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Exercise as a Component of Enhanced Recovery After Surgery (ERAS): A Narrative Review

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Abstract

Background. Enhanced Recovery After Surgery (ERAS) protocols represent a multimodal, evidence-based approach aimed at reducing surgical stress, minimizing complications, and accelerating postoperative recovery. While ERAS pathways have demonstrated significant improvements in perioperative outcomes, the role of exercise—encompassing both prehabilitation and early postoperative mobilization—remains insufficiently standardized and inconsistently implemented despite growing evidence supporting its clinical benefits.

Aim. The aim of this narrative review was to evaluate the role of exercise as a component of ERAS protocols, with particular emphasis on prehabilitation and early postoperative

mobilization, and to identify current limitations and propose a structured framework for integrating physical activity into perioperative care.

Material and methods. A narrative literature review was conducted using PubMed, Scopus, and Web of Science databases. The search strategy included keywords such as “ERAS”, “prehabilitation”, “exercise”, “physical activity”, and “early mobilization”. Eligible studies included randomized controlled trials, systematic reviews, meta-analyses, and observational studies related to perioperative exercise. The selected literature was analyzed qualitatively to identify key mechanisms, clinical outcomes, and implementation barriers.

Results. Exercise interventions were shown to improve functional capacity, enhance metabolic resilience, and reduce postoperative complications. Prehabilitation was associated with increased cardiorespiratory fitness and improved tolerance to surgical stress, particularly in high-risk and oncological patients. Early postoperative mobilization contributed to improved pulmonary function, reduced thromboembolic risk, and faster recovery of functional independence. However, significant variability was observed in exercise protocols, including differences in timing, intensity, and implementation, highlighting a lack of standardization within ERAS pathways. Key barriers included patient-related factors, organizational constraints, and limited integration of exercise into clinical practice.

Conclusions. Exercise represents a critical yet underutilized component of ERAS protocols. Its structured integration, including prehabilitation and early mobilization, has the potential to significantly improve perioperative outcomes and recovery. The development of standardized, evidence-based exercise protocols and enhanced interdisciplinary collaboration are essential to optimize implementation and maximize clinical benefits.

Key words: Enhanced Recovery After Surgery (ERAS); prehabilitation; early mobilization; exercise therapy; perioperative care; physical activity; postoperative recovery; surgical outcomes; functional capacity; rehabilitation

1. Introduction

Enhanced Recovery After Surgery (ERAS) represents a multimodal, evidence-based approach to perioperative care designed to reduce surgical stress, minimize complications, and accelerate recovery (Gillis et al., 2025; Kehlet, 2011; Ljungqvist et al., 2017). Since its introduction by Kehlet, ERAS protocols have been widely implemented across multiple surgical disciplines, demonstrating reductions in postoperative morbidity, length of hospital stay, and healthcare costs (Kehlet, 2011; Ljungqvist et al., 2017). Core components of ERAS pathways include optimized analgesia, early enteral nutrition, minimally invasive techniques, and early mobilization, all aimed at attenuating the metabolic response to surgery and preserving physiological function (Fearon et al., 2005; Gillis et al., 2025; Ljungqvist et al., 2017).

Surgical trauma induces a complex physiological response characterized by increased inflammatory activity, insulin resistance, and accelerated muscle catabolism, which collectively contribute to impaired functional recovery (Desborough, 2000; Gillis et al., 2025). In this context, physical activity has emerged as a potentially critical yet underutilized component of perioperative care (de Almeida et al., 2017; Minnella et al., 2017). Exercise interventions, including prehabilitation and early postoperative mobilization, have been shown to improve cardiorespiratory fitness, enhance metabolic resilience, and reduce postoperative complications (Carli, 2020; de Almeida et al., 2017; Minnella et al., 2017; Moran et al., 2016).

Prehabilitation, defined as structured physical activity performed before surgery, aims to increase functional reserve and improve the patient's ability to withstand surgical stress (Carli, 2020; Minnella et al., 2017) Evidence suggests that prehabilitation programs can improve functional capacity and reduce complication rates, particularly in high-risk and oncological populations (Barberan-Garcia et al., 2018; Minnella et al., 2017, 2018; Moran et al., 2016). Similarly, early postoperative mobilization has been associated with improved pulmonary function, reduced thromboembolic risk, and faster return to baseline functional status (de Almeida et al., 2017; Gando et al., 2013; Ljungqvist et al., 2017).

Despite these benefits, the integration of exercise into ERAS protocols remains inconsistent, with significant variability in timing, intensity, and implementation strategies (Carli, 2020; Minnella et al., 2018). Current recommendations are often based on institutional

practices rather than standardized evidence-based guidelines, which may limit their effectiveness and reproducibility (Hughes et al., 2014; Minnella et al., 2018).

The aim of this narrative review is to evaluate the role of exercise as a component of ERAS protocols, with particular emphasis on prehabilitation and early postoperative mobilization. Additionally, this study seeks to identify current limitations in implementation and propose a structured framework for integrating exercise into perioperative care.

Research Objective. The objective of this study is to assess the role of exercise in ERAS protocols and evaluate its impact on postoperative outcomes and functional recovery.

Research Problems. What is the physiological basis for exercise in perioperative care? What is the evidence supporting prehabilitation and early mobilization? What are the limitations in implementing exercise within ERAS protocols? How can exercise be effectively integrated into ERAS pathways?

Research Hypotheses. Exercise significantly improves postoperative outcomes in ERAS protocols. Lack of standardization contributes to variability in clinical outcomes. Structured integration of exercise enhances recovery and reduces complications.

2. Research materials and methods

2.1. Participants.

Not applicable. This study is a narrative literature review.

2.2. Procedure / Test protocol / Skill test trial / Measure / Instruments.

A narrative literature review was conducted using PubMed, Scopus, and Web of Science databases. Search terms included “ERAS”, “prehabilitation”, “exercise”, “physical activity”, and “early mobilization”. Eligible studies included randomized controlled trials, systematic reviews, meta-analyses, and observational studies related to perioperative exercise.

2.3. Data collection and analysis / Statistical analysis.

2.3.1. Statistical Software.

Not applicable.

2.3.2. AI.

AI was utilized for two specific purposes in this research. Text analysis of clinical reasoning narratives to identify linguistic patterns associated with specific logical fallacies. Assistance in refining the academic English language of the manuscript, ensuring clarity, consistency, and adherence to scientific writing standards. **AI** were used for additional linguistic refinement of the research manuscript, ensuring proper English grammar, style, and clarity in the presentation of results. It is important to emphasize that all AI tools were used strictly as assistive instruments under human supervision. The final interpretation of results, classification of errors, and conclusions were determined by human experts in clinical medicine and formal logic. The AI tools served primarily to enhance efficiency in data processing, pattern recognition, and linguistic refinement, rather than replacing human judgment in the analytical process.

2.3.3. Statistical Methods.

Not applicable.

3. Research results

3.1. Physiological rationale for exercise in ERAS protocols

Surgical procedures trigger a systemic stress response characterized by activation of inflammatory pathways, increased insulin resistance, and enhanced protein catabolism (Desborough, 2000; Gillis et al., 2025; Thorell et al., 2016). These physiological alterations contribute to reduced functional capacity and delayed recovery (Desborough, 2000; Thorell et al., 2016). Exercise has been shown to modulate these processes by improving metabolic efficiency and reducing systemic inflammation (Carli, 2020; Pedersen & Saltin, 2015).

Preoperative exercise improves cardiorespiratory fitness, commonly assessed by VO_2 max, which is a strong predictor of postoperative outcomes (Low, 2013; Moran et al., 2016). Higher preoperative fitness levels are associated with lower complication rates and improved

recovery trajectories (Low, 2013; Makary et al., 2010). Additionally, exercise enhances mitochondrial function and oxygen utilization, thereby increasing tolerance to surgical stress (Booth et al., 2000; Pedersen & Saltin, 2015).

Exercise also plays a critical role in reducing insulin resistance, a key feature of the postoperative metabolic response (Ljungqvist, 2009; Thorell et al., 2016). Improved insulin sensitivity contributes to better glycemic control and reduced risk of complications (Ljungqvist, 2009). Furthermore, physical activity has been shown to modulate cytokine profiles, reducing pro-inflammatory markers and promoting an anti-inflammatory state (Gleeson et al., 2011; Pedersen & Saltin, 2015).

Early postoperative mobilization further supports recovery by improving pulmonary function and preventing complications such as atelectasis and pneumonia (Gando et al., 2013; Ljungqvist et al., 2017). It also enhances venous return, reducing the risk of thromboembolic events (Gando et al., 2013; Gould et al., 2012). Collectively, these mechanisms highlight the multifactorial benefits of exercise in perioperative care.

3.2. Prehabilitation as a component of ERAS

Prehabilitation has gained increasing attention as a strategy to optimize patients before surgery and improve postoperative outcomes (Carli, 2020; Minnella et al., 2017). It typically includes aerobic training, resistance exercise, and, in some cases, nutritional and psychological support (Minnella et al., 2017, 2018).

Multiple studies have demonstrated that prehabilitation improves functional capacity and reduces postoperative complications (Barberan-Garcia et al., 2018; Gillis et al., 2014; Minnella et al., 2017, 2018; Moran et al., 2016). In colorectal and oncological surgery, prehabilitation has been associated with improved walking capacity, reduced length of hospital stay, and lower complication rates (Barberan-Garcia et al., 2018; Gillis et al., 2014; Moran et al., 2016). These effects are particularly pronounced in frail and high-risk patients (Huisman et al., 2016; Makary et al., 2010).

Prehabilitation also has psychological benefits, reducing anxiety and improving patient engagement in the recovery process (Minnella et al., 2018; Powell et al., 2016). Improved

mental readiness may contribute to better adherence to postoperative protocols and enhanced overall outcomes (Powell et al., 2016).

Despite strong evidence, implementation of prehabilitation remains limited (Hughes et al., 2014; Minnella et al., 2018). Barriers include lack of time before surgery, insufficient resources, and absence of standardized protocols (Hughes et al., 2014). This gap between evidence and practice highlights the need for better integration of prehabilitation into ERAS pathways.

3.3. Early postoperative mobilization

Early mobilization is a cornerstone of ERAS protocols and is associated with improved recovery and reduced complication rates (de Almeida et al., 2017; Ljungqvist et al., 2017). Initiating movement within the first 24 hours after surgery has been shown to improve functional outcomes and reduce hospital stay (de Almeida et al., 2017; Gando et al., 2013).

Mobilization enhances pulmonary function by improving ventilation and reducing the risk of respiratory complications (Gando et al., 2013; Gould et al., 2012). It also promotes gastrointestinal motility, reducing the incidence of postoperative ileus (Fearon et al., 2005; Vather et al., 2013). Additionally, early ambulation decreases the risk of venous thromboembolism and supports cardiovascular stability (Geerts et al., 2008; Gould et al., 2012).

Randomized controlled trials have demonstrated that structured mobilization protocols significantly improve functional recovery compared to standard care (de Almeida et al., 2017; Gando et al., 2013). However, variability in implementation remains a challenge, with differences in timing, intensity, and progression of activity (Hughes et al., 2014).

Barriers to mobilization include pain, fatigue, and organizational constraints such as staffing limitations and lack of physiotherapy support (Boden et al., 2018; Hughes et al., 2014). Addressing these barriers is essential for optimizing ERAS outcomes.

3.4. Barriers to implementation of exercise in ERAS protocols

Despite robust evidence supporting the role of exercise in perioperative care, its implementation within ERAS protocols remains inconsistent and often suboptimal across healthcare systems (Boden et al., 2018; Gillis et al., 2025; Hughes et al., 2014; Minnella et al., 2018). One of the primary barriers is the lack of standardized, procedure-specific guidelines that clearly define the type, intensity, frequency, and progression of exercise interventions (Hughes et al., 2014; Minnella et al., 2018). Although ERAS recommendations emphasize early mobilization, they frequently lack detailed operationalization, leading to variability in clinical practice and reduced reproducibility of outcomes (Gillis et al., 2025; Hughes et al., 2014).

Patient-related factors represent another important limitation. Reduced baseline physical fitness, frailty, and comorbidities may limit the feasibility of prehabilitation programs, particularly in elderly and oncological populations (Hoogeboom et al., 2012; Huisman et al., 2016; Makary et al., 2010). Psychological factors, including anxiety, low motivation, and fear of postoperative complications, may further reduce adherence to exercise interventions (Hoogeboom et al., 2012; Powell et al., 2016). Pain and fatigue in the postoperative period are also commonly reported barriers that negatively influence participation in early mobilization (Boden et al., 2018; Kehlet & Wilmore, 2008).

Organizational constraints significantly impact implementation. Limited access to physiotherapy services, insufficient staffing, and time constraints within fast-track surgical pathways may hinder the integration of structured exercise programs (Boden et al., 2018; Hughes et al., 2014). In addition, variability in interdisciplinary collaboration between surgeons, anesthesiologists, physiotherapists, and nursing staff may result in fragmented perioperative care (Hughes et al., 2014; Ljungqvist et al., 2017).

Another critical barrier is the relative underrepresentation of exercise in ERAS education and training programs. While clinicians are generally well-trained in pharmacological and nutritional aspects of ERAS, exercise interventions are often perceived as secondary rather than integral components of recovery pathways (Gillis et al., 2025; Minnella et al., 2018). This imbalance may contribute to inconsistent prioritization and implementation in routine clinical practice.

Finally, heterogeneity in the available literature—including differences in study design, patient populations, outcome measures, and exercise protocols—limits the development of universally accepted recommendations (Carli, 2020; Hughes et al., 2014). These factors highlight the need for standardized frameworks and high-quality randomized controlled trials to support evidence-based integration of exercise into ERAS protocols.

3.5. Proposed integration of exercise into ERAS protocols

Given the demonstrated benefits of physical activity in perioperative care, a structured and standardized framework for integrating exercise into ERAS pathways is warranted (Carli, 2020; Gillis et al., 2025). Based on current evidence, a phased model encompassing prehabilitation, early postoperative mobilization, and progressive return to activity is proposed.

In the preoperative phase, patients should be encouraged to participate in structured exercise programs for at least 2–4 weeks prior to surgery, when feasible (Minnella et al., 2017, 2018). These programs should include a combination of aerobic and resistance training tailored to individual functional capacity and comorbidities (Carli, 2020; Minnella et al., 2017). The primary goal is to improve cardiorespiratory fitness, enhance metabolic resilience, and increase tolerance to surgical stress (Low, 2013; Moran et al., 2016).

In the immediate postoperative phase (postoperative days 0–1), early mobilization should be initiated as soon as clinically feasible (de Almeida et al., 2017; Ljungqvist et al., 2017). Interventions at this stage may include passive limb movements, sitting upright, and assisted standing, with the aim of preventing complications such as atelectasis, venous stasis, and muscle deconditioning (Gando et al., 2013; Gould et al., 2012).

During the early recovery phase (postoperative days 1–7), patients should progress to active mobilization, including walking and low-intensity functional activities (de Almeida et al., 2017; Gando et al., 2013). Gradual increases in duration and intensity should be guided by clinical status and patient tolerance (de Almeida et al., 2017). At this stage, the focus is on restoring functional independence and supporting physiological recovery.

In the late recovery phase (beyond postoperative day 7), patients may begin moderate-intensity physical activity, with the aim of returning to preoperative functional levels (Carli,

2020; Minnella et al., 2017). Structured rehabilitation programs may be particularly beneficial for high-risk patients or those undergoing major surgical procedures (Huisman et al., 2016).

Importantly, this framework should be individualized according to patient characteristics, type of surgery, and perioperative risk profile (Hoogeboom et al., 2012; Makary et al., 2010). Standardization should serve as a foundation for personalization rather than a rigid protocol. Additionally, effective implementation requires interdisciplinary collaboration and clear communication of activity goals to patients, which may improve adherence and reduce anxiety associated with postoperative movement (Ljungqvist et al., 2017; Powell et al., 2016).

The incorporation of objective functional measures, such as walking tests or performance-based assessments, may further enhance monitoring and optimization of recovery (Low, 2013; Moran et al., 2016). Overall, structured integration of exercise into ERAS protocols has the potential to improve clinical outcomes and reduce variability in perioperative care.

4. Discussion

The present review demonstrates that exercise represents a critical yet underutilized component of ERAS protocols, despite substantial evidence supporting its benefits in perioperative care (Carli, 2020; Gillis et al., 2025; Ljungqvist et al., 2017). While ERAS pathways have significantly improved surgical outcomes, the role of structured physical activity remains less emphasized compared to other components such as analgesia and nutrition (Ljungqvist et al., 2017).

Consistent with previous studies, both prehabilitation and early postoperative mobilization have been shown to improve functional capacity, reduce complication rates, and accelerate recovery (Barberan-Garcia et al., 2018; Carli, 2020; de Almeida et al., 2017; Minnella et al., 2017; Moran et al., 2016). Prehabilitation enhances physiological reserve and may be particularly beneficial in high-risk populations, including elderly and oncological patients (Huisman et al., 2016; Makary et al., 2010). Similarly, early mobilization contributes to improved pulmonary function, reduced thromboembolic risk, and faster return to baseline activity (de Almeida et al., 2017; Gando et al., 2013; Gould et al., 2012).

However, a major finding of this review is the significant heterogeneity in exercise-related practices within ERAS protocols (Hughes et al., 2014; Minnella et al., 2018). Differences in timing, intensity, and progression of activity may contribute to variability in outcomes and limit the reproducibility of results across institutions (Hughes et al., 2014). The lack of standardized exercise guidelines represents a key gap in current ERAS implementation.

Another important observation is the discrepancy between evidence and clinical practice. Despite strong support for prehabilitation, its adoption remains limited due to logistical, organizational, and patient-related barriers (Hughes et al., 2014; Minnella et al., 2018). This highlights the need for improved implementation strategies and integration of exercise into routine perioperative care.

The proposed framework presented in this review addresses these limitations by offering a structured yet flexible approach to exercise integration within ERAS pathways. By combining standardization with individualization, this model may enhance both feasibility and clinical effectiveness.

Nevertheless, this review has limitations. As a narrative review, it does not provide quantitative synthesis of data and may be subject to selection bias (Gillis et al., 2025). Additionally, heterogeneity in the included studies limits the ability to define optimal exercise protocols. Future research should focus on randomized controlled trials and the development of consensus-based guidelines for perioperative exercise.

Overall, the integration of exercise into ERAS protocols represents an important opportunity to further improve surgical outcomes and patient quality of life.

5. Conclusions

Exercise is a fundamental yet underutilized component of ERAS protocols, with strong evidence supporting its role in improving perioperative outcomes (Carli, 2020; Gillis et al., 2025; Ljungqvist et al., 2017). Both prehabilitation and early postoperative mobilization contribute to enhanced functional recovery, reduced complication rates, and shorter hospital stays (Carli, 2020; de Almeida et al., 2017; Gando et al., 2013; Minnella et al., 2017; Moran et al., 2016).

Despite these benefits, the integration of structured exercise into ERAS pathways remains inconsistent due to lack of standardization and implementation barriers (Hughes et al., 2014; Minnella et al., 2018). The proposed phased framework provides a practical approach to incorporating exercise into perioperative care.

Future research should focus on developing standardized, procedure-specific exercise protocols and strengthening interdisciplinary collaboration. Greater emphasis on patient education and adherence is also essential.

Integrating exercise as a core component of ERAS protocols has the potential to significantly improve recovery and overall quality of life in surgical patients.

6. Disclosure

6.1 Author Contributions

Conceptualization, K.A., and P.S.; methodology, N.H., K.N. and K.A.; software, M.S.; check, K.A., M.M., J.S., P.S. and K.N.; formal analysis, D.W., J.S., K.A. and P.S.; investigation, M.M., K.K., D.W., K.O., N.H. and K.A.; resources, D.W., K.A. and P.S.; data curation, P.S., N.H. and K.K.; writing – rough preparation, J.S., P.S. and K.A.; writing – review and editing, K.A., J.S., P.S., M.M. and M.S.; visualization, M.S. and K.A.; supervision, K.A.; project administration, K.K. and P.S. All authors have read and agreed to the published version of the manuscript.

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Not Applicable.

6.4 Informed Consent Statement

Not Applicable.

6.5 Conflict of Interests

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