



Early mobilization in enhanced recovery after surgery pathways: current evidence and recent advancements

Journal of **Comparative Effectiveness Research**

Reeana Tazreean¹, Gregg Nelson^{2,3} & Rosie Twomey^{*,4} 

¹Cumming School of Medicine, University of Calgary, 2500 University Dr NW, Calgary, AB, T2N 1N4, Canada

²Department of Oncology, Faculty of Medicine, Arnie Charbonneau Cancer Institute, University of Calgary, Calgary, AB, Canada

³Department of Obstetrics & Gynecology, Faculty of Medicine, University of Calgary, Calgary, AB, Canada

⁴Ohlson Research Initiative, Cumming School of Medicine, University of Calgary, Calgary, AB, Canada

*Author for correspondence: rosemary.twomey@ucalgary.ca

Early mobilization is a crucial component of enhanced recovery after surgery (ERAS) pathways that counteract the adverse physiological consequences of surgical stress and immobilization. Early mobilization reduces the risk of postoperative complications, accelerates the recovery of functional walking capacity, positively impacts several patient-reported outcomes and reduces hospital length of stay, thereby reducing care costs. Modifiable barriers to early mobilization include a lack of education and a lack of resources. Education and clinical decision-making tools can improve compliance with ERAS mobilization recommendations and create a culture that prioritizes perioperative physical activity. Recent advances include real-time feedback of mobilization quantity using wearable technology and combining ERAS with exercise prehabilitation. ERAS guidelines should emphasize the benefits of structured postoperative mobilization.

First draft submitted: 19 October 2021; Accepted for publication: 26 November 2021; Published online: 20 January 2022

Keywords: ambulation • early mobility • enhanced recovery after surgery • ERAS • mobilization • perioperative care • quality of care • rehabilitation • surgical outcomes • surgical pathways

Enhanced recovery after surgery (ERAS) is an initiative that aims to improve the quality of care for surgical patients [1] via evidence-based recommendations (guidelines) to optimize care in the preoperative, intraoperative and postoperative periods [2]. ERAS guidelines are multimodal and involve multidisciplinary teams of surgeons, anesthesiologists, nurses and allied healthcare professionals [1]. The first ERAS guideline was developed for colorectal surgery [3], and there are now over 20 published ERAS guidelines across multiple surgical disciplines [4]. Despite widespread adoption, one of the challenges of ERAS implementation is achieving high compliance to several care elements. However, with good compliance, ERAS pathway implementation is associated with improvements in important patient and process outcomes, including a reduced risk of complications, hospital length of stay (LOS) and healthcare costs [5–9]. Early postoperative mobilization is a central tenet of ERAS [1], and several care elements are also adjuvant measures to encourage early mobilization, including those related to optimal postoperative analgesia and early removal of urinary catheters [3].

Typically, the goal is to achieve meaningful mobilization as soon as possible after surgery (within the first 24 h). Early mobilization can include activities such as sitting upright, transferring from bed to chair, rising from a chair, exercises in or out of bed and walking in the room or hallway. At first, these activities are performed with the assistance of a physical therapist or nurse and progression toward independent mobilization across the hospital stay is the ultimate goal. Protocols vary, and there is no standard definition (Table 1), but ERAS pathways often include specific targets for the total amount of time spent out of bed, the total distance walked or the frequency of periods of walking. The evidence for the benefit of early mobilization in specific surgical settings is increasing. While the majority of ERAS guidelines strongly recommend early postoperative mobilization (Table 1), compliance with mobilization targets can be low [6]. Therefore, this narrative review aims to summarize the current evidence for

Table 1. Enhanced recovery after surgery (ERAS®) society recommendations for early postoperative mobilization.

Study (year)	Surgical discipline	Guideline summary	Evidence level	Recommendation grade	Ref.
Batchelor <i>et al.</i> (2019)	Lung surgery	Patients should be mobilized within 24 h of surgery	Low	Strong	[7]
Debono <i>et al.</i> (2021)	Lumbar spinal fusion surgery	Early mobilization and early physical therapy are recommended. Patients should be encouraged to mobilize as soon as they are able	Low	Strong	[8]
Cerantola <i>et al.</i> (2013)	Radical cystectomy for bladder cancer	Early mobilization should be encouraged. Two hours out of bed on postoperative day 0, 6 h out of bed on postoperative day 1	NA/Low	Strong	[9]
Dort <i>et al.</i> (2017)	Major head and neck surgery with free flap reconstruction	Early mobilization, within the first 24 h after surgery is recommended for patients	Moderate	Strong	[10]
Feldheiser <i>et al.</i> (2016)	Gastrointestinal surgery	Achievement of mobilization goals requires a multidisciplinary approach. Patients should be given written information setting daily targets for ambulation in hospital. Patients should be encouraged to increase their physical activity in the preoperative period. Patients should use a diary or pedometer to record their daily physical activity	NA	Weak	[11]
Gustafsson <i>et al.</i> (2019)	Elective colorectal surgery	Early mobilization through patient education and encouragement is an important component of enhanced recovery after surgery programs; prolonged immobilization is associated with a variety of adverse effects and patients should therefore be mobilized	Moderate	Strong	[12]
Hübner <i>et al.</i> (2020)	Cytoreductive surgery	Mobilization and physiotherapy starting the day of surgery (out of bed) with goals for >2 h of physical exercises for postoperative day 2 and >6 h, thereafter should be performed routinely	Low	Strong positive	[13]
Low <i>et al.</i> (2019)	Esophagectomy	Postoperatively, early mobilization should be encouraged as soon as possible using a standardized and structured approach with daily targets	Moderate	Strong	[14]
Macones <i>et al.</i> (2019)	Cesarean delivery	Early mobilization after cesarean delivery is recommended	Very low	Weak	[15]
Melloul <i>et al.</i> (2020)	Pancreatoduodenectomy	Early and active mobilization should be encouraged from day 0. No evidence for specific protocol or daily targets is available for pancreatoduodenectomy	Low	Strong	[16]
Melloul <i>et al.</i> (2016)	Liver surgery	Early mobilization after hepatectomy should be encouraged from the morning after the operation until hospital discharge	Low	Weak	[17]
Mortensen <i>et al.</i> (2014)	Gastrectomy	Patients should be mobilized actively from the morning of postoperative day 1 and encouraged to meet daily targets for mobilization	Very low	Strong	[18]
Nelson <i>et al.</i> (2019)	Gynecologic/oncology surgery	Patients should be encouraged to mobilize within 24 h of surgery	Low	Strong	[19]
Temple-Oberle <i>et al.</i> (2017)	Breast reconstruction	Patients should be mobilized within the 24 h after surgery	Moderate	Strong	[20]
Wainwright <i>et al.</i> (2020)	Total hip replacement and total knee replacement surgery	Patients should be mobilized as early as they are able to in order in order to facilitate early achievement of discharge criteria	Strong	Strong	[21]

early mobilization across ERAS surgical pathways and highlight recent advancements and future perspectives on helping patients move early and move more after surgery.

Evidence for the benefit of early postoperative mobilization

Hospitalization can result in a rapid decline in function, especially in older adults [22]. The adverse physiological effects of prolonged bed rest and immobility have long been recognized as a major cause. Immobilization increases insulin resistance, impairs gastrointestinal function, results in de-conditioning of the cardiovascular, respiratory and musculoskeletal systems, and exposes patients to an increased risk of thromboembolism [23,24]. Furthermore, surgery causes inflammation and other homeostatic disruptions [25]. While the evidence for the harmful effects of bed rest and the surgical stress response is clear, the evidence for the benefit of dedicated early mobilization intervention is limited in some surgical disciplines with ERAS guidelines (Table 1). However, early postoperative mobilization is safe and feasible, and an increasing number of observational studies report associations between a faster time-to-mobilization or more mobilization (measured objectively using wearable technology) and improved

health outcomes. For example, after cesarean delivery (where thromboembolic events are a leading cause of maternal death), patients who developed complications after discharge walked significantly less during their hospitalization compared with those who did not [26]. Similarly, after major head and neck surgery with free flap reconstruction, delayed time-to-mobilization (in this case, after postoperative day 2) was a significant predictor of postoperative complications and a prolonged LOS (>10 days) [27].

There is now evidence from several randomized controlled trials (RCTs), indicating that mobilization benefits both patients and the healthcare system. In an RCT involving 120 patients undergoing liver tumour resection, targeted guidance for the early mobilization group resulted in faster gastrointestinal recovery, improved sleeping time and a shorter LOS compared with a control group [28]. The early mobilization intervention included preoperative education with patients and their families, daily mobilization activities for early, middle and late periods of the day, and comprehensive safety assessments before ambulation. Supervised mobilization has also been successful after major abdominal cancer surgery. Almeida *et al.* [29] found that an early mobilization intervention including supervised exercises performed twice daily was superior to usual care. This resulted in a greater proportion of patients being able to walk without human assistance by postoperative day 5, as well as improved functional exercise capacity (determined by the 6-minute walk test). Early mobilization interventions also improve functional exercise capacity at hospital discharge following cardiac surgery [30]. However, the impact of allocating additional resources to ensure mobilization is not always clear. For example, in an RCT involving 99 patients undergoing colorectal surgery, Fiore *et al.* [31] found that although facilitated early mobilization (staff dedicated to assist transfers and walking) did improve step counts and compliance with mobilization targets, by four weeks after surgery, there was no difference in the recovery of walking capacity or secondary outcomes, such as postoperative pulmonary function [32]. Others have suggested that these results show that assisted walking within the confines of the hospital environment may not be enough of a stimulus to provoke a favourable response [33]. Alongside objective measurements of improved recovery, patient-reported outcomes are also important. Mobilization can be used to empower patients to play an active role in their recovery after surgery. Early mobilization protocols reduce pain [28], improve health-related quality of life, and reduce the incidence and intensity of postoperative fatigue [29].

We conducted a nonsystematic search of databases (PubMed® and Web of Science™) from September 2011 to September 2021 to get a snapshot of the past decade of research on early mobilization. We used combinations of key terms including ‘mobilization’ and ‘ambulation’ (modified by ‘early’ and ‘postoperative’) alongside ‘ERAS.’ For relevant publications, we hand-searched the reference list. Articles were also recommended by the senior author, who is an acknowledged expert in the field.

Barriers to early mobilization

There are several factors that can lead to delayed mobilization and low compliance with ERAS mobilization recommendations. First, delayed mobilization may be unavoidable if caused by delirium or early surgical complications and returns to the operating room. Several preoperative risk factors also predict delayed mobilization, including advanced age, physical/performance status and malnutrition [6]. It is well understood that early removal of catheters, intravenous lines and optimal pain management (opioid-sparing with adequate pain control) facilitates early mobilization. Strategies that result in improved pain control (such as pumps that continuously deliver a local anesthetic medication) and specific surgical techniques that result in less pain (minimal access surgeries) can be expected to improve postoperative mobilization. If compliance with the related discipline-specific ERAS recommendations is good, poor compliance with early mobilization targets may be primarily due to a lack of awareness and education about the benefits of early mobilization, resource limitations or a culture that does not prioritize physical activity during hospitalization. Fortunately, relatively simple interventions involving education and clinical decision-making tools can dramatically improve adherence to the ERAS mobilization recommendations [27].

Even if the clinical team understands the benefits of early mobilization and considers the benefits to outweigh the perceived risks, there can still be significant barriers such as technical difficulty (multiple tubes and drains and the complexity of specific surgical sites), and insufficient staff or time to mobilize patients [34]. A lack of staff to assist with out-of-bed activity is consistently highlighted as a barrier to mobilization [35]. In particular, mobilization can depend on the availability of physical therapists. In a prospective observational study conducted by Garzon-Serrano *et al.* [36], a patient’s ability to mobilize was significantly higher with a physical therapist present. Additionally, physical therapists achieve a higher level of mobilization, particularly with critically ill patients, compared with nurses. Ideally, especially in high-acuity postoperative settings, support from physical therapists should be a part of usual care, starting within 24 h after surgery. After hepatopancreatobiliary surgery, the main barriers to early

postoperative mobilization were pain, followed by lethargy or giddiness and a lack of inclusion of early mobilization in postoperative instructions [37]. After cardiac surgery, patients reported that alongside pain, the main barriers to ambulation were insecurity and demotivation [38]. Some patients may have been influenced by the historical belief that limited activity or complete bed rest is necessary for the body to recover after surgery [39], and this might be responsible for low motivation when nurses attempt to mobilize patients. Therefore, preoperative patient education is invaluable, and this can be linked with patient motivations, such as 'to do whatever it takes to get home earlier' [40]. Interviews with patients who had been mobilized immediately after abdominal surgery indicate that patients experienced mobilization as an important part of their care and that it had an impact on recovery and overall well-being [40]. In general, the nursing team plays a crucial role in the postoperative mobilization of patients and must be supported through dedicated training and sufficient staffing to allow time to help patients with symptoms (such as pain and fatigue) and concerns who might otherwise be highly motivated to get moving. For example, in adults aged over 75 years, the main concern preventing mobilization is a fear of falls [35], and patients are unlikely to walk without assistance. However, systematic implementation and high compliance with ERAS pathways lead to a decrease in nursing workload [41].

Recent advancements

Educational strategies to increase postoperative mobilization

Novel education delivery methods have shown potential for improving patient outcomes. Jones *et al.* [42] developed an educational presentation that included animated visualizations of physiological processes (reduced heart rate, blood circulation and lung function). The visualization showed deleterious processes when immobile, contrasted with improved processes when mobile. The presentation also included video footage of patient actors on the hospital unit and challenged lay beliefs about bed rest with an explanation of better patient outcomes within ERAS pathways. Patients were then provided with specific mobilization recommendations and were asked to discuss examples of how they could include exercise in their routines both in-hospital and once discharged [42]. In comparison to usual care, the intervention resulted in increased step counts after hospital discharge and a more positive perception of the quality of recovery after surgery. However, there were few differences when the intervention was compared with an active control group and no between-group differences in self-reported exercise.

Strategies to facilitate a culture shift to prioritize helping patients move after surgery, having open discussions about barriers within specific surgical disciplines and taking an integrative team approach may improve mobilization and, ultimately, patient outcomes [37,43]. Even at the peak of the COVID-19 pandemic, some institutions have been able to demonstrate the long-term sustainability of early mobilization improvement strategies that empower nurses and patients. For example, Chan *et al.* [44] found that a perioperative management and prehabilitation program for patients undergoing major hepatopancreatobiliary surgery resulted in high compliance (79%) to mobilization recommendations (sitting out of bed for >6 h on postoperative day 1 and walking >30 m on postoperative day 2).

Wearable technology within ERAS

A significant challenge for research on early postoperative mobilization is getting an accurate measurement of the quantity of mobilization without causing undue burden to the clinical team [45]. Finding ways to increase patient self-adherence to mobilization targets without increasing the workload of the clinical team are of particular interest, and wearable technology is one option. Wearable technology are devices worn on the body that can provide continuous accelerometry-derived data on physical activity (e.g., step counts, distance walked). There is already evidence that objective measurements of postoperative mobilization are linked with improved clinical outcomes. Daskivich *et al.* [46] found that the quantity of ambulation on postoperative day 1 is important: a higher number of steps were linearly associated with a decreased probability of a prolonged hospital LOS (up to a step count of 1000 steps). Furthermore, walking more in hospital is predictive of a shorter LOS and lower morbidity after laparoscopic colorectal surgery, and lower risk of readmission to hospital after major cytoreductive cancer surgery [47]. In one of the first RCTs on the topic, Wolk *et al.* [48] found a wrist-worn activity monitor with continuous patient feedback resulted in a significantly increased mean step count on postoperative days 1–5, in comparison to usual care. Although these results could not be confirmed in an open surgery arm, these early findings highlight the potential of wearable technology for improving mobilization in ERAS settings. It may be the presence of an activity tracker and real-time feedback that improves mobilization because Waller *et al.* [49] did not find differences in daily step counts in patients who had undergone colorectal surgery when comparing activity trackers with and without tactile and auditory alarms to remind patients to move. Two important considerations regarding the use of

wearable technology within the inpatient postoperative setting are user experience and data accuracy [45]. Wearable activity trackers may be feasible after major surgery, but clear instructions must be communicated to both the patient and the nursing team [50]. Data accuracy differs depending on the device (e.g., commercially available or research-grade), and step count accuracy may be reduced for altered or slow gait patterns [51] (particularly relevant to the postoperative settings).

Physical activity & exercise as part of perioperative care

Once patients achieve meaningful mobilization (within 24 h after surgery, if possible), structured and progressive movement that helps patients accelerate toward independent mobilization is also crucial. Including resistance exercise to regain lost muscle mass or strength, and improve overall function, may make the transition to recovery at home easier. Tanaka *et al.* [52] found that bodyweight resistance exercises in the early postoperative period increased functional walking capacity (distance walked in the 6-minute walk test) at hospital discharge in geriatric patients who underwent laparoscopic surgery for gastrointestinal cancer. Schram *et al.* [33] evaluated tailored resistance training in 40 patients undergoing colorectal resection within an ERAS pathway. In the early postoperative period, patients were stratified according to their functional ability and encouraged to take part in either in-bed, seated or standing resistance routines. Patients performed exercises under the supervision of a kinesiologist once per day for the duration of the hospital stay and were advised to continue with the resistance training (up to 30 minutes per day) after they were discharged. The results showed that patients are willing and able to participate in light–moderate resistance training (tailored to individual needs) after colorectal surgery. It is also important to note that a proportion of patients were unable to ambulate during postoperative days 1–3 but were able to participate in resistance training, which may prevent such patients from remaining entirely sedentary early after surgery [33].

There is growing interest in the role of exercise prehabilitation as a part of ERAS-guided care [53–59]. Cancer prehabilitation has been defined as: ‘a process on the continuum of care that occurs between the time of cancer diagnosis and the beginning of acute treatment, includes physical and psychological assessments that establish a baseline functional level, identifies impairments and provides targeted interventions that improve a patient’s health to reduce the incidence and the severity of current and future impairments’ [54]. Although exercise prehabilitation is safe and feasible, the role of preoperative exercise for enhancing mobilization and improving outcomes within ERAS has not been extensively studied. Au *et al.* [55] found that home-based exercise prehabilitation versus usual care significantly increased objectively measured physical activity on postoperative day 1, following radical prostatectomy. However, larger studies are needed to determine the impact on clinical outcomes. In a retrospective analysis, Ploussard *et al.* [56] highlighted the synergistic effect of ERAS and prehabilitation, including physical activity workshops delivered by a physiotherapist and several other elements. Following implementation, the combination of ERAS and the prehabilitation program for patients undergoing radical prostatectomy was associated with shorter hospital stays and reduced costs. Prehabilitation involving individualized exercise programs for patients undergoing liver resection has also been shown to reduce complications and improve social/family well-being [57]. There is clearly potential to further optimize the postoperative course of patients treated within ERAS pathways through the addition of exercise prehabilitation.

Future perspective

The future of measuring, monitoring and prescribing mobilization after surgery lies in the use of wearable technology that syncs seamlessly with the electronic medical record and provides data to both patients and clinicians in real-time. We envision wearable technology being used to help identify patients who are not meeting mobilization targets within the context of busy clinical workflows. In addition, the use of wearable technology can be used as a motivational tool for patients, and it could help overcome a key barrier to exploring the impact of postoperative mobilization within ERAS: the unnecessary burden placed on many nursing teams to accurately document mobilization in the hospital wards. Despite the recognition of its value by the ERAS® Society, the definition of mobilization differs across ERAS guidelines (Table 1) and interpretation of the less precise recommendations is currently specific to individual hospitals where the recommendations are implemented. Other authors have also highlighted that mobilization and ambulation are not synonymous, and it is the latter that is more relevant to patients’ physiologic function and return to daily activities [44]. As our understanding of the dose-response relationship between ambulation quantity and clinical outcomes improve, we anticipate that recommendations will become more exact. There is also a role for machine learning in ERAS to allow predictions about the most beneficial elements of ERAS based on large datasets without explicit programming [58]. For example, machine-learning

algorithms have been used to determine which subset of ERAS is most impactful on postoperative outcomes [27,59]. In line with our summary of current evidence, Olson *et al.* [59] found that early mobilization, alongside multimodal pain management, were the elements most protective against a prolonged LOS. In the future, preoperative clinical data and data collected by wearable technology could be used for decision-making in operative planning and postoperative care [58]. The potential role of ERAS to help minimize healthcare disparities also deserves in-depth attention [60]. Finally, the success of ERAS is not only due to its multidisciplinary approach and high standard, evidence-informed method to guideline development [61]. It is also dependent on the involvement of patients and the ability of the healthcare team to engage patients to take an active role in their preparedness for surgery and recovery in the hospital. Therefore, understanding patient experiences of ERAS-guided care, involving patients as partners in ERAS research [62], and creating opportunities for patients to take on a collaborative role across the perioperative period, are essential to the continued success of ERAS.

Executive summary

- Early mobilization is a crucial component of enhanced recovery after surgery (ERAS) pathways that counteract the adverse physiological consequences of immobilization and surgical stress.
- Evidence from prospective randomized controlled trials comparing early mobilization interventions to usual care in several surgical specialties is convincing and continues to accumulate.
- Early mobilization reduces the risk of postoperative complications, accelerates the recovery of functional walking capacity, positively impacts several patient-reported outcomes and reduces hospital length of stay, thereby reducing care costs.
- Several modifiable barriers to early mobilization include a lack of awareness and education about the benefits, a lack of resources and a lack of culture that prioritizes physical activity after surgery.
- Fortunately, relatively simple strategies such as education and clinical decision-making tools can dramatically improve compliance with ERAS mobilization recommendations.
- Recent advances include improving the measurement of mobilization quantity and providing real-time feedback to patients via wearable technology, adding exercise across the perioperative period (including exercise prehabilitation) and using animated visualization to improve recovery.
- ERAS guidelines in new surgical disciplines and updates to existing guidelines should emphasize the benefits of structured mobilization by providing targets for the quality and quantity of mobilization (such as time spent out of bed, ambulation distance and frequency in the early postoperative period) alongside a target for the time-to-mobilization (within 24 h). Although there may not yet be evidence supporting specific protocols, collaboration with physical therapists who help mobilize patients within specific surgical disciplines will aid prescription.
- Collaboration with clinical exercise physiologists and physical therapists in the development of patient resources for online/virtual exercise prehabilitation provides an opportunity to improve outcomes within ERAS pathways.

Author contributions

R Tazreean was responsible for the conceptualization, investigation, writing – original draft, writing – reviewing and editing; G Nelson contributed to the conceptualization, supervision, writing – reviewing and editing; R Twomey was responsible for the conceptualization, writing – original draft, writing – reviewing and editing.

Financial & competing interests disclosure

R Tazreean was supported by an Alberta Innovates Summer Studentship, and R Twomey was supported by the Ohlson Research Initiative and a Canadian Institute of Health Research Fellowship during the conduct of this review. G Nelson served as the secretary of the Enhanced Recovery After Surgery (ERAS®) Society during the conduct of this review, and reports speaker/advisory fees from Abbot, GSK, 3M and Medtronic outside the submitted work. The authors have no other relevant affiliations or financial involvement with any organization or entity with a financial interest in or financial conflict with the subject matter or materials discussed in the manuscript apart from those disclosed.

No writing assistance was utilized in the production of this manuscript.

References

Papers of special note have been highlighted as: • of interest; •• of considerable interest

1. Ljungqvist O, Scott M, Fearon KC. Enhanced recovery after surgery: a review. *JAMA Surg.* 152, 292–298 (2017).
- **This review describes the development and implementation of enhanced recovery after surgery and some of the main outcome improvements.**

2. Ljungqvist O, de Boer HD, Balfour A *et al.* Opportunities and challenges for the next phase of enhanced recovery after surgery: a review. *JAMA Surg.* 156, 775–784 (2021).
- **This review highlights opportunities and challenges in the field of enhanced recovery.**
3. Fearon KCH, Ljungqvist O, Von Meyenfeldt M *et al.* Enhanced recovery after surgery: a consensus review of clinical care for patients undergoing colonic resection. *Clin Nutr.* 24, 466–477 (2005).
4. ERAS[®] Society. List of Guidelines. <https://erassociety.org/guidelines/list-of-guidelines/>
5. Thanh N, Nelson A, Wang X *et al.* Return on investment of the enhanced recovery after surgery (ERAS) multiguideline, multisite implementation in Alberta, Canada. *Can. J. Surg.* 63, E542–E550 (2020).
6. Grass F, Pache B, Martin D *et al.* Feasibility of early postoperative mobilisation after colorectal surgery: a retrospective cohort study. *Int. J. Surg.* 56, 161–166 (2018).
7. Batchelor TJP, Rasburn NJ, Abdelnour-Berchtold E *et al.* Guidelines for enhanced recovery after lung surgery: recommendations of the Enhanced Recovery After Surgery (ERAS[®]) Society and the European Society of Thoracic Surgeons (ESTS). *European Journal of Cardio-Thoracic Surgery* 55, 91–115 (2019).
8. Debono B, Wainwright TW, Wang MY *et al.* Consensus statement for perioperative care in lumbar spinal fusion: Enhanced Recovery After Surgery (ERAS[®]) Society recommendations. *Spine J.* 21, 729–752 (2021).
9. Cerantola Y, Valerio M, Persson B *et al.* Guidelines for perioperative care after radical cystectomy for bladder cancer: Enhanced Recovery After Surgery (ERAS[®]) Society recommendations. *Clinical Nutrition.* 32, 879–887 (2013).
10. Dort JC, Farwell DG, Findlay M *et al.* Optimal perioperative care in major head and neck cancer surgery with free flap reconstruction: a consensus review and recommendations from the Enhanced Recovery After Surgery Society. *JAMA Otolaryngol Head Neck Surg.* 143, 292–303 (2017).
11. Feldheiser A, Aziz O, Baldini G *et al.* Enhanced recovery after surgery (ERAS) for gastrointestinal surgery, part 2: consensus statement for anaesthesia practice. *Acta Anaesthesiologica Scandinavica.* 60, 289–334 (2016).
12. Gustafsson UO, Scott MJ, Hubner M *et al.* Guidelines for perioperative care in elective colorectal surgery: Enhanced Recovery After Surgery (ERAS[®]) Society recommendations: 2018. *World J Surg.* 43, 659–695 (2019).
13. Hübner M, Kusamura S, Villeneuve L *et al.* Guidelines for perioperative care in cytoreductive surgery (CRS) with or without hyperthermic IntraPeritoneal chemotherapy (HIPEC): Enhanced Recovery After Surgery (ERAS[®]) Society Recommendations — Part II: Postoperative management and special considerations. *Eur. J. Surg. Oncol.* 46, 2311–2323 (2020).
14. Low DE, Allum W, De Manzoni G *et al.* Guidelines for Perioperative Care in Esophagectomy: Enhanced Recovery After Surgery (ERAS[®]) Society Recommendations. *World J Surg.* 43, 299–330 (2019).
15. Macones GA, Caughey AB, Wood SL *et al.* Guidelines for postoperative care in cesarean delivery: Enhanced Recovery After Surgery (ERAS) Society recommendations (part 3). *Am. J. Obstet. Gynecol.* 221, 247.e1–247.e9 (2019).
16. Melloul E, Lassen K, Roulin D *et al.* Guidelines for Perioperative Care for Pancreatoduodenectomy: Enhanced Recovery After Surgery (ERAS) Recommendations 2019. *World J Surg.* 44, 2056–2084 (2020).
17. Melloul E, Hübner M, Scott M *et al.* Guidelines for Perioperative Care for Liver Surgery: Enhanced Recovery After Surgery (ERAS) Society Recommendations. *World J Surg.* 40, 2425–2440 (2016).
18. Mortensen K, Nilsson M, Slim K *et al.* Consensus guidelines for enhanced recovery after gastrectomy. *Br J Surg.* 101, 1209–1229 (2014).
19. Nelson G, Bakkum-Gamez J, Kalogera E *et al.* Guidelines for perioperative care in gynecologic/oncology: Enhanced Recovery After Surgery (ERAS) Society recommendations – 2019 update. *Int. J. Gynecol. Cancer* 29(4), 651–668 (2019).
20. Temple-Oberle C, Shea-Budgell MA, Tan M *et al.* Consensus review of optimal perioperative care in breast reconstruction: Enhanced Recovery after Surgery (ERAS) Society recommendations. *Plast Reconstr Surg.* 139, 1056e–1071e (2017).
21. Wainwright TW, Gill M, McDonald DA *et al.* Consensus statement for perioperative care in total hip replacement and total knee replacement surgery: Enhanced Recovery After Surgery (ERAS[®]) Society recommendations. *Acta Orthopaedica.* 91(1), 3–19 (2020).
22. Graf C. Functional decline in hospitalized older adults. *Am. J. Nurs.* 106, 58–67; quiz 67–68 (2006).
23. Harper CM, Lyles YM. Physiology and complications of bed rest. *J. Am. Geriatr. Soc.* 36, 1047–1054 (1988).
24. Brower RG. Consequences of bed rest. *Crit. Care Med.* 37, S422–S428 (2009).
25. Alazawi W, Pirmadjid N, Lahiri R, Bhattacharya S. Inflammatory and immune responses to surgery and their clinical impact. *Ann. Surg.* 264, 73–80 (2016).
26. Engel O, Herzberger EH, Yagur Y *et al.* Walking to a better future? Postoperative ambulation after cesarean delivery and complications: a prospective study. *Int. J. Gynaecol. Obstet.* doi:10.1002/ijgo.13815 (2021).
27. Twomey R, Matthews TW, Nakoneshny S *et al.* Impact of early mobilization on recovery after major head and neck surgery with free flap reconstruction. *Cancers* 13, 2852 (2021).
28. Ni C-Y, Wang Z-H, Huang Z-P *et al.* Early enforced mobilization after liver resection: a prospective randomized controlled trial. *Int. J. Surg.* 54, 254–258 (2018).

29. de Almeida EPM, de Almeida JP, Landoni G *et al.* Early mobilization programme improves functional capacity after major abdominal cancer surgery: a randomized controlled trial. *Br. J. Anaesth.* 119, 900–907 (2017).
- **This is an randomized controlled trial (RCT) of an early mobilization intervention.**
30. Kanejima Y, Shimogai T, Kitamura M, Ishihara K, Izawa KP. Effect of early mobilization on physical function in patients after cardiac surgery: a systematic review and meta-analysis. *Int. J. Environ. Res. Public Health* 17, 7091 (2020).
- **This is an RCT involving an early mobilization intervention.**
31. Fiore JF Jr, Castellino T, Pecorelli N *et al.* Ensuring early mobilization within an enhanced recovery program for colorectal surgery: a randomized controlled trial. *Ann. Surg.* 266(2), 223–231 (2017).
32. Balvardi S, Pecorelli N, Castellino T *et al.* Impact of facilitation of early mobilization on postoperative pulmonary outcomes after colorectal surgery: a randomized controlled trial. *Ann. Surg.* 273, 868–875 (2021).
- **This is an RCT involving an early mobilization intervention.**
33. Schram A, Ferreira V, Minnella EM, Awasthi R, Carli F, Scheede-Bergdahl C. In-hospital resistance training to encourage early mobilization for enhanced recovery programs after colorectal cancer surgery: a feasibility study. *Eur. J. Surg. Oncol.* 45, 1592–1597 (2019).
34. Fontela PC, Forgariini LA Jr, Friedman G. Clinical attitudes and perceived barriers to early mobilization of critically ill patients in adult intensive care units. *Rev. Bras. Ter. Intensiva* 30, 187–194 (2018).
35. Brown CJ, Williams BR, Woodby LL, Davis LL, Allman RM. Barriers to mobility during hospitalization from the perspectives of older patients and their nurses and physicians. *J. Hosp. Med.* 2, 305–313 (2007).
36. Garzon-Serrano J, Ryan C, Waak K *et al.* Early mobilization in critically ill patients: patients' mobilization level depends on health care provider's profession. *PMR* 3, 307–313 (2011).
37. Tang JH, Wang B, Chow LJ *et al.* Improving postoperative mobilisation rates in patients undergoing elective major hepatopancreatobiliary surgery. *Postgrad. Med. J.* 97, 239–247 (2021).
38. Gama Lordello GG, Gonçalves Gama GG, Lago Rosier G, Viana PAD de C, Correia LC, Fonteles Ritt LE. Effects of cycle ergometer use in early mobilization following cardiac surgery: a randomized controlled trial. *Clin. Rehabil.* 34, 450–459 (2020).
39. Brieger GH. Early ambulation. A study in the history of surgery. *Ann. Surg.* 197, 443–449 (1983).
40. Svensson-Raskh A, Schandl A, Holdar U, Fagevik Olsén M, Nygren-Bonnier M. "I have everything to win and nothing to lose": patient experiences of mobilization out of bed immediately after abdominal surgery. *Phys. Ther.* 100, 2079–2089 (2020).
41. Hübner M, Addor V, Sliker J *et al.* The impact of an enhanced recovery pathway on nursing workload: a retrospective cohort study. *Int. J. Surg.* 24, 45–50 (2015).
42. Jones ASK, Kleinstäuber M, Akroyd A *et al.* Using animated visualization to improve postoperative mobilization: a randomized controlled trial. *Health Psychol.* 38, 748–758 (2019).
43. Gramlich LM, Sheppard CE, Wasylak T *et al.* Implementation of enhanced recovery after surgery: a strategy to transform surgical care across a health system. *Implement. Sci.* 12, 67 (2017).
44. Chan KS, Wang B, Tan YP *et al.* Sustaining a multidisciplinary, single-institution, postoperative mobilization clinical practice improvement program following hepatopancreatobiliary surgery during the COVID-19 pandemic: prospective cohort study. *JMIR Perioper. Med.* 4, e30473 (2021).
45. Twomey R, Culos-Reed SN, Daun JT, Ferber R, Dort JC. Wearable activity trackers and mobilization after major head and neck cancer surgery: you can't improve what you don't measure. *Int. J. Surg.* 84, 120–124 (2020).
46. Daskivich TJ, Houman J, Lopez M *et al.* Association of wearable activity monitors with assessment of daily ambulation and length of stay among patients undergoing major surgery. *JAMA Netw. Open* 2, e187673–e187673 (2019).
47. Low CA, Bovbjerg DH, Ahrendt S *et al.* Fitbit step counts during inpatient recovery from cancer surgery as a predictor of readmission. *Ann. Behav. Med.* 52, 88–92 (2017).
48. Wolk S, Linke S, Bogner A *et al.* Use of activity tracking in major visceral surgery-the enhanced perioperative mobilization trial: a randomized controlled trial. *J. Gastrointest. Surg.* 23, 1218–1226 (2019).
49. Waller GC, Kim TG, Perez S *et al.* Comparing activity trackers with vs. without alarms to increase postoperative ambulation: a randomized control trial. *Am. Surg.* 87, 1093–1098 (2021).
50. Daun JT, Twomey R, Dort J *et al.* Exercise in the care pathway for surgical head and neck cancer patients: the patient and health care provider perspective. *SportRxive* (2020). DOI: 10.31236/osf.io/dpmjq
51. Feehan LM, Geldman J, Sayre EC *et al.* Accuracy of Fitbit devices: systematic review and narrative syntheses of quantitative data. *JMIR Mhealth Uhealth.* 6, e10527 (2018).
52. Tanaka K, Taoda A, Kashiwagi H. Resistance exercise after laparoscopic surgery enhances improvement in exercise tolerance in geriatric patients with gastrointestinal cancer. *Cureus* 13, e15454 (2021).
53. Twomey R, Culos-Reed SN, Dort JC. Exercise prehabilitation-supporting recovery from major head and neck cancer surgery. *JAMA Otolaryngol. Head Neck Surg.* 8, 689–690 (2020).

54. Silver JK, Baima J. Cancer prehabilitation: an opportunity to decrease treatment-related morbidity, increase cancer treatment options, and improve physical and psychological health outcomes. *Am. J. Phys. Med. Rehabil.* 92, 715–727 (2013).
55. Au D, Matthew AG, Lopez P *et al.* Prehabilitation and acute postoperative physical activity in patients undergoing radical prostatectomy: a secondary analysis from an RCT. *Sports Med. Open* 5, 18 (2019).
56. Ploussard G, Almeras C, Beauval J-B *et al.* A combination of enhanced recovery after surgery and prehabilitation pathways improves perioperative outcomes and costs for robotic radical prostatectomy. *Cancer* 126, 4148–4155 (2020).
57. Wang B, Shelat VG, Chow JJL *et al.* Prehabilitation program improves outcomes of patients undergoing elective liver resection. *J. Surg. Res.* 251, 119–125 (2020).
58. Hashimoto DA, Rosman G, Rus D, Meireles OR. Artificial intelligence in surgery: promises and perils. *Ann. Surg.* 268, 70–76 (2018).
59. Olson KA, Fleming RYD, Fox AW *et al.* The enhanced recovery after surgery (ERAS) elements that most greatly impact length of stay and readmission. *Am. Surg.* 87, 473–479 (2021).
60. Patel K, Zakowski M. Enhanced recovery after cesarean: current and emerging trends. *Curr. Anesthesiol. Rep.* 1–9 (2021).
61. Brindle M, Nelson G, Lobo DN, Ljungqvist O, Gustafsson UO. Recommendations from the ERAS[®] Society for standards for the development of enhanced recovery after surgery guidelines. *BJS Open* 4, 157–163 (2019).
62. Gillis C, Gill M, Marlett N *et al.* Patients as partners in enhanced recovery after surgery: a qualitative patient-led study. *BMJ Open* 7, e017002 (2017).

