovery at baseline and postoperatively. Words "illness" and “treatment” were replaced with “surgery” and “recovery”. Items assessed beliefs of treatment control (of surgery), identity (post-surgery symptoms), concerns (for both surgery and recovery), emotional response (to surgery), consequences (of surgery), timeline (of recovery), and personal control (of recovery). The post-surgery questionnaire excluded the concern about surgery item. Each item was scored on an 11-point scale from 0 to 10, where higher scores on each item indicate higher perceived levels of the construct (e.g. more control or more distress).

Perceptions of ERAS recovery behaviours. Six items were created to assess perceptions of early mobilisation and early oral nutrition. Participants reported how much they understood each behaviour, how motivated, and how anxious they were about completing each behaviour at all three assessments. At post-presentation and follow-up only, participants also answered how difficult they felt it was to be active and to eat healthily during their recovery. Each item was answered on an 11-point scale from 0 to 10, with relevant anchors for each item in order to ensure response familiarisation. Each item was analysed as a separate outcome in the analysis.

Traditional Surgery Recovery Beliefs. Three items at baseline and post-surgery assessed traditional surgery beliefs. These items asked participants how important they felt complete bed rest, extended hospital stay, and intravenous fluids were after surgery. These questions were answered on the same 11-point scale as previous items, with relevant anchors for each item. Items were summed to create a composite total score, which demonstrated good internal reliability (baseline α= .82, post-surgery α= .83). Higher scores indicated stronger traditional beliefs.

Health Visual Information Preference Scale. The Health Visual Information Preference Scale (Health VIPS) (Jones, Kleinstäuber, Martin, Fernandez, & Petrie, 2018) was included in the baseline questionnaire to assess differences between preferences for receiving supplementary visual health information between groups. The 9-item Health VIPS is measured on a 5-point Likert-type scale (from 1 to 5), with anchors from strongly disagree to strongly agree. Total Health VIPS score is calculated by averaging the items (items 4, 7, and 9 are reverse-coded), and internal consistency was good in the current sample (α=.79).

Evaluation of Intervention and Active Control Materials. At post-surgery, the intervention and active control group answered seven items evaluating the material they received in-hospital. Items asked how material improved understanding, and whether it increased motivation or anxiety about being active and re-introducing food and drink. One item also asked how interesting participants found the material. Items related to either the "animations" (intervention) or "information" (active control) received. Items were answered on an 11-point scale from 0 to 10 with relevant anchors for each.

Statistical Analysis

Data were analysed using SPSS version 25.0. Tests were considered significant at $p< .05$. Independent samples t-tests and Chi-Square tests for independence assessed associations or differences between groups in demographic, clinical, and baseline variables.

A linear mixed-effect model using heterogeneous first order autoregressive covariance matrix and Type III sum of squares was used to assess changes between groups in step count data from discharge across each day of the following week. This procedure is appropriate for outcomes with multiple repeated measures and is robust against skewed and missing data (Arnau, Bendayan, Blanca, & Bono, 2013; Krueger & Tian, 2004).

ANCOVAs (with length of hospital stay as a covariate) were used to assess between group differences in QOR-15 scores at both post-surgery and follow-up, perceived difficulty regarding ERAS behaviours at post-surgery and follow-up, and differences between groups in change scores from baseline to post-surgery in traditional surgery recovery beliefs.

A MANOVA (with length of hospital stay as a covariate) was used to assess differences in change scores from baseline to post-surgery between groups in perceptions of surgery and recovery. MANOVAs (with length of hospital stay as a covariate) were also used to assess differences in change scores from baseline to post-surgery, and baseline to follow-up, in perceptions of ERAS behaviours. Bonferroni adjustment was used for post-hoc multiple comparisons in all of the analyses conducted. In both the step count data and the psychological outcomes, intention-to-treat analyses were performed and missing data values were imputed using the SPSS multiple imputation procedure. The procedure provides five data sets using the monotone multiple imputation algorithm. Statistical analyses described above were applied and the results were aggregated across the datasets

Independent samples *t*-tests were used to assess differences in intervention ratings between the intervention and active control conditions.

Results

Demographic and clinical characteristics of the sample

Figure 1 shows the study CONSORT scheme. Of the 96 participants randomised to the three study groups, 89 completed the post-surgery assessment, and 87 completed the seven day follow-up. Participants ranged from 18 to 91 years old (M= 58.71, SD= 16.48). Most participants identified as NZ European or European (69/97, 71.1%), were female (61/97, 62.9%), and had completed at least secondary level education (45/96, 46.9%). Participants reported an average of 182 minutes of moderate exercise in the last seven days at baseline (SD= 186.10). There were no baseline differences in demographic, clinical, or baseline variables between groups except for length of hospital stay, where the control group had a significantly longer hospital stay than the active control group (p= .031) (see Table 1).

As reported above, usable step count data was available for 57 out of 96 participants who completed baseline assessments. Data was exclusively available from colorectal patients. Clinical and demographic variables that did differ between those with and without step count data were a reflection of differences between the colorectal and gynaecological oncology patient samples. These differences included a significant association between those who did and did not have data and both ethnicity (χ^2= 11.59, p=.021, ϕ= .34), and gender (χ^2= 17.07,

$p < .001$, $\phi = .42$). There were more male participants with available step count data (26/30, 86.7%) than without, and more NZ European participants with available step count data (42/67, 62.7%) than without. There was also a significant difference between the groups in length of hospital stay (with step count data *M* = 6.82, *SD*= 4.07; without step count data *M*= 4.27, *SD*= 3.30; $t_{(83)} = -3.22$, $p = .002$), which again was a reflection of this difference between the gynaecological oncology and colorectal samples.

Within the participants who did have step count data, there were no significant differences in any demographic and clinical variables between groups, except for a significant main effect of length of hospital stay between groups ($F_{(2, 54)} = 3.89$, $p = .026$). Multiple comparisons however revealed no significant differences between any of the three groups ($p > .05$). The sample with step count data were demographically similar to the whole study sample, regarding age (*M*=58.96, *SD*= 14.96), gender (45.6% female), ethnicity (80.7% NZ European/European), and education (47.4% completed secondary education).

<<INSERT TABLE 1 ABOUT HERE>>

Post-surgical mobility

The mixed model analysis revealed no interaction effect between group and time in step count data. There was, however, a significant main effect of group ($F_{(2, 67.95)} = 3.58$, $p = .033$, partial $\eta^2 = .10$). Post-hoc comparisons revealed a significantly greater step count in the intervention group ($M_{adj} = 2294.60$, CI [1746.11, 2744.89], range= 12310), compared to the control group ($M_{adj} = 1347.25$, CI [826.51, 1871.20], range= 6872; $p = .05$, $d = .49$). There were no significant differences between the intervention group and the active control group ($M_{adj} = 1504.28$, CI [1078.41, 2038.14], range= 7550.31; $p > .05$), or the active control group and the control group ($p > .05$) (see Figure 3).

There was also a significant main effect of time on step count ($F_{(6, 123.6)} = 2.69$, $p = .017$, partial $\eta^2 = .12$). Post-hoc comparisons revealed a significantly greater step count at day 4 ($M_{adj} = 1934.84$, CI [1503.26, 2366.43], range= 6677) compared to day 2 post-discharge

(M_{adj}= 1180.9, CI [837.28, 1524.37], range = 8467; p= .02, d= .47). There were no differences in time for any other days (p's> .05).

<<INSERT FIGURE 3 about here>>

Psychological outcomes

Perceptions of surgery and recovery. A MANOVA revealed a between groups difference in change scores bordering significance for perceptions of surgery and recovery outcomes from baseline to post-surgery ($F_{(14, 164)}$= 1.71, p= .058, Wilks' Lambda= .76, partial η^2= .13). However, when the univariate tests were inspected there were no significant differences between groups (p> .05).

Quality of recovery. An ANCOVA (controlling for length of hospital stay) revealed a significant main effect of group in quality of recovery scores at post-surgery ($F_{(2, 90)}$= 3.27, p= .043, partial η^2= .07). Post-hoc comparisons revealed significantly greater QOR-15 score in the intervention group (M_{adj}= 104.34, CI [97.95, 110.73], compared to the control group at post-surgery (M_{adj}= 92.65, CI [86.01, 99.29]; p= .043, d= .75). There were no differences between the active control group (M_{adj}= 96.91, CI [90.35, 103.48]; p> .05) and the intervention, or the active control and control groups (p> .05). Differences between groups were not maintained at follow-up (p> .05).

<<INSERT FIGURE 4 ABOUT HERE>>

Perceptions of early mobilisation and early oral nutrition. A MANOVA (controlling for length of hospital stay) conducted to assess differences in change scores in perceptions of early mobilisation and early oral nutrition from baseline to post-presentation, found no differences between groups (p> .05).

A separate MANOVA (controlling for length of hospital stay) conducted to assess differences in change scores in perceptions of early mobilisation and early oral nutrition from baseline to follow-up, bordered on significance ($F_{(12, 166)}$= 1.79, p= .053, Wilks' Lambda= .79, partial η^2= .11). Univariate tests revealed a between groups difference in change scores from baseline to follow-up in anxiety about re-introducing food and drink ($F_{(2, 88)}$= 4.27, p= .017, partial η^2= .09). The intervention group had a significantly greater reduction in anxiousness (M_{adj}= -1.92, CI [-3.05, -0.79) compared to the control group (M_{adj}= 0.53, CI [-0.68, 1.75], p= .016, d= .73). There were no significant differences between the active control (M_{adj}= -0.74, CI [-1.90, 0.42]) and intervention (p> .05), or the active control and control group (p> .05). There were no significant differences between the other univariate tests (p> .05).

MANOVAs (controlling for length of hospital stay) were also conducted at post-surgery and follow-up respectively, to assess between groups differences in difficulty being active, and eating and drinking during recovery. At post-surgery, there was a significant difference found between groups in the dependent measures ($F_{(4, 178)}$= 2.60, p= .038, Wilks' Lambda= .89, partial η^2= .06). Univariate tests revealed a significant between groups effect in anticipated difficulty regarding being active ($F_{(2, 90)}$= 4.02, p= .021, partial η^2= .08), but not eating and drinking (p> .05). Post-hoc comparisons revealed significantly greater anticipated difficulty with being active in the control group (M_{adj}= 5.32, CI [4.40, 6.24]) compared to the intervention group (M_{adj}= 3.64, CI [2.76, 4.53], p= .037, d= .80). There were no differences found between the active control and intervention group (M_{adj}= 5.05, CI [4.14, 5.96], p> .05), or the control group (p> .05).

At follow-up, there was also a significant difference between groups in the dependent measures ($F_{(4, 178)}$= 3.10, p= .017, Wilks' Lambda= .87, partial η^2= .07). Univariate tests revealed a significant difference between groups in difficulty eating and drinking during recovery ($F_{(2, 90)}$= 4.96, p= .009, partial η^2= .10), but not for difficulty being active (p> .05). Post hoc comparisons revealed significantly greater difficulty with eating and drinking during recovery for the control group (M_{adj}= 4.42, CI [3.44, 5.40]), as compared to the intervention group (M_{adj}= 2.33, CI [1.38, 3.27], p= .010, d= .86). There were no significant differences between the active control group (M_{adj}= 2.80, CI [1.83, 3.77]) and the intervention group (p> .05), or the control group (p> .05).

Traditional Surgery Recovery Beliefs. An ANCOVA (controlling for length of hospital stay) found no differences between groups in change scores of traditional surgery recovery beliefs from baseline to post-surgery ($p > .05$).

Evaluation of intervention and active control materials

There were no significant differences between the intervention and active control group in their ratings of the information received ($p > .05$). Overall, both intervention and active control participants rated the presentation high in helping to improve their understanding of ERAS behaviours, as being interesting, and in improving their motivation regarding ERAS behaviours (*M*s range from 7.64 to 9.17). Both forms of information also did not make either group highly anxious regarding being active and eating and drinking post-surgery (*M*s range from 1.48 to 2.66).

Discussion

This study is the first to examine how an active visualisation intervention could improve adherence to early mobilisation following surgery. Although limited by a reduced sample size, our study found that intervention participants, consisting of colorectal surgery patients, showed greater step count across discharge and the following week post-surgery compared to those who received standard care only.

The intervention also produced changes in psychological outcomes regarding postoperative ERAS behaviours and patients' perceived quality of recovery. Intervention participants had more positive perceptions of recovery at post-surgery and found mobilisation less difficult than control participants. Intervention participants also had a decrease in their anxiety about eating and drinking at follow-up compared to the control group, and found eating and drinking during their recovery less difficult.

Overall, these findings provide initial evidence for the intervention to improve adherence to early mobilisation. It may be that seeing the physiological processes of early mobilisation provides a link between the information and behaviour, as compared to standard care or only receiving this information verbally. These results align with visualisation theory which suggests that visual information has increased salience, is easier to understand (Brotherstone, Miles, Robb, Atkin, & Wardle, 2006), and therefore can increase intentions to change behaviour (Williams, Anderson, Barton, & McGhee, 2012).

As highlighted above, previous studies with ERAS patients have relied upon one-on-one staff-directed methods to increase adherence to mobilisation (Castelino et al., 2016). To the authors' knowledge, this is the first intervention with ERAS surgery patients that has not used staff-direction and monitoring to increase adherence to early mobilisation. These findings suggest that this brief intervention may be useful in encouraging patients to self-manage their mobilisation effectively

The changes in psychological outcomes also demonstrate a shift in mindset that would promote adherence and support the objective data. It has been suggested that changing traditional recovery beliefs can be challenging (Pearsall et al., 2015). If traditional recovery beliefs are associated with hesitations to mobilise, simply instructing a patient to undertake ERAS behaviours will likely be ineffective. This intervention demonstrates how these beliefs can be modified. Furthermore, the intervention was able to not only increase adherence to mobilisation, but also appeared to reduce anxiety and difficulty with eating and drinking post-surgery, which is an important complementary ERAS behaviour to early mobilisation.

No previous visualisation studies have reported objective improvements in a health behaviour other than adherence to medicine. A similar animated intervention successfully improved seven week self-reported exercise in patients recovering from acute coronary syndrome (Jones et al., 2016). Our findings provide initial objective evidence that visualisation can improve postoperative mobilisation, a behaviour important to recovery from any surgery.

The findings of the current study also suggest that visual information appears to be more effective than receiving verbal information only, as demonstrated by a lack of significant differences between the control and active control groups in outcomes. This is an important finding, as previous visualisation interventions have only compared receiving visualisation with standard care. The results of this study are the first to suggest that visual information appears to provide an important, additive effect in changing outcomes that is not achieved by providing the same information verbally.

There are strengths of the current study and findings presented. First, the study used a randomised controlled design. The primary outcome was assessed using an objective, continuous, non-invasive measure of physical activity, which has been a limitation of previous ERAS research (Abeles et al., 2017). Nearly all studies included in a recent review of post-surgical mobilisation (Castelino et al., 2016) assessed outcomes such as complications and length of stay, which are not direct measures of adherence to mobilisation. Furthermore, the current study assessed mobilisation at and following discharge. This provides an indication of how participants' self-managed their recovery behaviour in the home environment. Finally, another strength of the study is the use of a three-arm trial and an active control group, to ascertain the additive effects of visual information in comparison to receiving the same information verbally.

This intervention has high clinical applicability to be incorporated into post-surgical care. The intervention is not resource-intensive, and is brief and portable. Any staff member could deliver the presentation on a computer tablet at the patients' bedside. This could be useful before initial mobilisation. The intervention seems particularly worthwhile if it can increase patient self-management of their mobility without additional staff input. The intervention could also be utilised by ERAS nurse specialists as part of the preoperative education materials provided during surgical pre-admission.

Limitations of the study findings should also be taken into consideration. First, although all participants wore our trackers, data was not retrievable for over 40% of our sample. This issue was uncontrollable as the company suddenly removed their online servers and application preventing access to data received later in the recruitment period. This had clear implications for statistical power and ability to detect significant results. Regardless, the significance found provides initial evidence with a reduced sample size that the intervention appears efficacious in objectively increasing adherence to early mobilisation.

A related limitation is that step count data was only available from colorectal surgery patients. As discussed above, there are clinical and demographic differences between the two samples, meaning that results cannot be generalised to gynaecological oncology patients. It is uncertain whether the intervention would also have been effective in this group. The psychological outcomes, however, do suggest that the intervention is effective in improving perceptions of ERAS behaviours and traditional surgery beliefs for both patient groups.

Another important consideration is that simply wearing a fitness tracker can influence patient behaviour (Low et al., 2018). Attempts to limit this influence included selecting a fitness tracker without numerical display of step count. Step count average was only visible around the perimeter of the tracker face by pushing a button. Participants were not informed about this function and were instructed not to push any buttons on the tracker. Furthermore, study participants in all groups wore trackers to account for any influence upon mobilisation.

Finally, potential limitation of the intervention and active control information delivery is the lack of an evaluation of intervention fidelity and participant engagement between the two researchers delivering these materials. However, a standardised script was used by both researchers to ensure that intervention content was matched.

Future research should attempt replication of our findings within a larger trial. The same presentation could be used with other ERAS patients or any surgery patients who would benefit from increasing early mobilisation. Future research should also attempt to understand the underlying mechanisms of improved adherence to early mobilisation. Theoretically, these may include improved understanding of these behaviours, decreased anxiety, increased social support, or lack of symptoms such as fatigue and pain. Although the current study was not adequately powered to perform mediation and moderation analyses, future research should focus on deducing these mechanisms to further inform intervention design and increase potential efficacy. This brief intervention, however, provides initial promise of a new strategy for promoting patient self-management to post-surgery mobilisation.

References

Abeles, A., Kwasnicki, R. M., & Darzi, A. (2017). Enhanced recovery after surgery: Current research insights and future direction. *World Journal of Gastrointestinal Surgery*, *9*(2), 37–45. https://doi.org/10.4240/wjgs.v9.i2.37

Arnau, J., Bendayan, R., Blanca, M. J., & Bono, R. (2013). The effect of skewness and kurtosis on the robustness of linear mixed models. *Behavior Research Methods*, *45*(3), 873–879. https://doi.org/10.3758/s13428-012-0306-x

Balto, J. M., Kinnett-Hopkins, D. L., & Motl, R. W. (2016). Accuracy and precision of smartphone applications and commercially available motion sensors in multiple sclerosis. *Multiple Sclerosis Journal – Experimental, Translational and Clinical*, *2*, 205521731663475. https://doi.org/10.1177/2055217316634754

Bergman, S., Deban, M., Martelli, V., Monette, M., Sourial, N., Hamadani, F., … Fraser, S. (2014). Association between quality of care and complications after abdominal surgery. *Surgery*, *156*(3), 632–639. https://doi.org/10.1016/J.SURG.2013.12.031

Brieger, G. H. (1983). Early ambulation. A study in the history of surgery. *Annals of Surgery*, *197*(4), 443–449. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/6338846

Broadbent, E., Petrie, K. J., Main, J., & Weinman, J. (2006). The Brief Illness Perception Questionnaire. *Journal of Psychosomatic Research*, *60*(6), 631–637. https://doi.org/http://dx.doi.org.ezproxy.auckland.ac.nz/10.1016/j.jpsychores.2005.10.020

Brotherstone, H., Miles, A., Robb, K. A., Atkin, W., & Wardle, J. (2006). The impact of illustrations on public understanding of the aim of cancer screening. *Patient Education and Counseling*, *63*(3), 328–335. https://doi.org/10.1016/j.pec.2006.03.016

Castelino, T., Fiore, J. F., Niculiseanu, P., Landry, T., Augustin, B., & Feldman, L. S. (2016). The effect of early mobilization protocols on postoperative outcomes following abdominal and thoracic surgery: A systematic review. *Surgery*, *159*(4), 991–1003. https://doi.org/10.1016/J.SURG.2015.11.029

Faul, F., Erdfelder, E., Lang, A.-G., & Buchner, A. (2007). G* Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods*, *39*(2), 175–191. https://doi.org/10.3758/BF03193146

Fiore, J. F., Castelino, T., Pecorelli, N., Niculiseanu, P., Balvardi, S., Hershorn, O., … Feldman, L. S. (2017). Ensuring early mobilization within an enhanced recovery program for colorectal surgery. *Annals of Surgery*, *266*(2), 223–231. https://doi.org/10.1097/SLA.0000000000002114

Gustafsson, U. O., Scott, M. J., Schwenk, W., Demartines, N., Roulin, D., Francis, N., … Soop, M. (2013). Guidelines for perioperative care in elective colonic surgery: Enhanced Recovery After Surgery (ERAS®) Society recommendations. *World Journal of Surgery*, *37*(2), 259–284. https://doi.org/10.1007/s00268-012-1787-6

Henriksen, M. G., Jensen, M. B., Hansen, H. V., Jespersen, T. W., & Hessov, I. (2002). Enforced mobilization, early oral feeding, and balanced analgesia improve convalescence after colorectal surgery. *Nutrition*, *18*(2), 147–152. https://doi.org/10.1016/S0899-9007(01)00748-1

Jones, A. S. K., Coetzee, B., Kagee, A., Fernandez, J., Cleveland, E., Thomas, M., & Petrie, K. J. (2018). The use of a brief, active visualisation intervention to improve adherence to antiretroviral therapy in non-adherent patients in South Africa. *AIDS and Behavior*. https://doi.org/10.1007/s10461-018-2292-1

Jones, A. S. K., Ellis, C. J., Nash, M., Stanfield, B., & Broadbent, E. (2016). Using animation to improve recovery from acute coronary syndrome: A randomized trial. *Annals of Behavioral Medicine*, *50*(1), 108–118. https://doi.org/10.1007/s12160-015-9736-x

Jones, A. S. K., Fernandez, J., Grey, A., & Petrie, K. J. (2017). The impact of 3-D models versus animations on perceptions of osteoporosis and treatment motivation: A randomised trial. *Annals of Behavioral Medicine*, *51*(6), 899–911. https://doi.org/10.1007/s12160-017-9913-1

Jones, A. S. K., Kleinstäuber, M., Martin, L. R., Fernandez, J., & Petrie, K. J. (2018). Development and validation of the Health Visual Information Preference Scale (Health VIPS). *Manuscript Under Review.*

Jones, A. S. K., & Petrie, K. J. (2017). I can see clearly now: Using active visualisation to improve adherence to ART and PrEP. *AIDS and Behavior*, *21*(2), 335–340. https://doi.org/10.1007/s10461-016-1611-7

Krueger, C., & Tian, L. (2004). A Comparison of the General Linear Mixed Model and Repeated Measures ANOVA Using a Dataset with Multiple Missing Data Points. *Biological Research For Nursing*, *6*(2), 151–157. https://doi.org/10.1177/1099800404267682

Lee, L., Li, C., Landry, T., Latimer, E., Carli, F., Fried, G. M., & Feldman, L. S. (2014). A systematic review of economic evaluations of enhanced recovery pathways for colorectal surgery. *Annals of Surgery*, *259*(4), 670–676. https://doi.org/10.1097/SLA.0b013e318295fef8

Low, C. A., Bovbjerg, D. H., Ahrendt, S., Choudry, M. H., Holtzman, M., Jones, H. L., …

Bartlett, D. L. (2018). Fitbit step counts during inpatient recovery from cancer surgery as a predictor of readmission. *Annals of Behavioral Medicine*, *52*(1), 88–92. https://doi.org/10.1093/abm/kax022

Pearsall, E. A., Meghji, Z., Pitzul, K. B., Aarts, M.-A., McKenzie, M., McLeod, R. S., & Okrainec, A. (2015). A Qualitative Study to Understand the Barriers and Enablers in Implementing an Enhanced Recovery After Surgery Program. *Annals of Surgery*, *261*(1), 92–96. https://doi.org/10.1097/SLA.0000000000000604

Perera, A. I., Thomas, M. G., Moore, J. O., Faasse, K., & Petrie, K. J. (2014). Effect of a smartphone application incorporating personalized health-related imagery on adherence to antiretroviral therapy: a randomized clinical trial. *AIDS Patient Care and STDs*, *28*(11), 579–586. https://doi.org/10.1089/apc.2014.0156

Smart, N. J., White, P., Allison, A. S., Ockrim, J. B., Kennedy, R. H., & Francis, N. K. (2012). Deviation and failure of enhanced recovery after surgery following laparoscopic colorectal surgery: early prediction model. *Colorectal Disease*, *14*(10), e727–e734. https://doi.org/10.1111/j.1463-1318.2012.03096.x

Stark, P. A., Myles, P. S., & Burke, J. A. (2013). Development and psychometric evaluation of a postoperative quality of recovery score: The QoR-15. *Anesthesiology*, *118*(6), 1332–1340. https://doi.org/10.1097/ALN.0b013e318289b84b

Stephens, M. H., Grey, A., Fernandez, J., Kalluru, R., Faasse, K., Horne, A., & Petrie, K. J. (2016). 3-D bone models to improve treatment initiation among patients with osteoporosis: A randomised controlled pilot trial. *Psychology & Health*, *31*(4), 487–497. https://doi.org/10.1080/08870446.2015.1112389

Varadhan, K. K., Lobo, D. N., & Ljungqvist, O. (2010). Enhanced recovery after surgery: The future of improving surgical care. *Critical Care Clinics*, *26*(3), 527–547. https://doi.org/10.1016/j.ccc.2010.04.003

Vlug, M. S., Bartels, S. A. L., Wind, J., Ubbink, D. T., Hollmann, M. W., & Bemelman, W. A. (2012). Which fast track elements predict early recovery after colon cancer surgery? *Colorectal Disease*, *14*(8), 1001–1008. https://doi.org/10.1111/j.1463-1318.2011.02854.x

Williams, B., Anderson, A. S., Barton, K., & McGhee, J. (2012). Can theory be embedded in visual interventions to promote self-management? A proposed model and worked example. *International Journal of Nursing Studies*, *49*(12), 1598–1609. https://doi.org/10.1016/j.ijnurstu.2012.07.005

Wolk, S., Meißner, T., Linke, S., Müssle, B., Wierick, A., Bogner, A., … Welsch, T. (2017).

Use of activity tracking in major visceral surgery - the Enhanced Perioperative Mobilization (EPM) trial: study protocol for a randomized controlled trial. *Trials*, *18*(1), 77. https://doi.org/10.1186/s13063-017-1782-1

Table 1. Baseline differences in outcomes and clinical characteristics of the sample.

	Intervention M (SD) [%] (n= 33)	Active Control M (SD) [%] (n= 32)	Control M (SD) [%] (n= 31)	Test statistic (F or χ^2)	*df*	*p*	Total sample M (SD) [%] (n =97)
Baseline self-reported exercise (mins)	224.45 (245.29)	168.23 (163.11)	160.71 (135.29)	1.03	2, 87	.361	185.26 (188.75)
Health VIPS total score	3.66 (0.73)	3.83 (0.54)	3.56 (0.67)	1.38	2, 93	.256	3.68 (0.65)
Surgery Perceptions							
Helpfulness	9.42 (1.09)	9.28 (1.22)	9.23 (1.60)	0.19	2, 93	.824	9.31 (1.31)
Post-surgery symptoms	6.27 (1.89)	6.25 (2.27)	6.77 (1.96)	0.63	2, 92	.537	6.42 (2.04)
Concerns	5.69 (3.18)	6.09 (2.60)	6.25 (3.10)	0.30	2, 93	.739	6.01 (2.95)
Emotional response	4.72 (3.09)	5.66 (2.46)	5.03 (2.74)	0.95	2, 92	.392	5.14 (2.77)
Recovery Perceptions							
Consequences	6.06 (2.26)	6.65 (2.19)	6.48 (2.42)	0.58	2, 93	.561	6.40 (2.28)
Timeline	4.20 (1.63)	4.13 (1.64)	4.95 (2.54)	1.69	2, 93	.190	4.42 (1.99)
Personal control	7.45 (2.00)	6.72 (1.76)	6.84 (1.95)	1.39	2, 93	.254	7.01 (1.92)
Concerns	4.33 (2.35)	4.81 (2.40)	5.77 (3.13)	2.45	2, 93	.092	4.96 (2.68)
Early Mobilisation Perceptions							
Understanding	8.67 (1.98)	8.70 (1.56)	9.03 (1.12)	0.48	2, 91	.622	8.79 (1.60)
Motivation	8.48 (2.50)	8.56 (1.87)	8.40 (2.07)	0.05	2, 91	.954	8.48 (2.08)
Anxiousness	3.88 (3.24)	4.47 (2.82)	5.33 (3.13)	1.73	2, 91	.183	4.53 (3.09)
Early Oral Nutrition Perceptions							
Understanding	8.03 (2.58)	8.03 (2.01)	8.66 (1.61)	0.87	2, 91	.424	8.22 (2.12)
Motivation	8.21 (2.07)	7.97 (1.96)	8.25 (2.02)	0.19	2, 91	.830	8.14 (2.00)
Anxiousness	3.33 (2.99)	3.97 (2.97)	4.87 (3.03)	2.06	2, 91	.133	4.03 (3.03)
Traditional surgery beliefs	3.72 (2.47)	4.02 (2.09)	4.11 (2.80)	0.22	2, 91	.807	3.94 (2.44)
Confirmed cancer (Y)	28 [84.8%]	24 [75.0%]	23 [74.2%]	1.34	2	.513	75 [78.1%]

Length of hospital stay (days) (n= 92)	5.44 (3.37)	4.74 (3.05)	7.29 (4.85)	3.66	2, 91	**.030**	5.81 (3.94)
30 day re-admission (Y)	5 [15.6%]	6 [19.4%]	4 [12.9%]	0.49	2	.785	15 [16.0%]
Laparoscopic surgery (Y) (n= 92)	14 [43.8%]	22 [71.0%]	18 [58.1%]	4.78	2	.092	54 [57.4%]
Stoma (Y) (n=92)	3 [9.4%]	4 [12.9%]	3 [9.7%]	0.25	2	.882	10 [10.6%]
Primary procedure CR (n=66)				9.11	8	.333	
Segmental colectomy	4 [19.0%]	9 [39.1%]	5 [21.7%]				18 [26.9%]
Anterior resection	7 [33.3%]	9 [39.1%]	7 [30.4%]				23 [34.3%]
Ileostomy reversal	8 [38.1%]	2 [8.7%]	6 [26.1%]				16 [23.9%]
Proctectomy	0 [0.0%]	2 [8.7%]	2 [8.7%]				4 [6.0%]
Other	2 [9.5%]	1 [4.3%]	3 [13.0%]				6 [9.0%]
Primary procedure gynae (n= 26)				6.49	6	.370	
TAHBSO + PLND	6 [54.4%]	6 [75.0%]	6 [75.0%]				18 [66.7%]
RH + PLND	1 [9.1%]	1 [12.5%]	0 [0.0%]				2 [7.4%]
Ovarian debulking +/- BR	4 [36.4%]	0 [0.0%]	2 [25.0%]				6 [22.2%]
Staging laparoscopy	0 [0.0%]	1 [12.5%]	0 [0.0%]				1 [3.7%]

Note. Bolded P indicates significance at p< .05. TAHBSO= Total abdominal hysterectomy with bilateral salpingo-oophorectomy, PLND= Pelvic lymph node dissection, RH= Radical hysterectomy, BR= Bowel resection. Baseline self-reported exercise (mins) refers to week prior to baseline assessment.

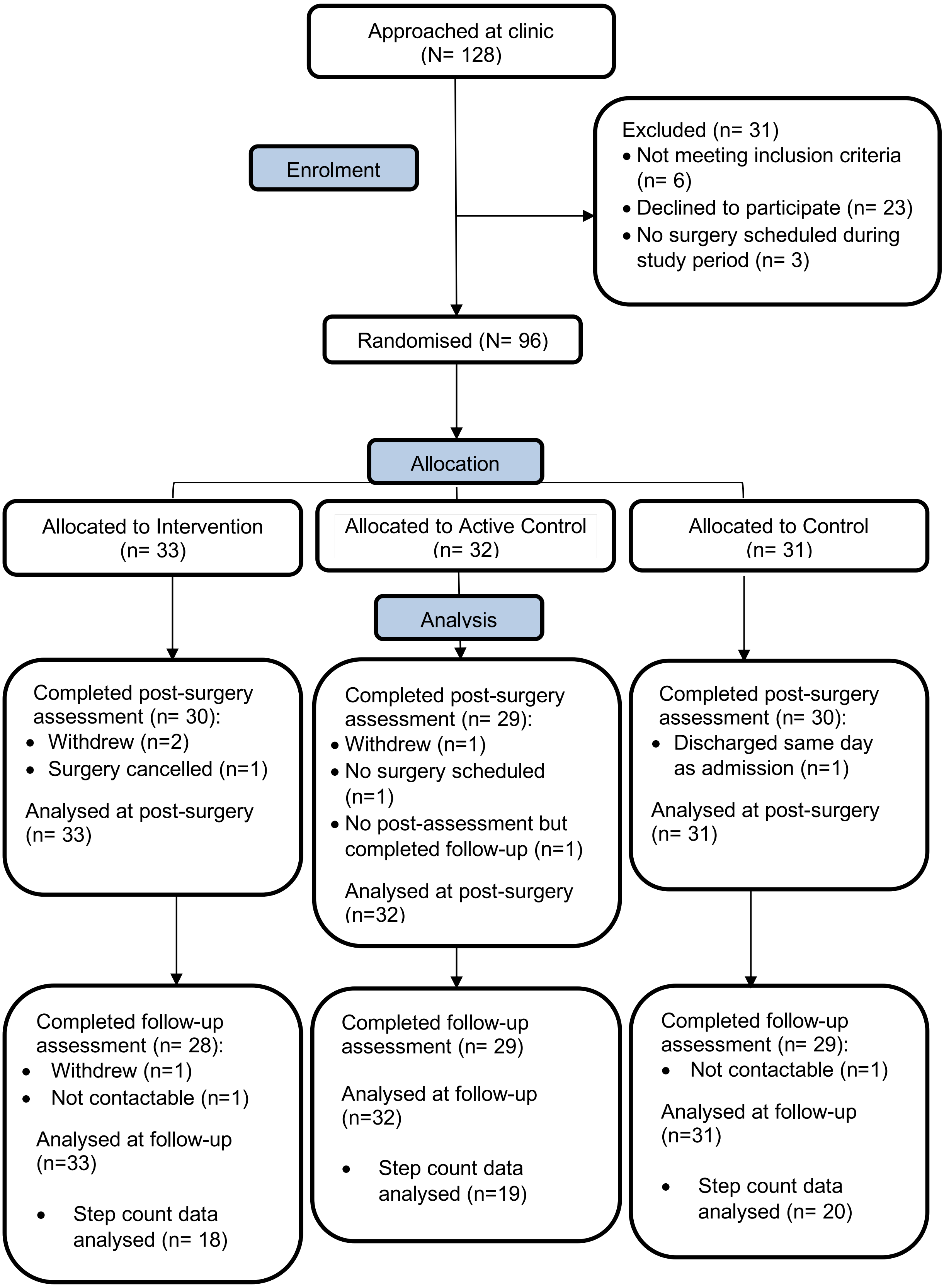

Figure 1. CONSORT Diagram depicting flow of participants through study.

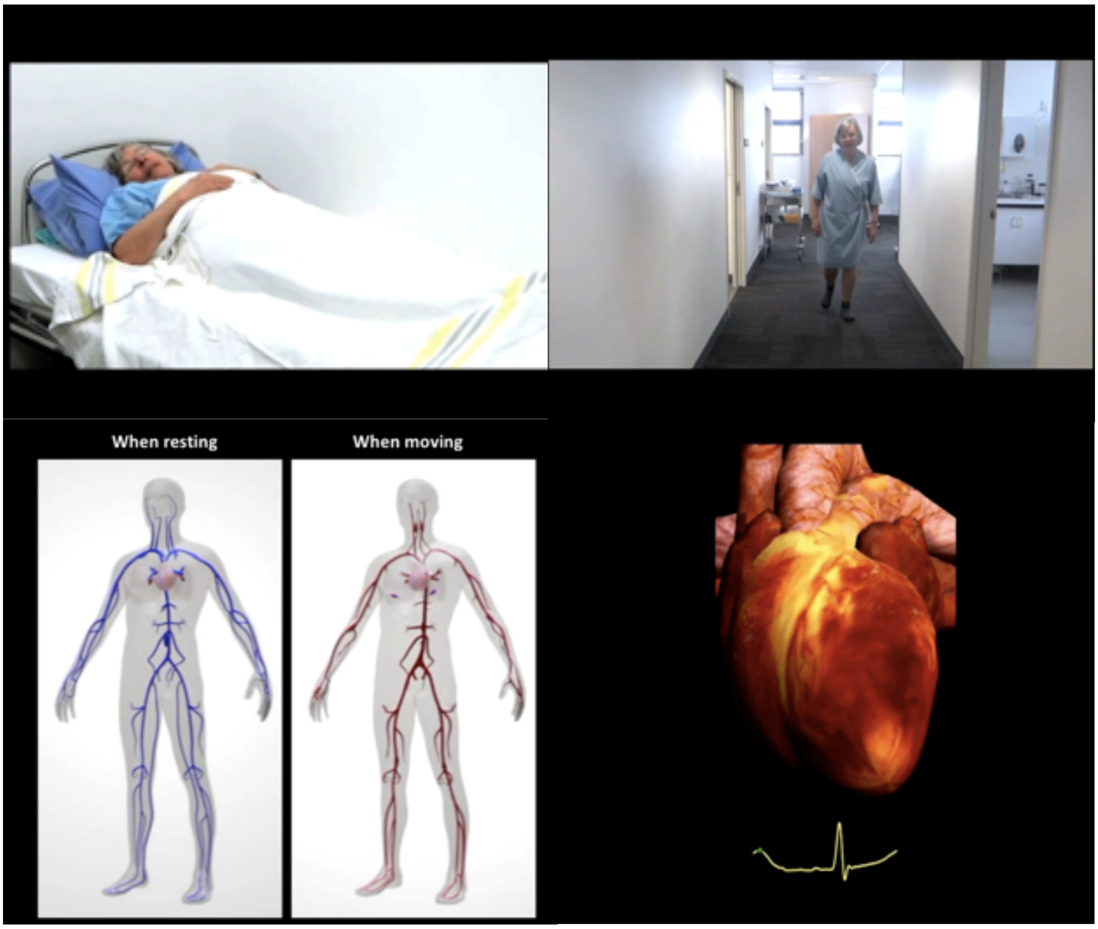

Figure 2. Screenshots from intervention. Top right and left show the patient actor. Bottom left shows blood circulation and bottom right shows heart rate.

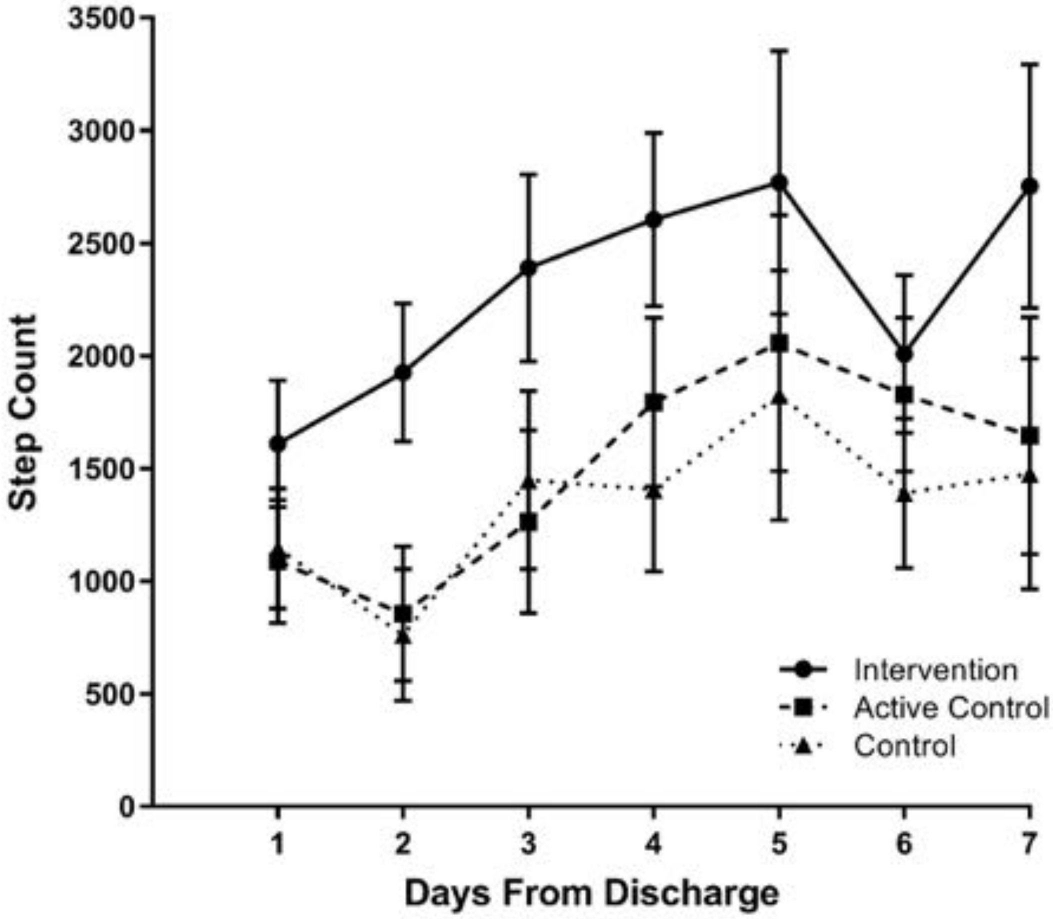

Figure 3. Adjusted mean average step count per day between groups from day of discharge for the following week. Error bars depict standard error.

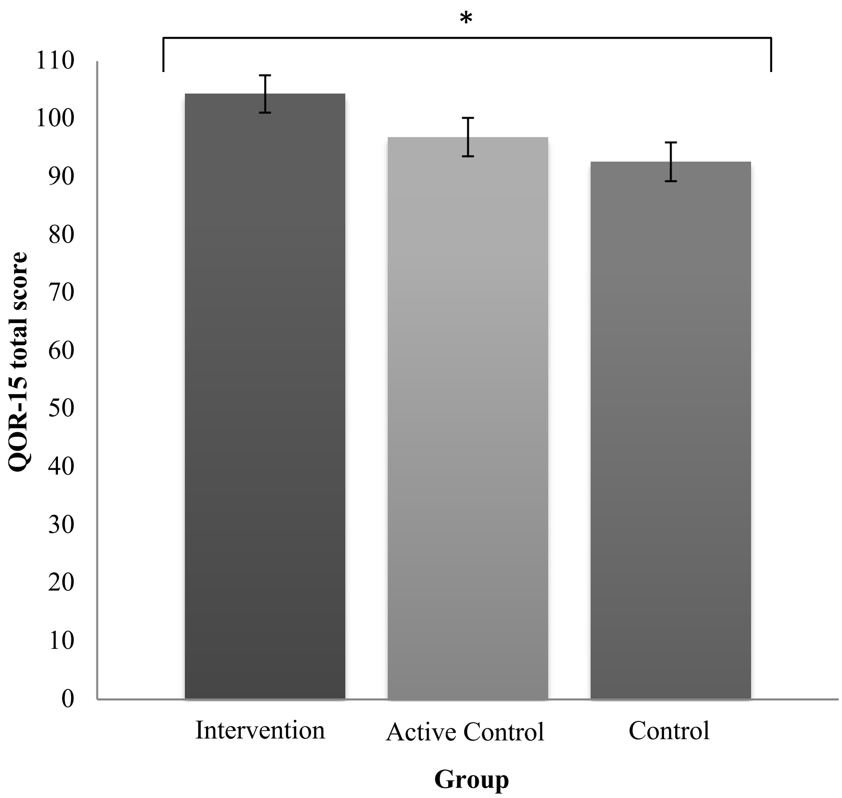

Figure 4. Bars represented adjusted mean in quality of recovery scores between groups at post-surgery. Error bars indicate standard error. *indicates significance at p> .05.