World J Surg (2013) 37:711–720
DOI 10.1007/s00268-012-1886-4

Effect of Preoperative Exercise on Cardiorespiratory Function and Recovery After Surgery: a Systematic Review

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Published online: 5 January 2013

Abstract
Background This systematic review aims to investigate the extent to which preoperative conditioning (PREHAB) improves physiologic function and whether it correlates with improved recovery after major surgery.
Methods An electronic database search identified randomized controlled trials (RCTs) investigating the safety and efficacy of PREHAB. The outcomes studied were changes in cardiorespiratory physiologic function, clinical outcomes (including length of hospital stay and rates of postoperative complications), and measures of changes in functional capacity (physical and psychological).
Results Eight low- to medium-quality RCTs were included in the final analysis. The patients were elderly (mean age >60 years), and the exercise programs were significantly varied. Adherence to PREHAB was low. Only one study found that PREHAB led to significant improvement in physiologic function correlating with improved clinical outcomes.
Conclusion There are only limited data to suggest that PREHAB confers any measured physiologic improvement with subsequent clinical benefit. Further data are required to investigate the efficacy and safety of PREHAB in younger patients and to identify interventions that may help improve adherence to PREHAB.

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Introduction

Prehabilitation (PREHAB) is a concept that challenges the traditional models of recovery by initiating the recovery process preoperatively [1]. It is broadly described as preoperative physical conditioning to improve preoperative functional and physiologic capacity of patients to prepare them for the major stress induced by surgery [2]. Despite previous review articles that have investigated the role of preoperative exercise, the efficacy and safety of this intervention remains uncertain.

Ackerman and Bennell reviewed five articles describing the efficacy of preoperative exercise in the setting of limb surgery and found no clinical improvement in postoperative functional outcomes [3]. Conversely, Valkenet et al. [4] reviewed 12 randomized controlled trials (RCTs) investigating the efficacy of preoperative exercise and found that it led to decreased length of hospital stay and pulmonary complications in the setting of abdominal and cardiovascular surgery.

Although previous reviews have included functional and in-hospital endpoints in their outcome measures, they have not described or quantified the effect that preoperative exercise has on physiologic function [3, 4]. There are also no reviews correlating physiologic improvement with clinical outcomes. More recent articles have investigated the role of preoperative exercise, adding to the current body of literature and allowing more detailed review of the evidence.

The current systematic review aimed to investigate whether preoperative exercise is effective in improving physiologic capacity during the preoperative period and whether it is associated with improved clinical outcomes. The authors hypothesized that improvements in surgical recovery in patients who have preoperative exercise are a result of improved cardiorespiratory physiologic capacity.

Methods

Search strategy

Two of the authors (D.P.L., P.P.S.) comprehensively reviewed the literature independently in concordance with the methods outlined in the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement [5]. The following medical databases were utilized from the time of inception to December 2011: MEDLINE, EMBASE, CINAHL, PubMed, and Cochrane Central Register of Controlled Trials. Table 1 details the combination of search terms used. These authors also manually scrutinized reference lists of recovered articles and relevant scientific meeting abstracts to identify any further articles.

Study selection

Studies were considered for review if they investigated, in an RCT, the efficacy of preoperative exercise prior to elective surgery of any kind. The exclusion criteria were as follows: The study was not an RCT, did not measure physiologic endpoints (specifically cardiorespiratory endpoints), did not include postoperative surgical recovery, had different postoperative care for each group, or the exercise program was inadequately explained so it could not be replicate. The decisions on article inclusion were made by three of the authors (D.P.L., P.P.S., A.D.M.) in consensus with two senior authors (B.A., A.G.H.). The methodologic quality of the studies was assessed using the Jadad criteria [6].

Data extraction

One author (D.P.L.) carried out the data extraction using predesigned, electronic tables. The outcomes of interest were adherence to the PREHAB intervention, measures of changes in cardiorespiratory physiological function, clinical outcomes [including length of hospital stay (LOS) and rates of postoperative complications], and measures of changes in functional capacity (physical and psychological). Assessment of individual study bias was performed at the study level. For the intervention group in each study, we recorded the individual components of the exercise programs, including total time required to complete each exercise, the number of exercise sessions per week, and the total duration of the exercise program. The care received by the control group in each study was also recorded.

Data analysis

Meta-analysis of the data could not be undertaken because of the significant heterogeneity resulting from the inherent differences between the included studies regarding the intervention design, study cohorts, surgery type, and outcome measures. The results are therefore presented as a narrative analysis of the data, with sections defined according to the outcomes of interest.

Results

There were eight studies included in this review [7–14]. Among them, three were in cardiothoracic surgery [7, 12, 14], three were in general abdominal surgery [8–10], and two were in orthopedic surgery [11, 13].

Table 1 Search terms

Database	Hits	Search terms
MEDLINE	536	Prehabilitation OR prehab OR prehab$ OR exercise OR preoperative AND exercise OR preop AND exercise OR preop$ AND exercise OR physical AND fitness OR preoperative AND physical AND fitness OR preop AND physical AND fitness OR preop$ AND physical AND fitness OR preconditioning OR precondition OR precondition$ OR preoperative AND preconditioning OR preoperative AND precondition OR preoperative AND precondition$ OR preop AND preconditioning or preop AND precondition OR preop AND precondition$ OR preop$ AND preconditioning OR preop$ AND precondition OR preop$ AND precondition$ OR Physical AND fitness OR preoperative AND physical AND fitness OR preop AND physical AND fitness OR preop$ AND physical AND fitness OR physical AND activity OR preoperative AND physical AND activity OR preop AND physical AND activity OR preop$ AND physical AND activity AND major AND surgery OR surgery OR major AND surg$ OR surg$
EMBASE	1487	
CINAHL	10	
Pubmed	218	
CENTRAL	329	

CENTRAL Cochrane Central Register of Controlled Trials

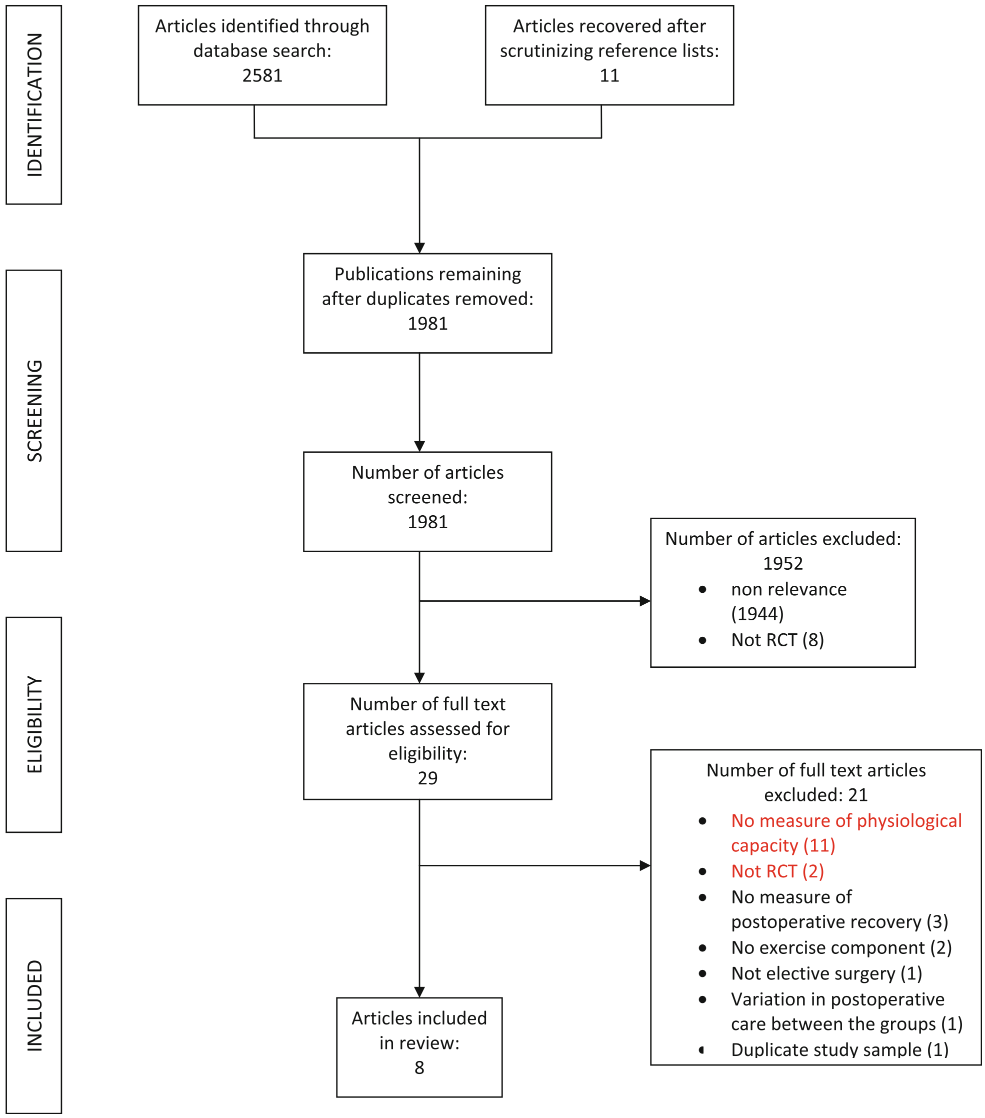

Fig. 1 Preferred reporting items for systematic reviews and meta-analyses (*PRISMA*) flow diagram shows selection of studies. *RCT* randomized controlled trial

Study characteristics

The PRISMA flow diagram for systematic reviews is presented in Fig. 1. The current systematic review includes 868 patients, 442 of whom were randomized to a preoperative exercise program and 426 to either a control or "sham" intervention group. All studies were conducted within an elderly cohort, with the mean age being >60 years in each study. The study characteristics of the eight included studies are described in Table 2. The exercise intervention and control group are summarized in Table 3. The PREHAB period ranged from 2 to 8 weeks. There was considerable variation in the composition of the exercise interventions utilized in each study.

Adherence

Of the eight studies, four reported on adherence with exercise regimens, with only two demonstrating adequate rates of adherence [7, 8, 10, 11]. In the setting of colon surgery, Dronkers et al. [10] found that attendance to the PREHAB training sessions was 97 %. In the setting of total hip arthroplasty, Hoogeboom et al. also reported excellent adherence, with 91 % of patients attending PREHAB sessions [11].

The PREHAB program utilized by Arthur et al. [7] in the setting of cardiothoracic surgery required patients to attend the program twice weekly during the waiting period prior to their scheduled surgery. The mean number of PREHAB sessions attended was 14, but there was a wide range of attendance

Table 2 Study characteristics and quality assessment according to Jadad et al. [6]

Study	Jadad score [6]	Operation	No. of patients	Mean age (years)	Physiologic outcome	Clinical outcome	Functional capacity outcome	Results
Arthur et al. [7]	3	Cardiothoracic (CABG)	249	62.8	VO_2max	LOS, time in ICU, utilization of health care resources	Health-related QoL, social support, anxiety level	ND VO_2max ↑LOS & Time in ICU ↑QoL preop ↑Social Support
Carli et al. [8]	3	Colorectal surgery	133	60.5	VO_2max	Cx, LOS	Hospital Anxiety and Depression Scale (HADS), amount of physical activity, 6MWT	ND VO_2max ND Cx or LOS ↓6MWT ↑ HADS
Dronkers et al. [9]	3	Elective AAA repair	20	70.0	PI_{max}, IME, FVC	PPC	–	↑IME ND PI_{max} or FVC ND PPC
Dronkers et al. [10]	3	Colonic surgery	42	69.9	Hand grip strength, PWC-170 test, PI_{max}, IME	Cx	QoL, amount of physical activity, fatigue, functional mobility (TUG)	↑IME only ND Cx or functional capacity
Hoogeboom et al. [11]	3	Orthopedic (THA)	21	76.0	PWC-170 test	Pain, LOS, patient satisfaction	Amount of physical activity, PSC, functional mobility (TUG), lower limb strength and power (CRT), 6MWT	ND PWC-170 ↑patient satisfaction ND in any other outcome measures
Hulzebos et al. [12]	3	Cardiothoracic (CABG)	279	66.9	PI_{max}, IME	LOS, PPC	–	↑MIP & IME ↑PPC and LOS
Weidenhielm et al. [13]	2	Orthopedic (unilateral TKA)	40	63.5	Oxygen cost	Pain, knee stability	Muscle strength, ROM, walking capacity	ND Oxygen cost ↑Pain ↑Walking Capacity ND other outcomes
Weiner et al. [14]	1	Cardiothoracic (CABG)	84	61.5	FVC, FEV_1, PI_{max}, IME, PaO_2, $PaCO_2$	PPC	–	↑FVC & FEV_1 ↑MIP & IME ↑PaO_2 & $PaCO_2$ ND PPC

↑ improved, ↓ decreased, *ND* no difference, *CABG* coronary artery bypass graft, *AAA* abdominal aortic aneurysm, *THA* total hip arthroplasty, *TKA* total knee arthroplasty, *6MWT* 6-minute walk test, *VO_2max* peak oxygen consumption, *PI_{max}* maximum inspiratory pressure/inspiratory muscle strength, *IME* inspiratory muscle endurance, *FVC* forced vital capacity, *PWC* physical work capacity, *FEV_1* forced expiratory volume at 1 second, *LOS* length of hospital stay, *ICU* intensive care unit, *Cx* complications, *PPC* postoperative pulmonary complications, *HOOS* Hip Osteoarthritis Outcome Score, *QoL* quality of life, *SSTAI* Spielberg State Trait Anxiety Inventory, *ISEL* Interpersonal Support Evaluation List, *CRT*: chair rise time, *PSC* patient-specific complaints questionnaire (assess physical function), *TUG* timed up and go test, *ROM* range of motion

Table 3 Summaries of the exercise intervention and control groups

Parameter	Arthur et al. [7]	Carli et al. [8]	Dronkers et al. [9]	Dronkers et al. [10]	Hoogeboom et al. [11]	Hulzebos et al. [12]	Weidenhielm et al. [13]	Weiner et al. [14]
Exercise intervention	Two 90-min group exercise sessions per week supervised by kinesiologists and exercise specialists in the hospital environment composed of: (1) walking warm-up (5–10 min) with general ROM exercises; (2) 10 min of stretching; (3) minimum 30 min of aerobic interval training on stationary cycles, treadmills, arm ergometers and stair climbers' (4) 5–10 min of cool-down and stretching	Aim to do 14 hours/week of the following exercises: (1) stationary cycle initially 20 min/day increased to 30 min; (2) weight training 3 times/week, 10–15 min/day (biceps, deltoids, quads); (3) push-ups, sit-ups, lunges until volitional fatigue, increasing to 12 repeats	Six sessions, 6 days per week for at least 2 weeks before surgery: (1) 15 min inspiratory muscle training (1 session/week supervised by physiotherapist); (2) keep a daily exercise diary	Two days/week of supervised exercise: (1) warm-up; (2) resistance training of the lower limb extensors; (3) inspiratory muscle training; (4) moderate-intensity aerobic exercise (20–30 min); (5) functional activities according to patient's capabilities and interest; (6) cool-down. Daily home-based exercise: (1) 30 min walking or cycling; (2) inspiratory muscle training	Moderate- to high-intensity supervised exercise, 60-min sessions, twice a week in the outpatient clinic plus additional supervised exercise at home, composed of four phases: (1) 5-min walk to warm up; (2) lower extremity resistance training; (3) aerobic training on a bicycle ergometer for 20–30 min; (4) tailor-made exercise that integrates functional physical activities into the patient's daily living. Patients were stimulated to expand their normal activity by use of a pedometer	Daily 20-min sessions of individually tailored, inspiratory muscle training for: (1) incentive spirometry; (2) education in active cycle of breathing techniques; (3) forced expiration techniques (six times/ week unsupervised, 1 day/week supervised)	Three-weekly sessions of: (1) 10-min warm-up on unloaded bicycle ergometer; (2) mobility exercises of the knee joint both sitting and supine; (3) muscle strengthening exercises with leg lifted (unloaded) against gravity for 10 sec; (4) knee extensor exercises with leg loaded at the ankle with 1- to 3-kg weight	Six-weekly sessions of inspiratory muscle training with a threshold inspiratory muscle trainer
Duration of program	8.3 weeks (mean)	4 weeks	2–4 weeks	2–4 weeks	3–6 weeks	2 weeks (minimum)	5 weeks	2–4 weeks

Table 3 continued

Parameter	Arthur et al. [7]	Carli et al. [8]	Dronkers et al. [9]	Dronkers et al. [10]	Hoogeboom et al. [11]	Hulzebos et al. [12]	Weidenhielm et al. [13]	Weiner et al. [14]
Control group	Not described	Described as a "sham intervention." Walk daily for 30 min. Breathing exercises 5 min/day. Exercise to activate the circulation (ankle rotations and pumping, static quadriceps contractions, bridging) 5–10 min/day	Home-based exercise advice, instruction in inspiratory muscle training techniques	Home-based exercise advice, instruction in inspiratory muscle training techniques	Group-based education session about early mobilization, surgery, anesthesia techniques; benefits of activity; proper use of crutches approximately 1 week before surgery	Instruction on deep breathing maneuvers, coughing, and early mobilization the day before surgery	No intervention	Control subjects breathed through the same trainer but with no resistance (sham intervention)

(1–57 sessions attended). The authors thought that this likely reflected nonadherence and lengthy waiting times for surgery [7]. Carli et al. [8] also found low adherence to PREHAB in the setting of colorectal surgery, with only 16 % of patients being fully adherent to exercise instruction. This was reflected by only 60 % of all patients in both groups having a complete set of data available for analysis [8].

Physiologic function

Physiologic outcomes varied in the included studies. Four of the included studies assessed inspiratory muscle strength, or maximum inspiratory pressure (PImax) and inspiratory muscle endurance (IME) [9, 10, 12, 14]. Four studies used exercise testing to assess aerobic capacity. Two of them utilized submaximum exercise tests using the physical working capacity 170 (PWC-170) [10, 11]. The other two utilized maximum exercise tests to assess peak oxygen consumption (VO_2max) [7, 8].

Results of spirometry and arterial blood gas (ABG) tests were used to assess the effects of PREHAB. Specific comparative analysis was performed for forced expiratory volume at 1 second (FEV_1), forced vital capacity (FVC), PaO_2, $PaCO_2$, and pH [9, 14]. Other physiologic outcomes assessed were oxygen cost accumulated during a walking test and hand grip strength (HGS) as a measure of skeletal muscle mass and predictor of postoperative complications [10, 13].

Inspiratory muscle endurance and strength

IME and Strength Inspiratory muscle training was effective at improving the IME during the preoperative period in the settings of oncologic colonic surgery (from 259 J to 404 J; $p < 0.01$) [10] and abdominal aortic aneurysm (AAA) repair (from 32 cmH_2O to 43 cmH_2O; $p = 0.05$) [9]. In patients undergoing cardiothoracic surgey, Hulzebos et al. found preoperative inspiratory muscle training to be effective in improving preoperative respiratory function as measured by inspiratory muscle strength (from 81.1 cmH_2O to 95.6 cmH_2O; $p < 0.001$) and IME (from 48.8 to 56.0 %; $p < 0.001$) [12]. Weiner et al. demonstrated similar results in cardiothoracic surgery with improvement demonstrated in IME (from 76.1 to 87.0 %; $p < 0.001$) [14]. Postoperative PImax remained unchanged in the intervention group, whereas values in the control group deteriorated significantly [14].

Submaximum exercise testing: physical working capacity 170 (PWC-170)

Two studies utilized the PWC-170 tests as a submaximum measure of aerobic capacity [10, 11]. Dronkers et al. investigated change in PWC-170 results in patients undergoing elective colonic surgery and found no significant difference between the two groups with regard to change from baseline at the conclusion of the PREHAB period (PREHAB group –1.7 O_2mL/kg/min; control group 1.3 O_2mL/kg/min; $p = 0.16$) [10]. Hoogeboom et al [11]. investigated change in the results of PWC-170 in patients undergoing total hip arthroplasty and found no significant differences [between-group difference: –17.9; 95 % confidence interval (CI) –92.6 to 56.9].

Maximum exercise testing: peak oxygen consumption (VO_2max)

VO_2max was recorded in two studies to measure the effect PREHAB had on aerobic capacity [7, 8]. Using a standardized graded exercise test carried out until volitional exhaustion, Carli et al. demonstrated in the setting of colorectal surgery that both the PREHAB group (134 mL/min; $p = 0.003$) and control group (112 mL/min; $p = 0.007$) showed significant improvement in baseline VO_2max after the PREHAB period [8]. Because of an insufficient sample size, however, meaningful comparison of VO_2max was not possible between the two groups. In the study by Arthur et al. [7], VO_2max was measured in the setting of cardiothoracic surgery using a symptom-limited cycle ergometer. The baseline VO_2max was significantly higher in the PREHAB group (PREHAB group 1,327.6 mL/min versus control group 1,201.2 mL/min; $p = 0.009$). There was no significant difference between the two groups with regard to change in VO_2max at the conclusion of the PREHAB period [7].

Spirometry and arterial blood gas

In the setting of cardiothoracic surgery, Weiner et al. demonstrated that FEV_1, FVC, and $PaCO_2$ remained unchanged in the intervention group, whereas the corresponding values in the control group deteriorated significantly [14]. PaO_2 was significantly increased in the intervention group during the preoperative period following training (from 73.2 to 80.0 mmHg; $p < 0.05$) [14]. No significant changes were observed for oxygen cost or HGS [10, 13].

Clinical outcomes

Complication rate

Five papers recorded and analyzed postoperative complications [8–10, 12, 14]. Among them, three looked specifically at postoperative pulmonary complications (PPCs) [9, 12, 14]. Only one study found PREHAB to be associated with a reduction in complication rates, with Hulzebos et al. [12] demonstrating a significant reduction in the rate of grade two or higher pulmonary complications in the setting of cardiothoracic surgery (PREHAB group 18 %; control group 35 %; $p = 0.02$). No studies demonstrated an increase in adverse events in patients who underwent the PREHAB intervention.

Length of hospital stay

There were four articles that investigated the effect of PREHAB on LOS [7, 8, 11, 12]. Among them, two found a significant reduction in LOS [7]. In the setting of cardiothoracic surgery, Arthur et al. found that patients in the PREHAB group had a reduction in median length of postoperative day stay (PREHAB group 5 days, control group 6 days; $p = 0.001$) and total LOS l (PREHAB group 6 days; control group 7 days; $p = 0.002$). They also found a significant reduction in the median time spent in the intensive care unit postoperatively (PREHAB group 24.67 hours, control group 26.71 hours; $p = 0.038$) [7]. Hulzebos et al. [12] also found a significant reduction in median LOS in the setting of cardiothoracic surgery (PREHAB group 7 days, control group 8 days; $p = 0.02$). This was likely a result of the significant reduction in PPCs.

In the setting of total hip arthroplasty, Hoogeboom et al. [11] found no difference in median LOS between the two groups (PREHAB group 6 days, control group 6 days; $p = 0.228$). In the setting of colorectal surgery, Carli et al. also found no difference in mean LOS (minus one outlier; PREHAB group 7.4 days, control group: 6.5 days) [8].

Pain

Reduction in pain scores was measured in two studies [11, 13]. Using the Hip Osteoarthritis Outcome Score (HOOS) and a visual analogue scale (VAS) in the setting of total hip arthroplasty, Hoogeboom et al. [11] found no difference in pain scores between the two groups after the PREHAB period. Weidenhielm et al. [13] also used a VAS in the setting of total knee arthroplasty to assess pain and found a significant reduction in the PREHAB group at 3 months postoperatively.

Functional capacity

There was significant variation in the methods used to assess functional capacity. The endpoints recorded were measures of both physical and psychological function. Outcomes that focused specifically on single limb strength or function were not included in the analysis.

Level of physical activity

The level of physical activity (PA) was recorded in three studies [8, 10, 11]. Carli et al. measured PA preoperatively by recording the mean time that patients in each group partook in their assigned exercise program. They found patients in the PREHAB group to be more active than those in the control group (PREHAB group 8.3 hours, control group 6.0 hours; $p = 0.054$) [8]. No other study demonstrated significant change in pre- or postoperative PA.

Functional mobility

Four studies measured functional mobility. Two studies utilized the 6-minute walk test as an endpoint of interest. Neither study found a significant improvement in distance walked in the intervention group [8, 11]. In fact, Carli et al. [8] demonstrated a significant decrease of 34.4 m ($p < 0.001$) in distance walked over 6 min postoperatively in the PREHAB group.

Walking capacity was recorded by Weidenhielm et al. [13], who demonstrated a significant improvement in self-selected walking speed and maximum walking speed in the PREHAB group immediately prior to surgery ($p < 0.01$). It did not translate into postoperative improvement. Dronkers et al. [10] and Hoogeboom et al. [11] assessed functional mobility using the timed up and go test. They found PREHAB to confer no significant difference. Hoogeboom et al. [11] also assessed lower limb strength and power by measuring chair rise time and found no difference.

Quality of life

Two studies assessed quality of life (QoL). Arthur et al. [7] assessed QoL using the Medical Outcomes Study 36-Item Short Form Surgery (SF-36). The results of the physical composite score summary (PCSS) component of the SF-36 showed that the PREHAB groups had significant improvement from the baseline score during the preoperative period (mean difference of 3.0; $p = 0.04$) [7]. This result was due primarily to significant improvements in subscale scores for physical role (mean difference of 11.5; $p = 0.01$) and physical functioning (mean difference of 5.3; $p = 0.04$). Despite demonstrating a significant improvement in the PCSS component of the SF-36, there was no significant change in the mental composite summary score [7]. No difference in QoL was found by Dronkers et al. [10].

Anxiety, depression, fatigue

Levels of anxiety were recorded and analyzed in two studies [7, 8]. Arthur et al. [7] found no difference in anxiety between the two groups. Using the Hospital Anxiety and Depression Score (HADS), Carli et al. [8] found no change in anxiety preoperatively but did find a reduction postoperatively in both the PREHAB group (mean reduction in HADS of 1.8; $p = 0.007$) and the control group (mean reduction in HADS of 2.0; $p < 0.001$).

Carli et al. [8] also demonstrated a significant reduction in HADS for depression of 0.8 in the PREHAB group during the preoperative period ($p = 0.045$). Dronkers et al. [10] assessed fatigue using the Abbreviated Fatigue Score and found no significant difference between the two groups.

Discussion

This systematic review includes eight RCTs that investigated the efficacy and safety of PREHAB in elderly patients undergoing a variety of major elective surgical procedures. It shows that the current literature provides limited evidence demonstrating physiologic improvement in patients who undergo a PREHAB intervention. It also shows that there is little correlation between improvement of physiologic status and clinical outcomes. Also, adherence to these programs has been poor.

It is widely accepted that the systemic inflammatory response associated with major surgery has a profound effect on physiologic function [15]. PREHAB is described in the current literature as a means of preparing patients for the metabolic insult of surgery by enhancing physiologic function, thereby minimizing the risk of postoperative morbidity, particularly in high-risk surgical patients [1]. We found little evidence to suggest any significant physiologic improvement after PREHAP in patients undergoing various types of major surgery, and limited evidence of improved clinical outcomes. Only one study, by Hulzebos et al., demonstrated significant improvement in both physiologic endpoints and clinical outcomes. They showed, in the setting of cardiothoracic surgery, a significant improvement in respiratory muscle function and a reduction in PPCs and LOS [12].

One reason for the lack of positive results may be the difficulty in choosing the most appropriate physiologic endpoint. The efficacy of PREHAB may rely on its ability to improve cardiorespiratory fitness or aerobic capacity. Only four of the included studies measured changes in aerobic capacity, two of which utilized submaximum exercise tests. These tests extrapolate estimated values for VO_2max based on validated algorithms [16]. However, the reliability of these tests relies heavily on various assumptions that may significantly influence the validity of the extrapolated conclusions [16]. One such assumption is that patients are not taking heart rate altering medication, which, although not mentioned in either study, may be important given the elderly cohort on whom these trials were conducted.

The traditional way of assessing aerobic capacity is measuring VO_2max [17]. Carli et al., in the setting of colorectal surgery, and Arthur et al., in the setting of cardiothoracic surgery, reported VO_2max in their outcomes. Both studies found no significant difference between their PREHAB and control groups with respect to improvement in VO_2max [7, 8]. These findings must be interpreted with caution as VO_2max is influenced and limited by various factors. Peak oxygen uptake decreases naturally with age, and although the rate of decline can be slowed with regular exercise the intensity of exercise required to do so is relatively low. This may suggest that exercise that is too high in intensity leads to no change or even a decline in VO_2max [18]. The lack of difference in VO_2max reported by the two studies may therefore be a result of exercise regimens that were too high in intensity for this elderly cohort. Beta-blockade, which is likely to be prescribed to a significant proportion of these elderly patients, can also affect VO_2max by altering cardiac output and hence oxygen delivery [17].

Also, 11 studies [2, 19–28] were excluded that did not correlate physiologic endpoints with clinical or functional outcomes. They included nine studies in the setting of joint arthroplasty [2, 19–24, 26, 28]. The excluded papers were of lower methodologic quality (median Jadad score of 2) than the eight included studies (median Jadad score of 3). Among these excluded studies, nine reported clinical outcomes [19–22, 24–28], only four of which showed significant improvement [20, 22, 25, 26]. Crowe and Henderson demonstrated a significant reduction (4 days) in mean LOS and a significant reduction in postoperative complications in patients having PREHAB prior to knee and hip arthroplasty [20]. Rooks et al. [26] similarly showed a reduction in postoperative complications but only in patients undergoing hip arthorplasty. Nielsen et al. [25] demonstrated, in the setting of elective lumbar spine surgery for degenerative disease, a significant reduction in median LOS (2 days) in the PREHAB group and reduced pain scores. Ferrara et al. [22] also demonstrated a reduction in pain scores. As demonstrated in the 8 included studies, none of the 11 excluded studies showed PREHAB to have a detrimental effect on surgical recovery.

The studies included within this review had limited conclusions and hence lack generalizability. There is an inherent heterogeneity between studies due to differences in the type of surgery for which the efficacy of PREHAB was investigated that can affect the intended goal of PREHAB. There is also nonuniformity with respect to the individual components of the exercise regimens. It is therefore difficult to ascertain which components of the exercise program contribute to an optimal exercise program or the optimal duration period of PREHAB. The current convention in the literature suggests that the optimal duration would be 4 to 12 weeks, although there is limited evidence to support this assumption [1, 29]. Conclusions are also limited by the fact that most of the included studies lacked sufficient power to find a significant difference in physiologic or clinical outcomes. Also, they were of low to medium methodologic quality as assessed by the Jadad criteria [6].

The composition of a PREHAB program is a factor in determining whether PREHAB is effective in enhancing physiologic function and improving surgical recovery. However, more attention must be paid to exercise quantity. Only two of the studies demonstrated adequate levels of adherence to the designated exercise regimen. This may be a reflection of the excessive intensity of the exercise programs designed for the elderly patients in the included studies. Thus, further research is needed that focuses on interventions aimed at increasing the levels of physical activity. The current American College of Sports Medicine guidelines suggest that the minimum recommended amount of exercise is 30 min of light- to moderate-intensity exercise 5 days a week to maintain adequate physical fitness [16, 30]. This guideline may serve as exercise advice for patients in the weeks leading up to surgery.

Conclusions

This systematic review of the current literature shows that PREHAB confers limited benefit to physiologic function prior to surgery. Improvements that were demonstrated did not correlate well with improved clinical outcomes. The results of this review may have been influenced by a lack of appropriate physiologic endpoints, studies being conducted in elderly cohorts, excessively intense exercise programs, and lack of adherence to the designated PREHAB program. Further research is required to investigate the efficacy of PREHAB in younger cohorts and to identify interventions that may help improve adherence to PREHAB.

Acknowledgments This study required no external sources of funding. Dr, Lemanu is the recipient of a Clinical Research Training Fellowship awarded by the Health Research Council of New Zealand.

Conflicts of interest The authors have no potential or real conflicts of interest to declare.

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