International Journal of Surgery 12 (2014) 134–140

Contents lists available at ScienceDirect

International Journal of Surgery

journal homepage: www.journal-surgery.net

Original research

Preoperative exercise therapy for elective major abdominal surgery: A systematic review

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ARTICLE INFO

Article history:
Received 15 September 2013
Received in revised form
8 November 2013
Accepted 24 November 2013
Available online 8 December 2013

Keywords:
Preconditioning
Physical exercise
Preoperative training
Major surgery outcomes
Complications

ABSTRACT

Objectives: The impact of postoperative complications after Major Abdominal Surgery (MAS) is substantial, especially when socio-economical aspects are taken into account. This systematic review focuses on the effects of preoperative exercise therapy (PEXT) on physical fitness prior to MAS, length of hospital admission and postoperative complications in patients eligible for MAS, and on what is known about the most effective kind of exercise regime.
Methods: A systematic search identified randomised controlled trials on exercise therapy and pulmonary physiotherapy prior to MAS. The methodological quality of the included studies was rated using the 'Delphi List For Quality Assessment of Randomised Clinical Trials'. The level of agreement between the two reviewers was estimated with Cohen's kappa.
Results: A total of 6 studies were included, whose methodological quality ranged from moderate to good. Cohen's kappa was 0.90. Three studies reported on improving physical fitness prior to MAS with the aid of PEXT. Two studies reported on the effect of training on postoperative complications, showing contradictory results. Three studies focused on the effect of preoperative chest physiotherapy on postoperative lung function parameters after MAS. While the effects seem positive, the optimal training regime is still unclear.
Conclusion: Preoperative exercise therapy might be effective in improving the physical fitness of patients prior to major abdominal surgery, and preoperative chest physiotherapy seems effective in reducing pulmonary complications. However consensus on training method is lacking. Future research should focus on the method and effect of PEXT before high-risk surgical procedures.

1. Introduction

Surgery is a great stressor to patients and causes large physiological changes, ranging from tissue trauma, immobility and systemic effects to psychological distress and reduced quality of life.[1] Preoperative physical functioning appears to be an important predictor of morbidity and mortality in patients that undergo various types of surgery.[2–5] After Major Abdominal Surgery (MAS), 35% of the patients experience postoperative complications. The majority of these are pulmonary (pneumonia and respiratory failure), which occur in 9% of all patients after MAS.[6,7] Overall 30-day mortality was 10%.[6,7]

Physical capacity appears to be an important predictor for postoperative recovery after MAS.[8–13] Especially in elderly patients, physical capacity is often reduced due to a lack of regular physical activity before surgery.[14–17] Improvement of their functional capacity by means of Preoperative Exercise Therapy (PEXT) may enhance physical capacity at the moment of hospital admission and may facilitate better recovery after surgery.[18]

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http://dx.doi.org/10.1016/j.ijsu.2013.11.018

Several studies have shown that PEXT is effective in reducing postoperative pulmonary complications and length of hospital stay.[19–22] Recently, Valkenet et al.[23] performed a pooled analysis on the effects of preoperative exercise therapy on postoperative outcomes in cardiac and abdominal surgery patients; they concluded that preoperative training can be effective in reducing postoperative complications and length of hospital stay. By contrast, Lemanu et al.[24] reviewed eight randomised controlled trials (RCT's) investigating the correlation of preoperative improvement of physiologic function with recovery after surgery and concluded that the evidence for the effectiveness of PEXT was limited. While these reviews showed conflicting results of heterogenous PEXT programmes in heterogeneous patient populations in several surgical specialties, but there was no separate analysis. Since the effectiveness of preoperative exercise therapy might vary between various types of surgical interventions and various types of PEXT, a systematic review focussing on abdominal surgery only was warranted.

In this study, we performed a systematic review on the effects of PEXT on physical fitness prior to surgery, length of hospital admission and postoperative complications in patients eligible for MAS, and on the most effective exercise regime for this patient population.

2. Method

A systematic search of the available literature was performed to evaluate the effects of preoperative physical exercise therapy (PEXT). The population of interest were all patients undergoing elective MAS, e.g. colorectal, hepatobiliary and gastric surgery. The intervention studied was PEXT compared to regular care (no training programme). Outcomes were the effects of PEXT on preoperative fitness, complications, and convalescence. Also the different training programmes and the possibility to implement such programmes in daily practice were evaluated. Pubmed, Embase, Medline, The Cochrane Library, PEDro, CINAHL and Web Of Knowledge were searched from the earliest date available within each database up to February 2013.

Two reviewers (authors SP and RS), both blinded for authors and titles of the journal, separately screened and selected the studies on the basis of title and abstract. After consensus on the primary selection, both authors independently reviewed the full text of the selected studies to determine the suitability for inclusion, based on the established selection criteria. In addition, cross-references were screened for further eligible studies. Disagreements between the two reviewers were resolved by discussion with each other and the senior author (JT) until consensus was reached.

Studies were included if they met the following criteria:

- The study design was a randomised controlled trial.
- Eligible participants were patients awaiting elective major abdominal surgery (colorectal, liver, pancreatic or biliary).
- The intervention consisted of a preoperative physical exercise training programme (PEXT), defined as a regimen of physical activities (a stand-alone regimen, home-based or supervised) for specific therapeutic goals to gain or increase musculoskeletal and/or cardiovascular and/or respiratory (muscle) function.
- Reported as outcome measurements included improvement of preoperative physical fitness, length of hospital stay, and postoperative complications.

The methodological quality of the included studies was rated using the 'Delphi List For Quality Assessment of Randomised Clinical Trials',[25] which has an acceptable reliability. The Delphi List consists of 8 criteria (Table 1). Two reviewers (authors SP and RS) independently rated the methodological quality of the included studies. The level of agreement between the two reviewers was assessed by a Cohen's kappa score. The score was classified as follows: <0.20 was a poor agreement; 0.21–0.40 indicated a fair agreement; 0.41–0.60 was moderate agreement; 0.61–0.80 good agreement; 0.81–1.00 very good agreement.[26]

Table 1
Methodological quality of included studies using the 'Delphi List For Quality Assessment of Randomized Clinical Trials'.[25]

	Criteria[a]								
	1a	1b	2	3	4	5	6	7	8
Dronkers et al. 2010[27]	x	x	x	x	x	–	–	x	x
Fagevik Olsen et al. 1997[30]	x	x	x	x	–	–	–	x	x
Kim et al. 2009[29]	x	x	D	x	–	–	–	x	x
Kundra et al. 2010[31]	x	x	D	x	–	–	–	x	x
Carli et al. 2010[28]	x	x	x	x	–	–	–	x	x
Kulkarni et al. 2010[32]	x	x	x	x	–	–	–	x	x

X = Yes.
- = No.
D = Don't know.
[a] **The Delphi List**: (1a) Was a method of randomization performed?, (1b) Was the treatment allocation concealed?, (2) Were the groups similar at baseline regarding the most important prognostic indicators?, (3) Were the eligibility criteria specified?, (4) Was the outcome assessor blinded?, (5) Was the care provider blinded?, (6) Was the patient blinded?, (7) Were point estimates and measures of variability presented for primary outcome measures?, (8) Did the analysis include an intention-to-treat analysis?.

If the data in the studies were not presented in a consistent format and systematic reporting of comparable outcome variables was lacking, a systematic review was undertaken.

3. Results

The primary search strategy produced 1241 results, including 284 duplicate studies. Eight studies were identified as possibly relevant, and underwent critical appraisal on full text. After full text screening, 2 studies were excluded (another duplicate/no MAS). Fig. 1 summarises the search results. The methodological quality of the included studies ranged from moderate to good, as indicated by The Delphi List (Table 1). The level of agreement between the two reviewers was reflected by a Cohen's kappa of 0.90, which represents a very good agreement. The key findings of the included studies are shown in Table 2.

Since the data in the studies were not presented in a consistent format and systematic reporting of comparable outcome variables was lacking, the presented results could not be synthesized through meta-analysis. Consequently, a systematic review was undertaken.

3.1. Compliance

Of the six included studies, only three reported rates of compliance with the PEXT programmes.[27–29] Dronkers et al.[27] found a compliance rate of 97%. Kim et al.[29] found a compliance rate of 74 ± 16%. At the postoperative testing session, two participants in the PEXT group did not make a maximal effort and terminated the test prematurely. Carli et al.[28] found low compliance rates for PEXT, reporting that 16% of the patients had completed the exercise programme. This led to 60% of all patients in both groups who had complete data sets available for analysis.

3.2. Improvement of preoperative physical fitness

Three studies reported on the effects of PEXT on the physical fitness of patients prior to MAS; Dronkers et al.[27] reported a significant preoperative increase in respiratory muscle endurance in patients who received a short period (2–4 weeks) of intensive training,

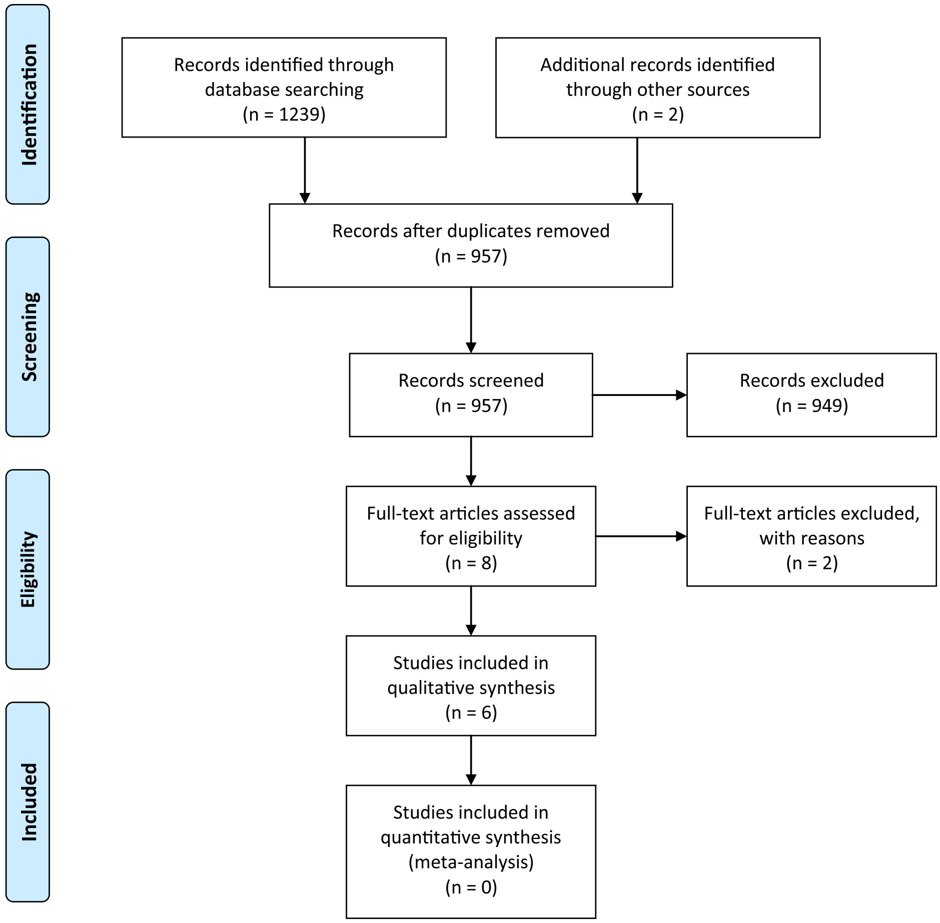

Fig. 1. PRISMA flowchart.

whereas the control group showed a slight decrease in respiratory muscle endurance in the preoperative period. (PEXT group: 259 ± 273 to 404 ± 349 J, control group: 350 ± 299 to 305 ± 323 J; $P < 0.01$). Carli et al.[28] compared the 6-min walking test of an intensive training group with a control group (before and after surgery). They found no significant difference in mean functional walking capacity between both groups. However, in the control group a significantly greater improvement in functional walking capacity was found at the end of the preoperative training period (47% versus 22%; $P = 0.051$) and after surgery (41% versus 11%; $P = 0.019$). Kim et al.[29] showed that the most responsive measurements after four weeks of preoperative training were heart rate (decrease by 13%, Effect Size (ES) = −0.24, Standardized Response Mean (SRM) = −0.57; $p < 0.05$), oxygen uptake (7% ± 6%, ES = −0.40, SRM = −0.97; $p < 0.05$) during a submaximal exercise, and peak power output during a maximal exercise (26 ± 27%, ES = 0.24, SRM = 1.05; $p < 0.05$) are the most responsive measurements after four weeks of preoperative training. In the control group, the heart rate and oxygen uptake during submaximal exercise did not significantly differ from the baseline values (heart rate: +1% ± 3%, ES = +0.05, SRM = 0.12; $p = 0.33$, oxygen uptake: 7% ± 6%, ES = −0.10, SRM = −0.12 $p > 0.05$). Similarly, the control group's peak power output during maximal exercise did not increase (ES = 0).

3.3. Preoperative exercise therapy and postoperative complications

In two studies, postoperative complication rates were mentioned and compared between patients with or without preoperative physical training; Dronkers et al.[27] reported no significant differences in postoperative complications (9 versus 8 respectively, $P = 0.65$) and length of hospital stay (16.2 versus 21.6 days, $P = 0.31$) between a short-term intensive training group (intervention group) and functional activities group (control group).

Fagevik Olsen et al.[30] showed a significant difference in postoperative pulmonary complications in patients who received prophylactic chest physiotherapy prior to major abdominal surgery: of these patients, 6% had postoperative pulmonary complications, compared to 27% in the control group ($p < 0.01$).

3.4. Preoperative chest physiotherapy and postoperative lung function parameters

Three studies focused on postoperative lung function parameters in estimating the effect of physiotherapy prior to MAS. Fagevik Olsen et al.[30] reported a significantly greater oxygen saturation on postoperative day 1 till 3 (day 1, $P < 0.001$, days 2 and 3, $P < 0.05$) in patients who had received prophylactic chest physiotherapy prior to MAS. There was no difference in peak expiratory flow rate or forced vital capacity within both groups. Kundra et al.[31] showed that incentive spirometry improved lung function significantly in the preoperative period; in the postoperative period, the lung function parameters decreased both in the PEXT group and in the controls, but far less in the group that had received PEXT in the form of preoperative incentive spirometry ($p < 0.05$). Kulkarni et al.[32] compared four groups with different training regimens (A: control, B: deep breathing exercises, C: incentive spirometry and D: specific inspiratory muscle training). In groups A, B, and C, the maximum inspiratory pressure did not increase from baseline to preoperative assessment. In group D, the most intensive therapy,

Table 2
Overview of study design, participants, intervention, outcome parameters and results.

Study	Participants			Intervention		Study results[a]
	N (male/female)	Characteristics	I: N (age[b] ± SD) C: N (age[b] ± SD)	Treatment	Comparison	
Dronkers et al. 2010[27]	42 (31/11)	Candidates awaiting first elective abdominal oncological surgery	I: 22 (71.1 ± 6.3) C: 20 (68.8 ± 6.4)	Supervised exercise training, consisting of lower limb extensor training, IMT, aerobic training functional activity training) twice a week, 60 min per session for 2–4 weeks. Also home based exercise 30 min a day, when not at the training department. Instruction about diaphragmatic breathing, deep inspirations with aid of incentive spirometry, coughing and forced expiration techniques.	Home based exercise for 30 min a day, in the period prior to hospital admission. Instruction about diaphragmatic breathing, deep inspirations with aid of incentive spirometry, coughing and forced expiration techniques.	Postoperative complications: I: 9, C: 8 ($P = 0.65$) Postoperative pulmonary complications (Atelectasis, hypoxia or pneumonia): I: 5, C: 5 ($P = 0.93$) Pneumonia: I: 1, C: 3 ($P = 0.27$) Length of stay: I: 16.2, C: 21.6 ($P = 0.31$)
Fagevik Olsen et al. 1997[30]	368 (158/210)	Candidates awaiting open abdominal surgery	I: 174 (53.5 ± 17.4) C: 194 (52.9 ± 17.5)	Training and education a day before surgery, which consisted of breathing exercises with pursed lips, huffing and coughing hourly and information about changing position in bed and early mobilization. High risk patients were given PEP masks for respiratory resistance training.	No information or education.	Postoperative pulmonary complications: I: 10, C: 52 ($P < 0.001$) Pneumonia: I: 1, C:13 ($P < 0.05$) Oxygen saturation (day 1 and day 3 postoperative) I: 96%, 97% C: 94%, 95% ($P < 0.001$, $P < 0.05$) Walking in room (days): I: 1.4, C: 1.8 ($P < 0.01$) Full mobilization (days): I: 1.8, C: 2.4 ($P < 0.01$)
Kim et al. 2009[29]	21 (13/8)	Candidates awaiting abdominal oncological surgery	I: 14 (55 ± 15) C: 7 (65 ± 9)	Four weeks of progressive, structured, presurgical aerobic exercise training at 40–65% of heart rate reserve.	Basic instructions to prepare for surgery, without an exercise prescription.	*Maximal Cardiopulmonary variable* I: Peak power Output Change: 26% Effect Size 0.24, Standardized Response Mean = 1.05 ($P < 0.05$) C: No changes *Submaximal Cardiopulmonary variable* I: Heartrate: decrease by 13%, Effect Size −0.24, Standardized Response Mean = −0.57 ($P < 0.05$) Oxygen: 7%, Effect Size −0.40, Standardized Response Mean = −0.97 ($P < 0.05$) C: No changes *Six Minute walking distance:* I: increase by 30 m, Effect Size 0.48, SRM0.50 C: increase by 30 m, Effect Size 0.27, SRM 0.53
Kundra et al. 2010[31]	50 (?/?)	Healthy individuals undergoing laparoscopic cholecystecomy	I: 25 (39.9 ± 12.3) C: 25 (46.4 ± 13.7)	Incentive spirometry seven days before surgery. They were instructed to use it 15 times, every fourth hourly	Incentive spirometry 15 times, every fourth hourly in the postoperative period.	Change in preoperative lung function: I: 2.8% of FVC baseline, C: 2.4 of FVC baseline ($P < 0.05$) Change in postoperative lung function (24 h after, 48 h after, discharge): I: 1.5, 1.7 and 2.0% of FVC baseline, C: 1.0, 1.3 and 1.5 of FVC baseline ($P < 0.05$)

(*continued on next page*)

ORIGINAL RESEARCH

Table 2 (*continued*)

Study	Participants			Intervention		Study results[a]
	N (male/female)	Characteristics	I: N (age[b] ± SD) C: N (age[b] ± SD)	Treatment	Comparison	
Carli et al. 2010[28]	112 (65/47)	Candidates awaiting colorectal surgery	I: 58 (61 ± 16) C: 54 (60 ± 15)	Exercise initially at 50% of maximal heart rate: increase by 10% if tolerable. Weight training 3 times a week. Cycling initially 20 min a day, increasing to 30 min daily	Advice to walk for a minimum of 30 min daily. Breathing exercises consisted of deep breathing at full VC, diaphragmatic breathing, huffing and coughing for 5 min per day. 5–10 min of exercises to activate circulation of lower limb (ankle rotations and pumping, static quadriceps contractions and bridging).	Improvement walking capacity: At the end of prehabilitation I: 22% C: 47% ($P = 0.051$) After surgery I: 11% C: 41% ($P = 0.019$)
Kulkarni et al. 2010[32]	80 (38/42)	Patients awaiting major abdominal or major urological surgery	I: Group B: 20 (64 ± ?) Group C: 20 (65 ± ?) Group D: 20 (60 ± ?) C: Group A 20 (65 ± ?)	Groups B, C and D were expected to train twice daily for 15 min for 2 weeks Group B: deep breathing exercises. Group C: Incentive spirometry. Group D: Specific inspiratory muscle training (training with the Powerbreathe device)	Group A: standard care without training.	Increase in Mean Inspiratory Pressure (MIP) Group A, B, C no increase from baseline to preoperative assessments. Group D: 51.5 cm H_2O to 68.5 cm H_2O ($P < 0.01$) Postoperative decline MIP Group A,B,C decline in MIP ($P < 0.01$, $P < 0.01$, $P = 0.06$) Group D : $P = 0.36$

Abbreviations: N, number; I, intervention; C, control group; SD, Standard deviation; IMT; inspiratory muscle training.
[a] *P*-values are reported when available from the original article.
[b] Mean age in years.

the maximum inspiratory pressure increased significantly, from 51.5 cm H_2O at baseline (range 33–97) to 68.5 cm H_2O at preoperative assessment (range 44–121). Postoperatively, groups A, B, and C showed a significant to near-significant decline in maximum inspiratory pressure compared to baseline ($p < 0.01$, $p < 0.01$, and $p = 0.06$). No such reduction was seen in group D ($p = 0.36$).[32]

4. Discussion

This systematic review focussed on the effects of PEXT on the improvement of preoperative physical fitness, length of hospital stay and postoperative complication rate following major abdominal surgery. In total, 6 studies of moderate to good methodological quality were included. The lack of uniformity in the investigated parameters preluded a meta-analysis. Instead, a systematic review was carried out, which to our knowledge is the first to highlight the available evidence on PEXT in major abdominal surgery.

Of the included studies, some showed that short-term preoperative inspiratory muscle training is effective in reducing postoperative complications.[27,30] Other studies demonstrated positive effects of physiotherapy prior to abdominal surgery by indicating that PEXT improved physical fitness[27–29] and preserved or improved lung function.[30–32]

Only three of the included studies reported compliance with the PEXT programme, which was 97%,[27] 74 ± 16%[29] and 16%[28] respectively. These differences are large and likely to be due to differences in the specific PEXT programmes.

Two studies reported differences in postoperative complication rates, but they mention these results as secondary outcome measurements and show conflicting results.[27,30] Hence questions regarding the clinical effects of preoperative physical optimisation remain unanswered, due to an absence of high quality prospective studies that specifically report on the effects of PEXT on complications after abdominal surgery.

While some studies have investigated the effects of preoperative educational interventions,[33,34] only a few studies examined the effects of preoperative training in elective surgery.[19–22,35] In patients undergoing cardiac surgery, Herdy et al.[21] demonstrated that a combination of pre- and postoperative exercise therapy programmes for cardiopulmonary rehabilitation proved to be superior to standard care, resulting in a reduced rate of postoperative complications and a shortened length of hospital stay.[21] In patients awaiting lung resection surgery, Bobbio et al.[19] and Jones et al.[22] showed that PEXT consisting of exercise training and pulmonary rehabilitation improved the patients' physical fitness. In high risk patients undergoing a coronary bypass procedure, Hulzebos et al.[20] found that inspiratory muscle training increased inspiratory muscle strength and reduced the incidence of postoperative pulmonary complications in high risk patients who underwent a coronary bypass procedure. A pilot study by Dronkers et al.[35] revealed similar results in patients undergoing elective abdominal aortic aneurysm surgery. In joint replacement surgery, however, reports of the effects of PEXT on postoperative outcome in joint replacement surgery are less consistent. A systematic review of Ackerman et al.[36] concluded that PEXT programmes were not effective before joint replacement surgery. However, this review only included functional measures as outcome parameters (no postoperative complications). A systematic review of Coudeyre et al.[37] concluded that exercise therapy prior to joint replacement surgery is effective in reducing length of hospital stay.

In the postoperative course, several studies have shown that physical exercise therapy after surgery is effective in reducing complications and length of hospital stay, for example after lung volume reductive surgery and after coronary bypass surgery.[38,39] In colorectal surgery, Vlug et al.[40] demonstrated that postoperative physical rehabilitation is effective in reducing the length of hospital stay. However, literature on the differences between preoperative and postoperative physical exercise therapy is sparse.

There is an increasing need for randomised controlled trials to compare the effects of different interventions and their specific limitations. Also, an intervention may be more effective if the duration is prolonged or if the frequency or intensity is increased. However, the time available for training is often limited before elective surgery, especially before oncological surgery. Consequently, oncological surgery may require different training regimes to achieve optimal results of PEXT programmes. These aspects are important for achieving optimal training effects.[41] Unfortunately, little is known about the length of training programmes and whether long-term or short-term training is more effective in reducing postoperative complications and length of hospital stay.

Various risk factors have been shown to be significantly related to postoperative surgical complications.[42,43] The combination of poor preoperative physical capacity and co-existent risk factors make patients more vulnerable to postoperative complications.[8,43] A valid risk model may help to identify patients at high risk for postoperative complications and poor postoperative outcome. One of the selected studies used a risk model to identify these high-risk patients,[30] while the others did not. This might explain why there is conflicting evidence on this subject, since high-risk patients presumably benefit most from PEXT interventions. While this underlines the importance of using predictive risk models, developing an appropriate and validated risk model requires more knowledge of the factors influencing poor postoperative outcome.

This study has several limitations, the first one being the narrow definition of MAS. We defined MAS as colorectal, hepatobiliary and gastric surgery, hence we did not include gynaecological, urological or vascular surgical procedures in the abdomen. The second limitation is that we included studies from the earliest date available within each database up to February 2013. As a result, one of the studies[30] had different outcomes in both experimental and control group compared to the other included studies, due to the fact that the standard of perioperative care during open colorectal surgery was different in 1997. Thirdly, due to the limited number of studies found, this review did not discriminate between open[27–30,32] and laparoscopic[31] procedures. However, future research should investigate the effect of PEXT on both procedures separately, since laparoscopic procedures are associated with a better postoperative recovery and fewer complications than open surgical procedures. The last limitation is the lack of clear definitions of PEXT and of accepted outcome variables, which made it difficult to measure the effect of PEXT. In particular, patient-related outcomes, such as quality of life, were hardly incorporated in the studies. Nevertheless, this review revealed a tendency towards improvement of physical fitness, which deserves further investigation.

Future research should first identify which surgical interventions have a high rate of postoperative complications. Both laparoscopic and open surgical procedures should be analysed, not just for abdominal surgery, but also for other surgical specialties. Next, PEXT regimes should be optimised for specific high-risk procedures and for specific patient populations. Additional research should focus on the effectiveness of combining a PEXT regime and a non-medical regime (for example, teaching patients about the surgical interventions) or of combining a PEXT regime and a postoperative rehabilitation programme, to determine whether the combination or the stand-alone programme is more effective. As was mentioned above, oncological surgical procedures may need a specially tailored PEXT programme, because treatment with chemoradiation in the preoperative phase may interfere with the PEXT regime. The specific goal is to prepare patients for surgery in the best possible way (specifically aimed at particular surgical procedures and patient populations) and to reduce postoperative complications, length of stay and healthcare costs. Finally, resumption of work should be included in the outcome parameters to investigate whether PEXT has an influence on recovery and resumption of daily activities.

5. Conclusion

Preoperative exercise therapy is associated with improved physical fitness of patients prior to major abdominal surgery. Whether or not this results in fewer complications or faster convalescence remains unclear. In view of the large impact of postoperative complications, it is important to explore the possible benefits of PEXT. A randomized controlled trial might provide insight into which preoperative exercise programme could result in improved postoperative outcomes.

Ethical approval

No Ethical approvel was needed for our work.

Funding

None.

Author contribution

Study design: SP, RS, EM, SN, CR, BvR, JT.
Literature search and data collection: SP, RS, EM, JT.
Data analysis: SP, RS, EM, SN, CR, BvR, JT.
Writing: SP, RS, EM, SN, CR, BvR, JT.

Conflicts of interest

None.

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