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Review Article

# Effectiveness of Prehabilitation Programs on Perioperative Outcomes

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***ABSTRACT***

*Prehabilitation, the structured optimization of a surgical patient's physical, nutritional, and psychological status before an operation, has expanded from a niche enhanced-recovery concept into a widely studied perioperative strategy across abdominal, thoracic, cardiac, and spine surgery.*

*This review synthesizes the comparative and pooled evidence for exercise-based, nutritional, and multimodal prehabilitation programs, drawing on recent systematic reviews and meta-analyses spanning colorectal, upper abdominal, esophagogastric, cardiac, and lung resection surgery.*

*The evidence most consistently favors prehabilitation in frail, sarcopenic, or functionally compromised patients, where multiple meta-analyses report reduced postoperative complications, shorter length of stay, and improved functional recovery, while benefit in fit, well-nourished patients is smaller and less consistently demonstrated.*

*Multimodal programs combining exercise, nutrition, and psychological support generally outperform single-domain interventions, though heterogeneity in program design and outcome reporting, along with real-world adherence challenges, complicate direct comparison across trials.*

*We conclude that frailty- and nutrition-based screening to target prehabilitation resources toward the patients most likely to benefit, alongside better integration with enhanced recovery pathways, represents the most promising direction for translating trial-level efficacy into routine perioperative practice.*

***Keywords:*** *prehabilitation; perioperative outcomes; frailty; enhanced recovery after surgery; postoperative complications*

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## INTRODUCTION

Surgeons and anesthesiologists have long known that the patient who walks into the preoperative holding area weak, deconditioned, or malnourished tends to walk out of the hospital later, and sometimes worse off, than the patient who arrives fit. What has changed

over the last decade is the willingness to act on that observation before the operation rather than simply document it. Prehabilitation, the structured optimization of a patient's physical, nutritional, and psychological status in the weeks between a decision for surgery and the day of surgery, has moved from a niche interest of a handful of enhanced-recovery enthusiasts into a mainstream perioperative strategy with a genuine evidence base [1]. The logic is straightforward even if the physiology is not: major surgery, whatever the indication, imposes a metabolic and inflammatory insult on top of whatever functional reserve a patient already has, and a patient who enters that insult closer to their physiologic ceiling has more room to fall before crossing into complication, prolonged length of stay, or loss of independence.

The term covers a family of interventions rather than a single protocol. Unimodal programs typically emphasize structured aerobic and resistance exercise, sometimes guided by cardiopulmonary exercise testing to individualize intensity [2]. Multimodal programs bundle exercise with nutritional counseling and supplementation, psychological support or anxiety-reduction coaching, and in some protocols smoking cessation or glycemic optimization, on the premise that these domains interact and that a patient who is anxious or malnourished will not adhere to an exercise program however well designed [3]. This review surveys the evidence for prehabilitation across the surgical populations where it has been most extensively studied, considers where the effect appears robust and where it remains uncertain, and discusses the practical barriers that still limit its uptake into everyday perioperative practice.

## EXERCISE-BASED AND MULTIMODAL PREHABILITATION BEFORE ABDOMINAL SURGERY

The abdominal surgical literature, particularly in colorectal cancer, is where prehabilitation has accumulated its deepest trial base, and it is a useful starting point precisely because the results are mixed enough to resist a simple verdict. A randomized clinical trial from a Canadian group compared multimodal prehabilitation against the same rehabilitation program delivered only after surgery in frail patients undergoing resection for colorectal cancer, and found a reduction in 30-day postoperative complications with the prehabilitation approach, an important result because it targeted the frail patients most plausibly able to benefit and least likely to tolerate a bad outcome [4]. A separate randomized trial testing multimodal prehabilitation before elective colorectal cancer surgery in patients with good baseline performance status reached a more equivocal conclusion, suggesting that the incremental benefit of prehabilitation may be smaller, or harder to detect, in patients who are not already frail [5].

Pooled analyses sit between these two signals. A systematic review and meta-analysis of randomized trials in laparoscopic colorectal cancer surgery reported improvements in functional capacity and some clinical outcomes with multimodal prehabilitation, though the authors were careful to flag substantial heterogeneity in how "functional capacity" and "complications" were defined and measured across trials [6]. A broader meta-analysis spanning colorectal surgery more generally found that both multimodal and exercise-only prehabilitation produced measurable gains, with the multimodal approach showing a modest edge, consistent with the additive-domains hypothesis described above [7]. The Journal of the American Geriatrics Society meta-analysis, focused specifically on prehabilitation in colorectal cancer surgery, reinforced that older and frailer patients appear to derive the most consistent benefit, a pattern that recurs throughout this literature and that has practical implications for how programs should be triaged given finite resources [8]. A recent narrative synthesis of the colorectal prehabilitation trial landscape catalogued the diversity of program designs currently in use and argued that the field has matured past the question of "does it work" toward the harder question of which components, delivered to which patients, produce the largest effect for the smallest burden [9].

Beyond colorectal disease, the upper abdominal surgery literature, which includes hepatobiliary, pancreatic, and gastric resections, shows a broadly similar pattern. A systematic review and meta-analysis of multimodal prehabilitation before upper abdominal surgery found reductions in postoperative pulmonary complications and length of stay, outcomes that track closely with the physiologic rationale for exercise-based preoperative conditioning in an anatomic region where postoperative pain and diaphragmatic splinting directly threaten lung mechanics [10]. A network meta-analysis comparing different prehabilitation program designs across the major abdominal surgery population attempted to rank which combinations of exercise, nutrition, and psychological components produced the best outcomes, and while the certainty of evidence for any single ranking remained low, the exercise plus nutrition combination performed consistently well across comparisons [11]. A World Journal of Surgery review of prehabilitation before major abdominal surgery reached a similarly cautious but favorable conclusion, noting reduced complication rates in several of the included trials while emphasizing that publication and selection biases likely inflate the apparent effect size in a still-maturing literature [12].

## NUTRITIONAL PREHABILITATION AND THE FRAILTY AND SARCOPENIA QUESTION

Exercise capacity and nutritional status are entangled in ways that make it difficult to attribute benefit to either domain alone, but the nutritional literature

deserves separate attention because it addresses a mechanism that exercise programs cannot reach on their own: the sarcopenic, hypoalbuminemic patient whose muscle mass and protein reserve are already depleted before the first incision. A focused review of nutritional prehabilitation strategies in abdominal surgery summarized the case for protein supplementation, immunonutrition formulas, and carbohydrate loading in the days before surgery, concluding that nutritional optimization is most clearly beneficial in patients who are already malnourished by validated screening criteria, rather than as a blanket intervention for all comers [13]. This targeting principle recurs in a meta-analysis of nutrition-based prehabilitation in esophagogastric cancer surgery, a population in which baseline nutritional depletion from dysphagia or tumor burden is common and where the meta-analysis found improvements in postoperative complication rates and nutritional biomarkers among patients receiving structured nutritional prehabilitation compared with standard preoperative care [14].

The frailty question sharpens this picture further. A meta-analysis restricted to frail and high-risk patients undergoing major abdominal surgery found that prehabilitation, whether exercise-based, nutritional, or multimodal, produced a more consistent reduction in postoperative complications in this subgroup than has generally been observed in unselected surgical populations [15]. This is an intuitive result rescued from mere plausibility by trial data: a frail patient has, almost by definition, more physiologic reserve to gain from even a modest improvement in strength or nutritional status, whereas a robust patient may already be near a functional ceiling that a few weeks of prehabilitation cannot meaningfully raise. The practical corollary, echoed across several of the abdominal surgery meta-analyses already discussed, is that frailty or functional screening at the point of surgical referral is probably a more efficient way to allocate scarce prehabilitation resources than offering a uniform program to every patient regardless of baseline status.

Adherence complicates even a well-targeted program, however. A systematic review and meta-analysis examining acceptability of and adherence to prehabilitation and rehabilitation programs in major abdominal surgery patients found that attrition and incomplete engagement were common, particularly in programs with short lead times between surgical booking and the operative date, and particularly among patients also coping with a new cancer diagnosis and its associated psychological burden [16]. A program that shows efficacy in a trial with intensive coaching and frequent contact may perform considerably worse once transplanted into routine practice with less support infrastructure, a gap between efficacy and effectiveness that anesthesiologists advocating for prehabilitation pathways need to take seriously when setting expectations with hospital administrators and referring surgeons.

## CARDIOTHORACIC AND LUNG RESECTION SURGERY

Prehabilitation was adopted comparatively early in cardiac and thoracic surgery, in part because cardiopulmonary exercise testing was already embedded in preoperative risk stratification for these populations and made it natural to extend testing into a training intervention. A systematic review and meta-analysis of prehabilitation in patients undergoing cardiac procedures found benefits in postoperative functional recovery and, in some included trials, reductions in length of stay, though the authors noted that trial quality and intervention intensity varied considerably, limiting the strength of pooled conclusions [17]. A parallel narrative synthesis on prehabilitation in cardiovascular surgery framed the current evidence as promising but still short of the trial size and consistency needed to change guideline-level recommendations, while identifying frailty assessment and exercise capacity testing as the most defensible near-term applications of the concept in cardiac surgical pathways [18].

Lung cancer surgery has produced some of the more encouraging recent data. A systematic review and meta-analysis of randomized controlled trials evaluating prehabilitation before lung cancer surgery reported improvements in postoperative pulmonary complications and functional recovery metrics, an outcome that aligns with the mechanistic argument that improved preoperative respiratory muscle strength and aerobic conditioning should translate directly into better tolerance of one-lung ventilation and postoperative pain-limited breathing [19]. A more targeted randomized controlled trial of preoperative respiratory prehabilitation specifically in patients undergoing lung resection for non-small cell lung cancer found measurable improvements in cardiopulmonary function following the intervention, supporting respiratory muscle training as a plausible mechanistic pathway rather than a purely statistical association [20]. Together, the thoracic and lung resection literature is arguably where the case for prehabilitation is most mechanistically coherent, since the intervention (respiratory and aerobic conditioning) maps directly onto the physiologic vulnerability of the surgery (single-lung ventilation and diaphragmatic-dependent postoperative breathing).

## SPINE SURGERY, BROADER SURGICAL POPULATIONS, AND THE ROLE OF ENHANCED RECOVERY PATHWAYS

Prehabilitation research has also extended into orthopedic and spine surgery, populations in which chronic pain, opioid exposure, and pre-existing deconditioning are common confounds. A systematic review and meta-analysis of prehabilitation before spine surgery found improvements in some patient-reported and functional outcomes, though the heterogeneity of spine procedures included, ranging

from single-level decompression to multilevel fusion, makes it harder to generalize a single effect estimate across the specialty [21]. A broader systematic review examining the impact of surgical prehabilitation on postoperative outcomes across multiple surgery types reached a cautiously positive overall conclusion while explicitly calling out the inconsistency of outcome reporting between studies as the single biggest obstacle to a confident summary judgment [22]. A similarly structured review focused on length of hospital stay and complication rates across major surgeries reported that prehabilitation programs were associated with shorter stays and fewer complications in the majority, though not all, of the included studies, a pattern consistent with a real but moderate and setting-dependent effect rather than a uniformly transformative one [23].

Much of the enthusiasm for prehabilitation has grown up alongside, and sometimes inside, enhanced recovery after surgery (ERAS) pathways, and the two concepts are frequently discussed together because they share an underlying philosophy: that perioperative outcome is shaped as much by preparation and process as by intraoperative technique. A narrative review addressing whether prehabilitation and ERAS should be viewed as complementary or competing strategies concluded that they are best understood as sequential phases of the same continuum, prehabilitation optimizing the patient before the insult and ERAS minimizing and accelerating recovery from the insult itself, rather than as alternative interventions between which a program must choose [3]. A separate commentary on moving prehabilitation from theory into practice argued that the main remaining barrier is not evidence but implementation: referral pathways, lead time between diagnosis and surgery, staffing for exercise physiology and dietetics, and reimbursement structures all lag behind the trial evidence supporting the concept [24]. Cardiopulmonary exercise testing, originally developed as a risk-stratification tool, has increasingly been repurposed within these pathways both to select patients most likely to benefit from prehabilitation and to individualize training intensity, blurring the line between preoperative assessment and preoperative treatment [2].

## DISCUSSION

Taken as a whole, this literature supports a qualified rather than unconditional endorsement of prehabilitation. The effect is most consistently demonstrated, and most mechanistically plausible, in patients who begin with a demonstrable deficit to correct: frail or sarcopenic patients before abdominal surgery, malnourished patients before esophagogastric resection, and patients with impaired pulmonary reserve before lung resection. In these populations, several independent meta-analyses converge on real reductions in complications, pulmonary morbidity, or length of stay [4,8,15,14,19]. The evidence is considerably softer, and in some trials essentially absent, in patients who are already fit and well-nourished at baseline, where a few weeks of preoperative conditioning may simply have less physiologic room to work with [5].

Two practical problems temper enthusiasm even in the populations most likely to benefit. First, heterogeneity in program design, from single weekly exercise sessions to daily multimodal coaching, and in outcome definitions, from patient-reported functional scores to standardized complication grading, makes it difficult to specify an optimal "dose" of prehabilitation that a hospital could implement with confidence [22,11]. Second, adherence in real-world settings appears meaningfully lower than in the closely supervised conditions of a randomized trial, particularly when the interval between the decision for surgery and the operative date is short, as is often the case in oncologic surgery where delay carries its own risk [16]. Anesthesiologists building or advocating for prehabilitation pathways should treat these implementation barriers as first-order problems rather than afterthoughts, since a program that cannot be delivered with reasonable fidelity outside a trial setting will not reproduce the outcomes that justified building it.

There is also a resource-allocation argument implicit in the frailty-stratified findings. If the benefit of prehabilitation concentrates in patients who are frail, sarcopenic, or otherwise physiologically compromised, then routine frailty and nutritional screening at the point of surgical referral becomes the more urgent intervention to establish, since it identifies who should be prioritized for a limited number of prehabilitation slots rather than diluting a scarce resource across an entire surgical population indiscriminately. Several of the reviews summarized here point toward this triage logic even when they do not state it explicitly [15,8,11].

## CONCLUSION

Prehabilitation has accumulated a genuine, if uneven, evidence base across abdominal, thoracic, cardiac, and spine surgery, with the most consistent benefit observed in frail, sarcopenic, or functionally compromised patients rather than as a uniform intervention for all surgical candidates. Multimodal programs combining exercise, nutrition, and psychological support generally outperform single-domain interventions, though the incremental advantage over exercise alone is often modest and inconsistently demonstrated. The field's next task is less about proving that prehabilitation works in principle and more about determining how to deliver it reliably: identifying which patients to prioritize, how much lead time is needed, and how to sustain adherence once the intervention leaves the closely monitored environment of a clinical trial. Anesthesiologists, positioned at the interface between surgical scheduling and perioperative risk assessment, are well placed to drive the screening and referral

processes that will determine whether prehabilitation's trial-proven benefits actually reach the patients most likely to need them.

## DECLARATIONS

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**Ethics Statement This is a literature review that did not involve new human or animal data; no ethics approval was required.**

**Data Availability No new data were generated for this review. All sources discussed are publicly available in the cited literature.**

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