OXFORD

Effects of early postoperative mobilization following gastrointestinal surgery: systematic review and meta-analysis

Antonie Willner[1,2], Christian Teske[3,4,5,6,7], Thilo Hackert[1] (iD) and Thilo Welsch[1,8,*]

[1]Department of General, Visceral and Thoracic Surgery, University Hospital Hamburg-Eppendorf, Hamburg, Germany
[2]Department of General, Visceral and Thoracic Surgery, St. Elisabethen-Klinikum Ravensburg, Academic Teaching Hospital University of Ulm, Ravensburg, Germany
[3]National Center for Tumor Diseases (NCT/UCC), Dresden, Germany
[4]German Cancer Research Center (DKFZ), Heidelberg, Germany
[5]Faculty of Medicine and University Hospital Carl Gustav Carus, Technische Universität Dresden, Dresden, Germany
[6]Helmholtz-Zentrum Dresden—Rossendorf (HZDR), Dresden, Germany
[7]Department of Visceral, Thoracic and Vascular Surgery, University Hospital Carl Gustav Carus, Technische Universität Dresden, Dresden, Germany
[8]Faculty of Medicine, Technische Universität Dresden, Dresden, Germany

Correspondence to: Thilo Welsch, Department of General, Visceral and Thoracic Surgery, University Hospital Hamburg-Eppendorf, Martinistraße 52, Hamburg 20246, Germany (e-mail: t.welsch@uke.de)

Abstract

Background: Early postoperative mobilization is considered a key element of enhanced recovery after surgery protocols. The aim of this study was to summarize the effect of early postoperative mobilization following gastrointestinal operations on patient recovery, mobility, the morbidity rate and duration of hospital stay.

Methods: A systematic literature search was conducted in December, 2022, using PubMed, Web of Science and the Cochrane Central Register of Controlled Trials. Controlled trials reporting the effects of early postoperative mobilization after gastrointestinal surgery were included. The risk of bias was assessed using a modified Downs and Black tool and the Cochrane Collaboration tool for randomized trials. The outcomes of interest were gastrointestinal recovery (defined passage of first flatus or bowel movements), mobility (step count on postoperative day 3), the morbidity rate and duration of hospital stay.

Results: After elimination of duplicates, 3678 records were identified, and 71 full-text articles were screened. Finally, 15 studies (eight RCTs) reporting on 3538 patients were included. Most trials evaluated early postoperative mobilization after different gastrointestinal operations, including upper gastrointestinal ($n = 8$ studies), hepatopancreatobiliary ($n = 10$ studies) and colorectal resections ($n = 10$ studies). The investigated early postoperative mobilization protocols, operative techniques (minimally invasive or open) and outcome parameters were heterogeneous between the studies. Early postoperative mobilization seemed to significantly accelerate clinical gastrointestinal recovery (mean difference, hours: −11.53 (−22.08, −0.97), $P = 0.03$). However, early postoperative mobilization did not significantly improve the morbidity rate (risk ratio: 0.93 (0.70, 1.23), $P = 0.59$), postoperative mobility of patients (step count mean difference: 1009 (−803, 2821), $P = 0.28$) or shorten the duration of hospital stay (mean difference, days: −0.25 (−0.99,0.43), $P = 0.47$) in randomized trials.

Conclusion: There is a large heterogeneity among the study cohorts, operations and interventions. The available evidence currently does not support specific early postoperative mobilization protocols as an isolated element to further reduce the morbidity rate and duration of hospital stay. Further well-designed trials are required to identify effective early postoperative mobilization protocols.

Introduction

Enhanced recovery after surgery (ERAS) protocols have been implemented in many centres for gastrointestinal operations, for example for colorectal, pancreatic, gastric or liver surgery[1–4]. Such protocols include pre-, intra- and postoperative elements to minimize surgical trauma and accelerate patient recovery. Early postoperative mobilization (EPM) is one of these postoperative core elements that is considered by all current ERAS guidelines and is thought to alleviate intestinal paresis, pulmonary complications or pain. In line with this concept, the grade of recommendation for EPM after gastrointestinal surgery is strong but only based on either low or moderate evidence levels[1–4]. Although there is a consensus on the harmful effects of prolonged bed rest, the optimal protocol for EPM and its effects on mental or physical recovery and morbidity rate are still unclear. However, despite the lack of evidence, enhanced postoperative mobilization is further encouraged by modern concepts: numerous trials are aimed to enhance postoperative patient mobilization by using activity trackers or equivalent wearables/digital systems[5–7]. Current recommendations on EPM after gastrointestinal surgery basically refer to a systematic review of trials involving early mobilization and published up to 2015, which identified four prospective trials conducted after

abdominal and gynaecological operations[8]. Since then, numerous studies have further focused on EPM effects after gastrointestinal surgery. The objective of this meta-analysis was to provide an updated body of evidence for guidance of effective patient education and early mobilization programmes in gastrointestinal surgery. The central question to be addressed is whether EPM of patients following gastrointestinal operations has advantages in terms of patient recovery, mobility, morbidity rate and length of hospital stay (LOS).

Methods
Eligibility criteria
Studies were included in the review if they fulfilled the following criteria: original full-text article (no congress abstracts) considering adult patients undergoing open or minimally invasive abdominal/gastrointestinal surgery; a specific protocol for early in-hospital mobilization used as an intervention (with out-of-bed activities starting at least within the first two postoperative days); patients who followed a specific EPM protocol were compared with a control group receiving either no structured mobilization protocol (that is mobilization at will) or patients with objectively documented different or delayed mobilization achievements; reported outcome measures of interest as defined and publication in English.

Studies were excluded if they involved mainly (>50 per cent) patients undergoing gynaecological, urological, thoracic, cardiac or orthopaedic procedures and data for gastrointestinal subgroups were not separately reported, the EPM protocol was not reported, and the EPM protocol was not studied in isolation (for example mobilization protocol within a multimodal enhanced recovery programme *versus* traditional care). Studies in which the control group mobilization protocol stipulated bed rest during the first postoperative days[9] were also excluded because this practice is regarded obsolete for the majority of standard gastrointestinal operations.

Outcome measures of interest for the present review included the postoperative morbidity rate, pulmonary function, clinical gastrointestinal function (first flatus or bowel movements), performance-based functional tests or other surrogate markers for recovery (pain intensity or sleep quality). Data on the adherence to the planned exercise protocol and quantitative measures of the amount of physical activity (for example step count) were also extracted if available.

Information sources, search strategy and collection process
This systematic review was performed in accordance with the PRISMA guidelines[10]. The following electronic databases were searched: PubMed, Web of Science and Cochrane Central Register of Controlled Trials (via Ovid). The last online search was conducted on 20 December, 2022.

The search strategy was built along the targeted cohort, intervention and outcome measures, and the term was adapted according to the respective database terminology (*Table S1, Supplementary material*). The following search query was used for PubMed:

abdominal OR colon OR rectal OR colorectal OR pancreatic OR liver OR gastrointestinal OR gastric; surgery OR resection OR operation; #1 AND #2; early OR enhanced OR immediate* OR accelerated; postoperative; mobilization OR mobilisation OR ambulat* OR exercise OR walking; #4 AND #5 AND #6; complications OR

morbidity OR 'pulmonary function' OR pain OR recovery OR 'hospital stay' OR 'bowel movements'; #3 AND #7 AND #8.

No further limits or filters were used regarding time frame, article type or language.

The retrieved items from all sources were imported into reference management software (Zotero, version 6.0.19) to eliminate duplicates. This process was supervised manually. All abstracts were screened independently by two investigators for eligibility criteria. Full-text articles were obtained only from studies that met the inclusion criteria or if inclusion could not be decided upon, based on the abstract data. The remaining full-text articles were then reviewed again in detail by the two investigators according to the inclusion and exclusion criteria. Discordant opinions were resolved by consensus discussion. The relevant data were extracted in an electronic data collection form covering the outcome measures of interest, the study design, number of patients enrolled (intervention and control group), age, gender, diagnosis and field of surgery, type of operation, type of operative technique (minimally invasive or open), description of the mobilization protocol, guidance of the exercise training (patient-based or assisted by professionals), patient compliance to completion of the protocol, physical activity (step counts) and information about devices used to support the mobilization protocol. The effect measures mean/ standard deviation, median/interquartile range, mean difference and risk ratio with 95 per cent confidence interval respectively, were considered to compare quantitative variables. If relevant data for quantitative analysis were collected but not reported in the full-text article, the authors were asked to provide the missing data from the original data sets[7].

Risk-of-bias assessment
The risk of bias of all included studies was assessed using a modified Downs and Black tool[8,11]. This tool is based on a checklist to evaluate the methodological quality of both randomized and non-randomized studies. As described in the literature, a modification of the original tool was applied regarding Item 27. Instead of rating according to an available range of study powers (scores 0–5), we rated whether the study did or did not perform a power calculation (scores 0 or 1 respectively). As a result, the maximum score of the tool was 28 instead of 32. In addition, the risk of bias of the included randomized controlled studies was assessed using the Cochrane Collaboration tool[12]. The assessment was performed independently by two authors (T.W., A.W.), and discrepancies were resolved in a consensus meeting.

Data synthesis
The inclusion criteria allowed the inclusion of retrospective trials if a control group was defined. This was considered important, so that the information of these trials was not lost in the review. First, all included studies were summarized to provide an overview of the study designs, cohorts, operations, mobilization protocols and outcome measures. Subgroups of studies were created according to the following specific endpoints reported: pulmonary function, morbidity rate, LOS, pain, exercise intervention (patient-based or assisted digitally or by professional staff), type of operation, technique (minimally invasive or open) and physical activity (step count, walking tests). Each of these effect sizes is addressed in a narrative review based on the available studies. Because of the heterogeneity of the operations and primary endpoints, a quantitative meta-analysis was intended for the subgroup of studies including colorectal operations and for RCTs reporting

the most frequently reported clinically relevant outcomes: LOS, morbidity rate and time to gastrointestinal recovery. Studies that did not report these outcomes as primary or secondary endpoints were not considered for the quantitative meta-analysis. If a mean value was not provided for the effect size of interest, the mean and standard deviation were approximated from the median and interquartile range (i.q.r./1.35) according to the handbook recommendations of the Cochrane Collaboration[13].

The *R* software package (version 3.1.3) was used for statistical calculations and graphs. For comparison of step counts, the Welch two-sample *t* test was applied. The forest plot and meta-analysis were performed using Review Manager (RevMan, Version 5.4.1, The Cochrane Collaboration, 2020). Because of the heterogeneity of the mobilization protocols and intervention effects across studies, a random-effects model was used for meta-analysis. To investigate considerable heterogeneity, standard strategies according to the Cochrane Handbook for Systematic Reviews of Interventions (version 6.3, 2022) were followed[13].

Results
Study selection and characteristics
The primary database search yielded 3678 abstracts after duplicate records were eliminated (*Fig. 1*). Based on the PubMed search, the number of search results doubled since the last systematic review, which included studies until January 2015: 992 abstracts (1946–2014) and 926 abstracts (2015–2023) (*Fig. 2*). After screening the abstracts, 71 full-text articles were reviewed for final inclusion, but several studies were further excluded for distinct reasons (*Fig. 1*). Sixteen articles (15 studies[7,14–27]) matched the eligibility criteria after careful review, including eight RCTs (*Table 1*). Two articles reported different outcomes of the identical RCT[19] and were not listed separately[19,28]. The included trials were published between 2013 and 2022, originated in 13 nations and reported on 3538 patients. Most frequently, the studies investigated EPM after different gastrointestinal operations, including upper gastrointestinal, hepatopancreatobiliary and colorectal resections (*n* = 7). The largest subgroup of studies focusing on a homogeneous surgical cohort reported on colorectal surgery (*n* = 4). The analysed mobilization interventions and outcomes were also heterogeneous (*Table 1*).

Risk of bias in studies
The risk-of-bias assessment of all included trials is shown in *Table S2* (*Supplementary material*). The RCT by de Almeida *et al.*[17] had the highest methodological quality, achieving a score of 24/28 on the modified Downs and Black tool. The study by Nishijima *et al.*[24] was identified as the study with the lowest quality (score 14/28). Common methodologic issues observed in the included studies were strong reporting data on adverse events due to intervention[15,18,26], ensuring external validity[7,22,23,26,27], blinding study subjects to the intervention as well as blinding those measuring the outcome parameters[17], ensuring concealment of allocation[7,17–19,22,23,27,28] and providing information on statistical power[14,17,19–22,25,27,28]. Relevant characteristics and variables of the intervention and control subgroups in retrospective studies were further extracted for comparison (*Table S3*, *Supplementary material*).

A further bias assessment of the included RCTs was performed according to the Cochrane Collaboration tool (*Fig. 3*). Selection bias (random sequence generation and allocation concealment), attrition bias and reporting bias were evaluated as low risk in all

included RCTs[7,14,17–19,22,23,27,28]. Performance bias was determined to be high risk in all studies except for the study by de Almeida *et al.*[7,14,17,18,19,22,23,27]. Detection bias was present in four further trials[7,22,23,27].

Types and characteristics of early mobilization protocols
The specific mobilization protocols of each RCT are described in detail in *Table S4* (*Supplementary material*). All except one trial[15] started patient mobilization before the second POD. Two studies started with a structured EPM programme as soon as the day of surgery (POD 0); study participants were visited to reinforce mobilization goals[19] or were mobilized in or out of bed[18,19] if haemodynamically stable. All trials provided different structured EPM protocols, including physical exercises/stretching, ambulation/walking or cycle ergometry/pedal exerciser (*n* = 3), which were supervised and facilitated either by trained health professionals (for example physiotherapists/graduate trainees), surgical fellows or study nurses. Activity tracking devices were used to quantify postoperative mobilization in several trials[7,22,23,27].

Impact of early mobilization on postoperative physical activity and step count
In theory, EPM protocols should enhance patient mobilization and subsequently shorten the recovery process and lower complications. On the other hand, many patients receiving gastrointestinal operations are of advanced age, have substantial co-morbidities and sustained major surgical trauma, all of which can mitigate enforced mobilization. Several studies therefore intended to measure the extent of postoperative physical activity after early enhanced mobilization compared with standard protocols. Physical activity as a surrogate parameter for recovery can be objectively recorded and studied using activity tracking devices or by standardized exercise tests.

Eight of the included studies (seven RCTs) objectively assessed postoperative activity, either by recording step counts[7,19,22,23,27], by conducting exercise tests (for example 6-minute walking test (6MWT)[17,19,26]) or by measuring walking distance[14].

Studies with prospectively documented step counts were further investigated. Patients who underwent EPM protocols had a mean step count of approximately 700, 2500 and 3600 during postoperative days 1, 3 and 5 respectively (*Fig. 4*). Not all studies reported the respective step counts on each postoperative day, which limited the analysis.

Interestingly, five of the eight studies provided evidence that EPM significantly enhanced the step count or 6MWT performance during the first postoperative days (de Almeida 2017: 6MWT on POD 5; Fiore 2017: POD 1 and 2; Ni 2018: POD 2–5; Ni 2022: POD 2–5; Wiklund 2015: POD 1–7). No improved 6MWT on the day of discharge was noted by van der Leeden[26] and no significantly increased step count after EPM was observed during POD 1–5 in two RCTs[7,14]. However, the latter trial did show a significant increase after enforced mobilization only in the laparoscopic group[7]. A meta-analysis was attempted based on five RCTs reporting step counts on postoperative day 3 (mean difference: 1009 (−803, 2821) steps, $I^2 = 99$ per cent, $P = 0.28$), but the results were limited by a large heterogeneity (*Fig. S1*, *Supplementary material*).

The percentage of a minimally invasive approach ranged from 22 to 83 per cent in studies that included both techniques (*Table 1*). But only a few studies investigated the impact of the minimally invasive approach on enhanced mobilization. According to one study[7], early

Identification of studies via databases and registers

Identification

Records identified from:
PubMed *n* = 1918
Web of Science *n* = 1327
Cochrane Library *n* = 1468

Records removed before screening:
Duplicate records removed *n* = 1035
Records marked as ineligible by automation tools *n* = 0
Records removed for other reasons *n* = 0

Records screened *n* = 3678

Records excluded** *n* = 3604

Screening

Reports sought for retrieval *n* = 74

Reports not retrieved *n* = 3, only congress abstracts

Reports assessed for eligibility *n* = 71

Reports excluded:
Study protocol *n* = 9
Multimodal ERAS intervention *n* = 14
No control group *n* = 4
No original data (commentary, abstract, review) *n* = 9
No gastrointestinal surgery *n* = 5
No defined intervention e.g. postop. mobilization protocol *n* = 13
Other language, Chinese, *n* = 1

Included

Studies (16*articles) included in review *n* = 15
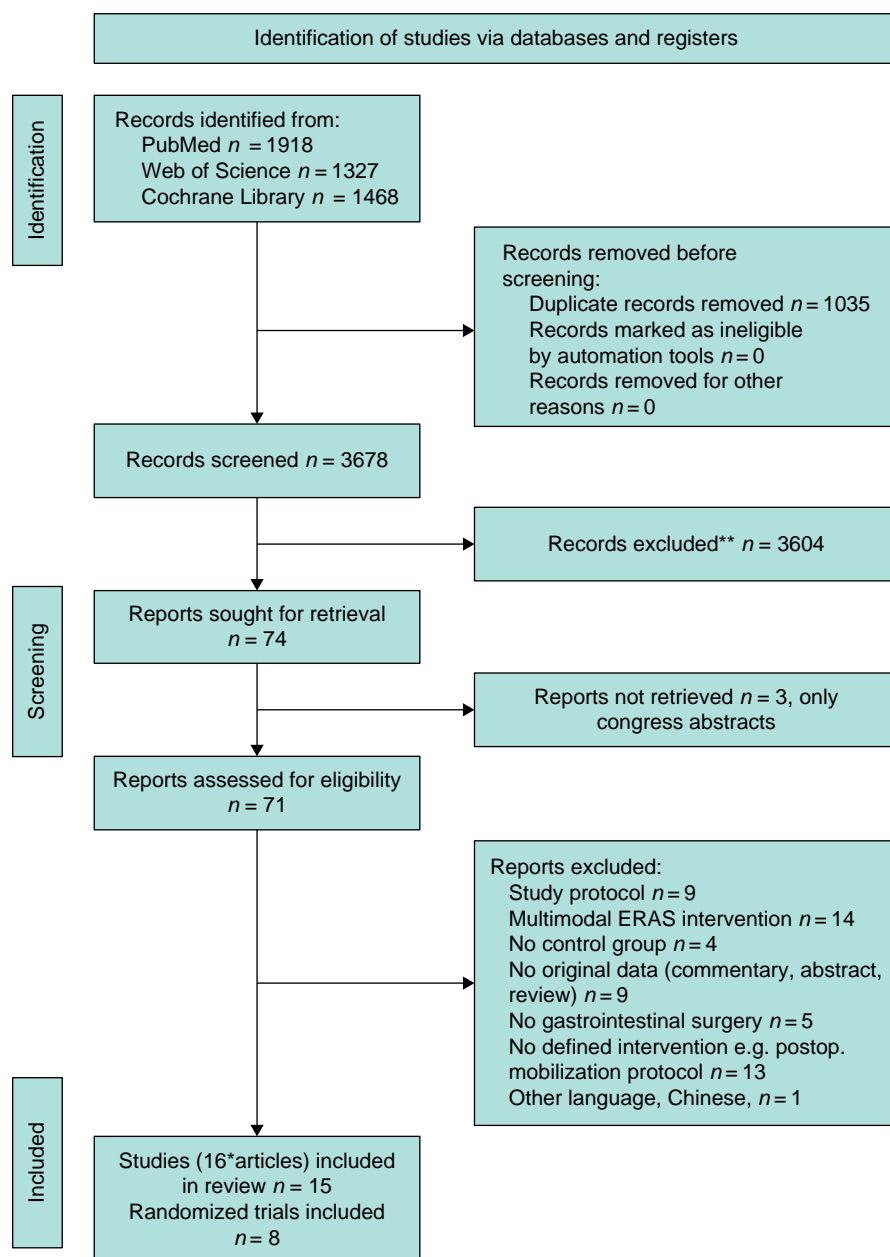Randomized trials included *n* = 8

Fig. 1 Flow chart for the systematic literature search algorithm (PRISMA 2020 template)
*Two articles reported different outcomes of the identical RCT and were not listed separately. ERAS, enhanced recovery after surgery.
**No automation tools were used.

mobilization of patients led to a higher mean step count on POD 5 after minimally invasive (laparoscopic) operations compared with open surgery: 2725 *versus* 1572 (P = 0.0747). Likewise, the cumulative steps during POD 1–5 were significantly increased after minimally invasive surgery: 4635 *versus* 9867 (P = 0.003)[7]. Other randomized studies did not discriminate between the minimally invasive and open approaches, but retrospective data including 718 patients after gastrointestinal and hepatobiliary operations also supported the conclusion that laparoscopic surgery may significantly facilitate early mobilization[24]. In contrast, the percentage of the minimally invasive approach (58 per cent) in the subgroups of patients who achieved early mobilization goals on postoperative day 1 after colorectal surgery was not significantly different[20].

Impact of early mobilization on postoperative morbidity rate

All except 4[16,21,22,27] of the 15 trials reported results on the postoperative morbidity rate. Whereas most studies listed standard surgical and non-surgical complications (within 30 days) graded in accordance with the Clavien–Dindo classification (CDC), three studies concentrated on defined postoperative pulmonary complications (PPC) only[15,18,26]. The three studies with the largest number of included patients (*n* = 291–1170) were retrospective and described a significantly lower complication rate in patients with EPM, mainly after colorectal surgery[20,24,25]. Consequently, a subgroup meta-analysis of morbidity rate after EPM in colorectal patients (*n* = 4 studies)[14,19,20,25] resulted in a significant relative risk (RR) reduction in postoperative complications (RR 0.60 (0.47, 0.77),
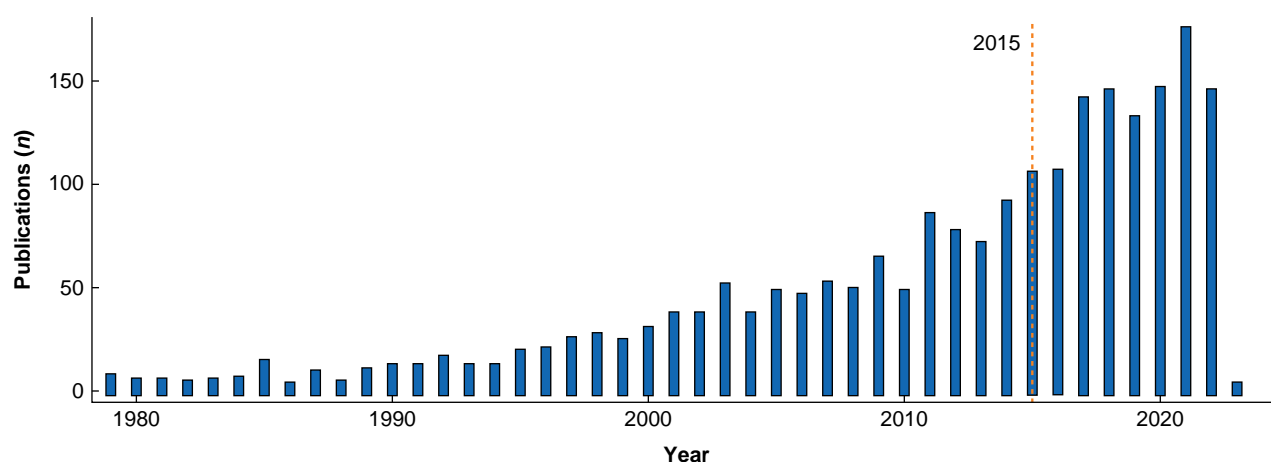
Fig. 2 Number of publications per year captured by the MEDLINE search term (PubMed) on early postoperative mobilization after gastrointestinal surgery (total number of retrieved records: 1918)

The dashed vertical orange line indicates the year 2015.

Table 1 Characteristics of the included studies

Study	Country	Design	Included patients (n)	Field of surgery	Technique*	Intervention† (duration/assistance/type)	Primary outcome (sec. outcomes)
Ahn 2013	Korea	RCT	41	Colon	o, l (77), r (6)	POD 1–dis/P/stretching and ambulation twice daily	LOS (time to flatus, morbidity rate, walking distance)
Fiore 2017, Balvardi 2021§	Canada	RCT	100	Colorectal	o, l (81)	POD 0–dis/P/ambulation 3 times daily	6MWT‡ (FVC, FEV1, PPC, step count, LOS, GI recovery, morbidity rate)
Bhatt 2017	Ireland	Prosp. observ.	60	UGI, hepatobiliary, colorectal	o, l	POD 2–dis/P/pedal exerciser twice daily	PPC (dyspnoea score, LOS)
Boerrigter 2022	Netherlands	Retro. observ.	373	UGI, HPB, colorectal	n.a.	POD 1–3/P/increased ambulation targets (max. 1125 m daily)	Ceiling effect of target goals (LOS)
de Almeida 2017	Brazil	RCT	108	UGI, HPB, colorectal, urological (3–6%)	o, l (22)	POD 1–dis/P/physical exercises including walking/strengthening exercise/cycle ergometry twice daily	Inability to ambulate at POD 5 (6MWT, fatigue, QoL, morbidity rate, LOS)
Fagevik Olsén 2021	Sweden	RCT	83	Pancreatic	o	POD 0–dis/P/ambulation and cycle ergometry (2–3 times daily)	Oxygenation (pulmonary function, pneumonia rate, LOS)
Grass 2018	Switzerland	Retro.	1170	Colorectal	o, l (58)	POD 1–3/E/ambulation out of bed ≥6 h on POD 1	Compliance to mobilization (morbidity rate, LOS)
Koyuncu 2021	Turkey	Prosp.	42	UGI, pancreatic, colorectal	n.a.	POD 0/E/ambulation 2 h out of bed on POD 0	Mobilization time (sleep quality, bowel function, LOS)
Ni 2018	China	RCT	120	Hepatic	n.a.	POD 1–5/P/ambulation beginning POD 2, 2–5 times daily	Step count (pain, sleeping state, bowel function, morbidity rate, LOS)
Ni 2022	China	RCT	120	Hepatic	n.a.	POD 1–5/P/ambulation beginning POD 2, 2–5 times daily	Sleep quality (pain, bowel function, step count, LOS)
Nishijima 2020	Japan	Retro.	718	UGI (excl. oesophagus), HPB, colon	o, l (50)	POD 1–dis/P/ambulation >20 m (during POD 1–2 *versus* later)	Morbidity rate (LOS)
Rosowicz 2022	USA	Retro.	291	Colorectal	o, l (76)	POD 0–dis/E/ambulation (within 24 h *versus* later begin)	Morbidity rate (LOS)
Van der Leeden 2016	Netherlands	Retro.	116	UGI, hepatic, colorectal, other	o, l (24)	POD 0–5/P/ambulation target goals (scheduled distance)	PPC (LOS, 6MWT)
Wiklund 2015	Sweden	RCT	66	Gastric bypass (bariatric)	l	POD 1–7/D, E/ambulation (target step count)	Step count (bowel function, LOS)
Wolk 2019	Germany	RCT	132	UGI, HPB, colorectal	o, l (51)	POD 1–5/D, P/ambulation (target step count)	Step count (morbidity rate, LOS)

6MWT, 6-minute walk test; dis, discharge from hospital; FEV1, forced expiratory volume in 1 s; FVC, forced vital capacity; GI, gastrointestinal; HPB, hepatopancreatobiliary; LOS, duration of hospital stay; n.a., not assessed; oberv., observational; POD, postoperative day; PPC, postoperative pulmonary complications; prosp., prospective; QoL, quality of life; RCT, randomized clinical trial; retro., retrospective; UGI, upper gastrointestinal. *o, open; l, laparoscopic; r, robot-assisted (percentage of the respective minimally invasive technique referred to the total cohort if the data were available). †Mobilization protocol was encouraged during the indicated postoperative days by education only (E), digital advice (D) or healthcare professionals (P). Details of the mobilization protocols in RCTs are presented in *Table S3, Supplementary material*. ‡Assessed 4 weeks after surgery. §These articles both report the results of the same RCT and were combined in this table.

$P < 0.01$, *Fig. S2, Supplementary material*). However, the retrospective design cannot exclude that the occurrence of complications negatively impacts patient mobility and co-morbidities were not balanced in all retrospective subgroups (*Table S3, Supplementary material*). Therefore, the meta-analysis was focused on morbidity rate of RCTs only.

volume in one second (FEV_1)) or the Borg breathlessness scale [15,18,28]. In addition, postoperative pulmonary complications were recorded. The two RCTs did not discover significantly different postoperative spirometry results after pancreatic or colorectal surgery with EPM [18,28]. However, in one trial, the SaO_2/FiO_2 ratio was significantly higher at 18.00 on the day of surgery in a same-day mobilization group [18].

Recovery of gastrointestinal function (first time to flatus or defaecation) was investigated in six studies as secondary outcome parameters[14,19,21–23,27]. A significantly shorter recovery of gastrointestinal function was demonstrated in four studies[14,21–23]. Across these studies, the mean time to gastrointestinal recovery was 53.5 h (approximately 2 days) after early mobilization, and 68.3 h (approximately 2.8 days) in the control groups. A meta-analysis of the RCTs revealed a significantly earlier gastrointestinal recovery (mean difference: −11.53 (−22.08, −0.97) hours, $P = 0.03$) (*Fig. 5b*).

Impact of early mobilization on postoperative pain and sleep quality

Only two of the included studies reported postoperative pain intensity[22,23]. From days 4 or 5 following liver resection, the pain scores in the early mobilization groups were significantly lower than those in the control groups (mean difference on day 5: −0.54 (−1.44, −0.04), $P = 0.03$; *Fig. S3*, *Supplementary material*). Additionally, sleeping times were longer on POD 3[22] and POD 5[22,23] than in the standard mobilization groups. As an additional parameter to evaluate recovery after major abdominal surgery, one study recorded the incidence and intensity of fatigue measured by the revised Piper fatigue scale (PFS-R). The results showed that patients undergoing the EPM programme had a lower incidence of fatigue at POD 5 than did the control group[17].

Impact of early mobilization on duration of hospital stay

The duration of postoperative hospital stay is one of the most relevant clinical and economic outcome parameters for the evaluation of ERAS and mobilization protocols. Accordingly, the LOS was reported in all included studies, although LOS was assessed as the primary endpoint in only one trial[14]. Nine studies described a positive effect of EPM protocols, resulting in a significantly shorter LOS[7,14,15,20–25]. However, a meta-analysis of RCTs demonstrated no significant difference in LOS after EPM (mean difference: −0.25 (−0.99, 0.43), $P = 0.47$) (*Fig. 5*). Of note, there was considerable heterogeneity among the LOS results (see also the funnel plot, *Fig. S4*, *Supplementary material*). Reasons for the heterogeneity are most likely the various included operations (from laparoscopic bariatric bypass to open pancreatic resection), patient characteristics and the different intervention protocols.

Discussion

It is believed that EPM after gastrointestinal surgery is an important element of the ERAS concept, although detailed descriptions of exercise protocols are scarce. Surgeons often recommend early ambulation to overcome postoperative gastroparesis and drive propulsive gut motility. However, experimental data revealed that early ambulation did not significantly affect gastrointestinal myoelectric activity[29]. The physiologic link between postoperative patient mobility and gastrointestinal recovery is of peculiar interest in gastrointestinal surgery because of the frequently altered gastrointestinal
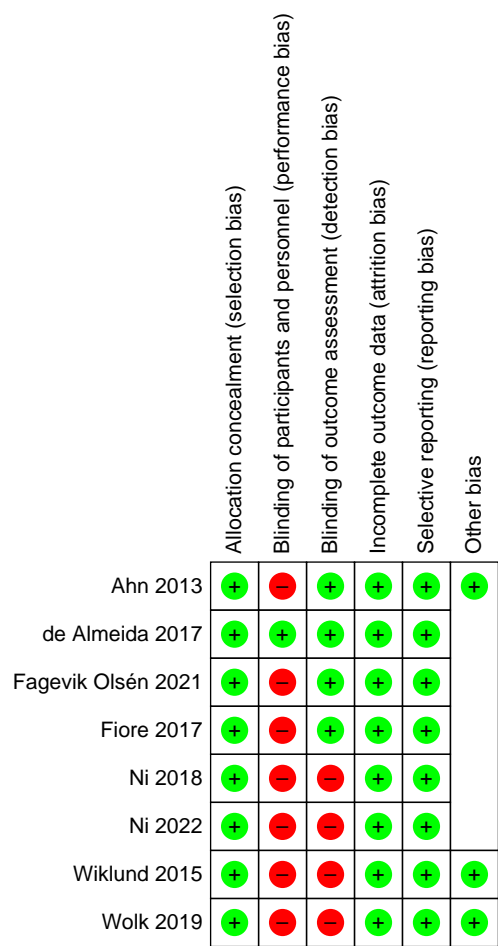

Fig. 3 Risk-of-bias assessment of the included RCTs according to the Cochrane Collaboration tool

To this end, morbidity rate results could be extracted from six RCTs (including colorectal, upper gastrointestinal and hepatopancreatic surgery) for meta-analysis, which showed no significant effect of EPM protocols on the postoperative morbidity rate (RR 0.93 (0.70, 1.23), $P = 0.59$), *Fig. 5*[7,14,17–19,23]. Most of the analysed trials included all relevant complications graded according to the CDC. However, one trial[18] only reported the rate of postoperative pneumonia. Exclusion of this RCT from the meta-analysis did not significantly alter the result (RR 0.94 (0.71, 1.25), $P = 0.94$). Further subgroup meta-analyses focusing on morbidity rate after specific operations other than colorectal (for example pancreatic (one study included pancreatic resections only) or upper gastrointestinal surgery (one study included bariatric resections only)) are currently not conclusive because of the paucity of available data.

Only three studies considered adverse events related to mobilization or the study intervention (for example collapse, falling, accidental drain removal), but no such adverse events were observed [15,18,26].

Impact of early mobilization on pulmonary and gastrointestinal function

Three prospective studies (one case control, two RCTs) assessed short-term pulmonary function after EPM by measuring oxygenation (for example oxygen saturation (SaO_2)), spirometry data (for example forced vital capacity (FVC) and forced expiratory
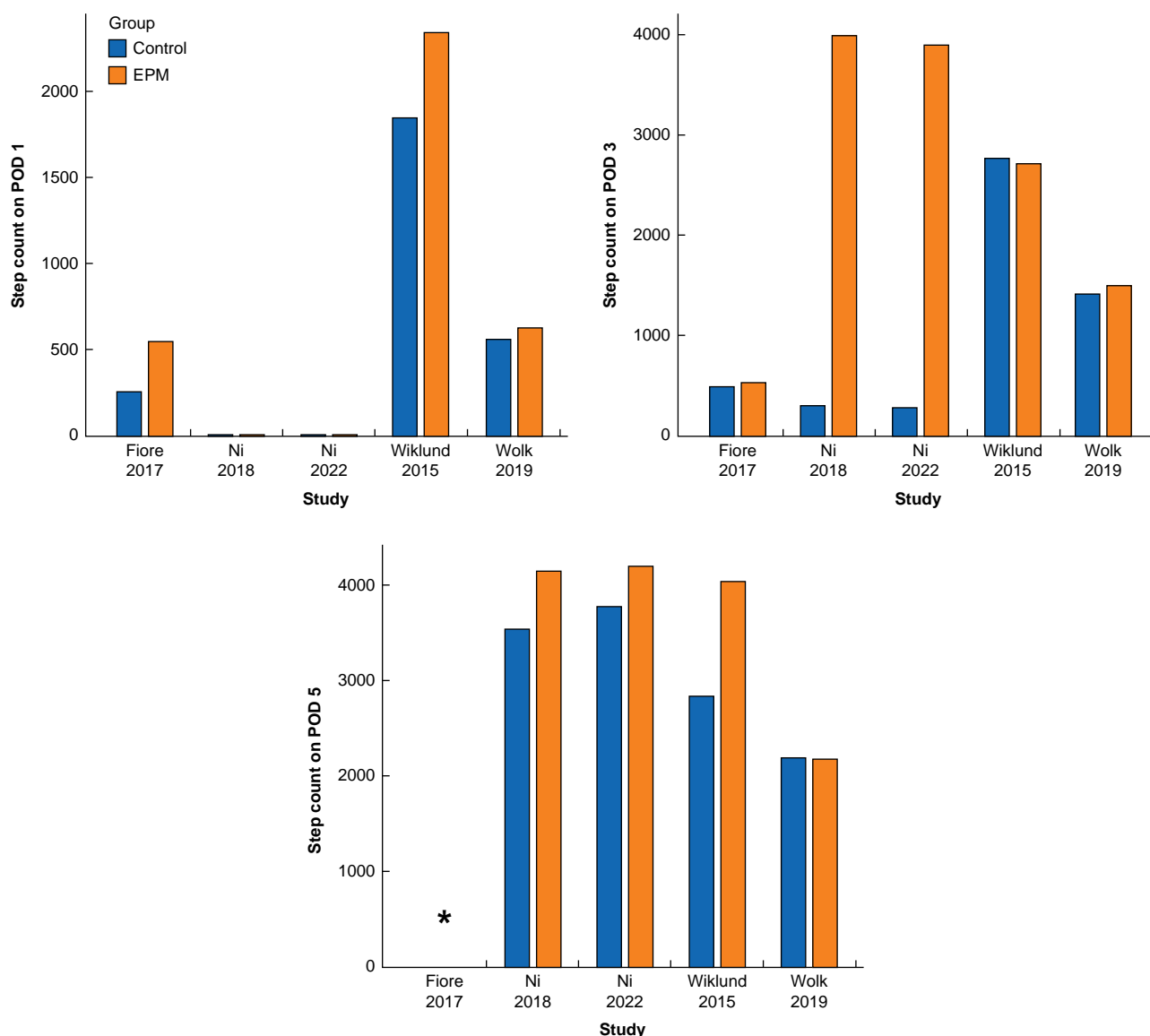
Fig. 4 Mean step count on postoperative days (POD) 1 (top left), 3 (top right) and 5 (bottom) in the early postoperative mobilization (EPM, intervention) and the control group respectively, reported by RCTs
*Step counts on POD 5 were not assessed in this study. EPM, early postoperative mobilization.

anatomy and anastomotic healing. Interestingly, the present meta-analysis now indicates that EPM positively correlates with a faster clinical gastrointestinal recovery.

In addition, patients scheduled for gastrointestinal operations are often advanced in age and have co-morbidities, which may limit physical fitness and motivation[6]. On the other hand, patients accept the need for early ambulation and experience early mobilization as an important part of care with an impact on recovery and well-being[6,30]. New tools such as digital apps or wearables are now supporting patient motivation, education and training, and help to objectively assess postoperative mobility[5,7,31,32]. The increasing use of minimally invasive (laparoscopic and robotic) approaches to gastrointestinal surgery reduces surgical trauma and will further facilitate enforced ambulation[7].

The present review and meta-analysis demonstrated that current trials frequently include heterogeneous patient cohorts, operations, mobilization protocols and outcome measures, which contribute to the fact that we cannot clearly describe the

effects of EPM protocols. The start of EPM programmes should begin on the day of surgery or the first postoperative day, which was respected by almost all included trials. There are discrepant observations between retrospective studies and prospective RCTs regarding the effect of EPM on morbidity rate and LOS. Larger retrospective studies have described a reduction in postoperative morbidity rate and LOS for patients with enhanced mobilization, but it remains unclear whether the control group patients did not ambulate because of emerging complications[20,24,25]. Thus, an RCT in a homogeneous patient cohort is a more appropriate design to minimize selection bias.

Based on the present review, the largest homogeneous subgroup of studies consists of patients evaluated after colorectal surgery. However, only a few trials analysed the intervention 'patient mobilization' in isolation and could be included in this review. Overall, there seems to be a significant link between EPM and reduced morbidity rate after colorectal surgery, but this has not been confirmed in RCTs so far. One could argue that the
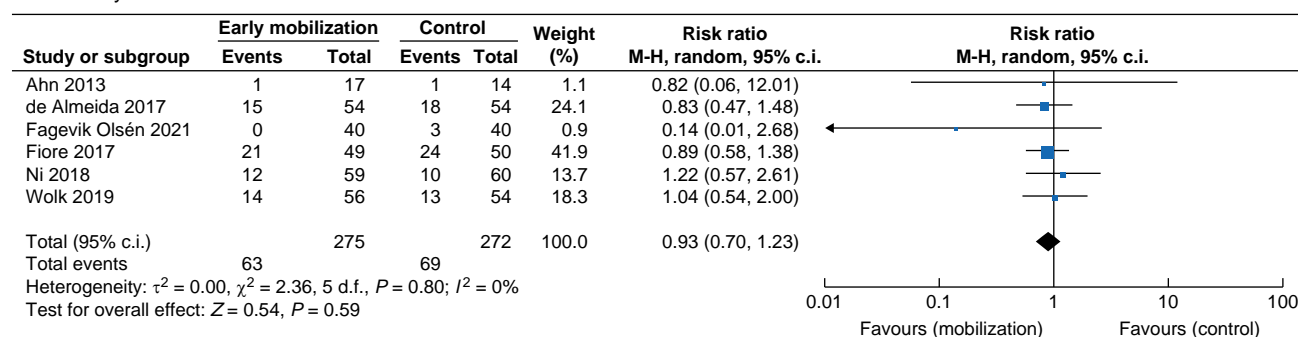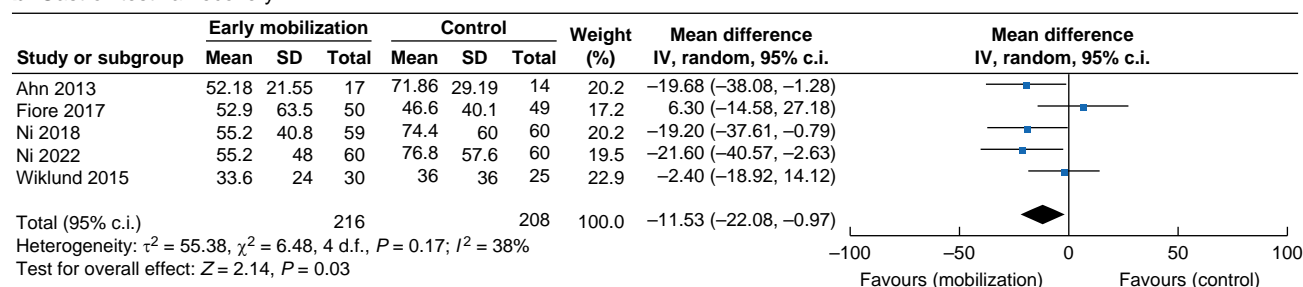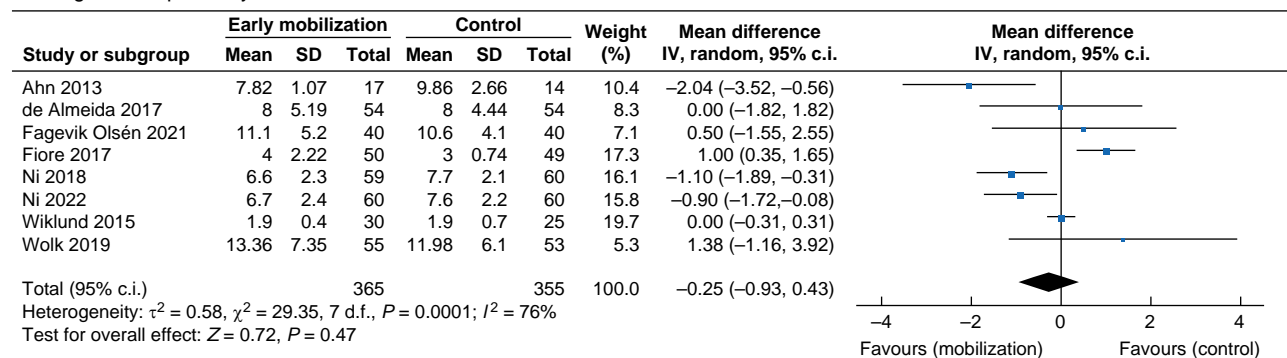
a Morbidity

Study or subgroup	Early mobilization		Control		Weight (%)	Risk ratio M-H, random, 95% c.i.	Risk ratio M-H, random, 95% c.i.
	Events	Total	Events	Total			
Ahn 2013	1	17	1	14	1.1	0.82 (0.06, 12.01)	
de Almeida 2017	15	54	18	54	24.1	0.83 (0.47, 1.48)	
Fagevik Olsén 2021	0	40	3	40	0.9	0.14 (0.01, 2.68)	
Fiore 2017	21	49	24	50	41.9	0.89 (0.58, 1.38)	
Ni 2018	12	59	10	60	13.7	1.22 (0.57, 2.61)	
Wolk 2019	14	56	13	54	18.3	1.04 (0.54, 2.00)	
Total (95% c.i.)		275		272	100.0	0.93 (0.70, 1.23)	
Total events	63		69				

Heterogeneity: $\tau^2 = 0.00$, $\chi^2 = 2.36$, 5 d.f., $P = 0.80$; $I^2 = 0\%$
Test for overall effect: $Z = 0.54$, $P = 0.59$

Favours (mobilization) — Favours (control) (0.01, 0.1, 1, 10, 100)

b Gastrointestinal recovery

Study or subgroup	Early mobilization			Control			Weight (%)	Mean difference IV, random, 95% c.i.	Mean difference IV, random, 95% c.i.
	Mean	SD	Total	Mean	SD	Total			
Ahn 2013	52.18	21.55	17	71.86	29.19	14	20.2	−19.68 (−38.08, −1.28)	
Fiore 2017	52.9	63.5	50	46.6	40.1	49	17.2	6.30 (−14.58, 27.18)	
Ni 2018	55.2	40.8	59	74.4	60	60	20.2	−19.20 (−37.61, −0.79)	
Ni 2022	55.2	48	60	76.8	57.6	60	19.5	−21.60 (−40.57, −2.63)	
Wiklund 2015	33.6	24	30	36	36	25	22.9	−2.40 (−18.92, 14.12)	
Total (95% c.i.)			216			208	100.0	−11.53 (−22.08, −0.97)	

Heterogeneity: $\tau^2 = 55.38$, $\chi^2 = 6.48$, 4 d.f., $P = 0.17$; $I^2 = 38\%$
Test for overall effect: $Z = 2.14$, $P = 0.03$

Favours (mobilization) — Favours (control) (−100, −50, 0, 50, 100)

c Length of hospital stay

Study or subgroup	Early mobilization			Control			Weight (%)	Mean difference IV, random, 95% c.i.	Mean difference IV, random, 95% c.i.
	Mean	SD	Total	Mean	SD	Total			
Ahn 2013	7.82	1.07	17	9.86	2.66	14	10.4	−2.04 (−3.52, −0.56)	
de Almeida 2017	8	5.19	54	8	4.44	54	8.3	0.00 (−1.82, 1.82)	
Fagevik Olsén 2021	11.1	5.2	40	10.6	4.1	40	7.1	0.50 (−1.55, 2.55)	
Fiore 2017	4	2.22	50	3	0.74	49	17.3	1.00 (0.35, 1.65)	
Ni 2018	6.6	2.3	59	7.7	2.1	60	16.1	−1.10 (−1.89, −0.31)	
Ni 2022	6.7	2.4	60	7.6	2.2	60	15.8	−0.90 (−1.72, −0.08)	
Wiklund 2015	1.9	0.4	30	1.9	0.7	25	19.7	0.00 (−0.31, 0.31)	
Wolk 2019	13.36	7.35	55	11.98	6.1	53	5.3	1.38 (−1.16, 3.92)	
Total (95% c.i.)			365			355	100.0	−0.25 (−0.93, 0.43)	

Heterogeneity: $\tau^2 = 0.58$, $\chi^2 = 29.35$, 7 d.f., $P = 0.0001$; $I^2 = 76\%$
Test for overall effect: $Z = 0.72$, $P = 0.47$

Favours (mobilization) — Favours (control) (−4, −2, 0, 2, 4)

Fig. 5 Meta-analysis results (forest plots) of different comparisons in RCTs evaluating early postoperative *versus* standard mobilization after gastrointestinal surgery
a Postoperative 30-day morbidity rate (CDC I–V[7,14,19,23], CDC III–V[17], pneumonia[18]). b Gastrointestinal recovery (time to first flatus or stool in hours). c Length of hospital stay (days). CDC: Clavien-Dindo classification of complications; M-H: Mantel-Haenszel.

intervention 'mobilization' alone has significant effects only in conjunction with additional ERAS elements. However, further RCTs tested a combined intervention comprising mobilization and diet after colorectal operations but also failed to show a significant reduction in morbidity rate and LOS[33,34].

In sum, the present study tested the effect of EPM after gastrointestinal surgery. This systematic review underscores that EPM is a rapidly growing and important research field in gastro intestinal surgery that is generating randomized data. Based on this finding, the study indicates that EPM may improve patient oxygenation during the first postoperative hours, which is additionally confirmed by RCTs including other than gastro intestinal operations[35]. Moreover, EPM significantly accelerates clinical gastrointestinal recovery (for example first time to flatus). Single-centre reports may also support reduced pain intensity and improved sleep quality[22,23]. However, EPM in isolation was not found to improve pulmonary function, or reduce morbidity rate or LOS in this meta-analysis. The review also summarized the mean

realistic amount of ambulation after gastrointestinal surgery, which was up to 4000 steps on POD 5. This mobilization target may be even higher in cohorts of fitter patients and patients evaluated after minimally invasive surgery.

Several limitations of the present study must be taken into account, which are mainly founded on the designs and heterogeneity (different operations, open and minimally invasive techniques, different mobilization protocols) of the included trials. First, patients with both oncological and bariatric surgery were analysed. Second, the study cohort sizes of the RCTs were maximally 50–60 patients in the intervention subgroups and not always calculated for the clinically relevant endpoints of morbidity rate or LOS. Third, many trials did not report the compliance of the patients for the specific mobilization protocols, so it is unknown how many participants in the intervention groups completed the respective protocols. Finally, poor evidence is provided for the effectiveness of the mobilization protocols because the protocols did not lead to increased activity (for

example step count) in all studies. A further limitation is the review process itself, which systematically excluded all trials that investigated EPM within a multimodal ERAS setting. According to the literature research term, studies reporting an EPM starting after POD 1 were included in the analysis, although mobilization after POD 1 is 'standard' rather than 'early'. The authors decided to include these studies as well to provide an overview of what is currently considered EPM in the scientific community.

The number of retrospective studies and RCTs investigating EPM after gastrointestinal surgery has relevantly increased during the last 8 years. However, the presently available evidence, including randomized data, does not currently support specific EPM protocols with additionally allocated resources or training elements as an isolated element to further reduce the morbidity rate and LOS. However, an effect in combination with other ERAS elements cannot be excluded. In order to generate a solid ground of evidence, further well-designed RCTs are needed to identify feasible, effective and procedure- or patient-specific EPM programmes. These trials should focus on more homogeneous cohorts (for example minimally invasive colon surgery) in an established ERAS setting, a consistent study cohort size calculation for clinically relevant endpoints and a clearly defined mobilization protocol beginning on the day of surgery.

Funding

Acknowledgements

Disclosure

The authors declare no conflict of interest.

Supplementary material

Supplementary material is available at *BJS Open* online.

Data availability

The raw data of the presented analysis are available upon request from the corresponding author.

Author contributions

Antonie Willner (Conceptualization, Data curation, Formal analysis, Investigation, Software, Visualization, Writing—original draft, Writing—review & editing), Christian Teske (Data curation, Formal analysis, Software, Writing—review & editing), Thilo Hackert (Supervision, Writing—review & editing) and Thilo Welsch (Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing—original draft, Writing—review & editing).

References

1. Gustafsson UO, Scott MJ, Hubner M, Nygren J, Demartines N, Francis N *et al.* Guidelines for perioperative care in elective colorectal surgery: Enhanced Recovery After Surgery (ERAS®) Society recommendations: 2018. *World J Surg* 2019; **43**:659–695

2. Joliat GR, Kobayashi K, Hasegawa K, Thomson JE, Padbury R, Scott M *et al.* Guidelines for perioperative care for liver surgery: Enhanced Recovery After Surgery (ERAS) Society recommendations 2022. *World J Surg* 2023;**47**:11–34

3. Melloul E, Lassen K, Roulin D, Grass F, Perinel J, Adham M *et al.* Guidelines for perioperative care for pancreatoduodenectomy: Enhanced Recovery After Surgery (ERAS) recommendations 2019. *World J Surg* 2020;**44**:2056–2084

4. Mortensen K, Nilsson M, Slim K, Schäfer M, Mariette C, Braga M *et al.* Consensus guidelines for enhanced recovery after gastrectomy: Enhanced Recovery After Surgery (ERAS®) Society recommendations. *Br J Surg* 2014;**101**:1209–1229

5. Mata J, Pecorelli N, Kaneva P, Moldoveanu D, Gosselin-Tardiff A, Alhashemi M *et al.* A mobile device application (app) to improve adherence to an enhanced recovery program for colorectal surgery: a randomized controlled trial. *Surg Endosc Interv Tech* 2020;**34**:742–751

6. Wolk S, Distler M, Müssle B, Söthje S, Weitz J, Welsch T. Adherence to ERAS elements in major visceral surgery–an observational pilot study. *LANGENBECKS Arch Surg* 2016;**401**:349–356

7. Wolk S, Linke S, Bogner A, Sturm D, Meißner T, Müssle B *et al.* Use of activity tracking in major visceral surgery–the enhanced perioperative mobilization trial: a randomized controlled trial. *J Gastrointest Surg* 2019;**23**:1218

8. Castelino T, Fiore JF Jr, Niculiseanu P, Landry T, Augustin B, Feldman LS. The effect of early mobilization protocols on postoperative outcomes following abdominal and thoracic surgery: a systematic review. *SURGERY* 2016;**159**:991–1003

9. Calotta NA, Coon D, Bos TJ, Ostrander BT, Scott AV, Grant MC *et al.* Early ambulation after colorectal oncologic resection with perineal reconstruction is safe and effective. *Am J Surg* 2019;**218**:125–130

10. Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD *et al.* The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ* 2021;**372**:n71

11. Downs SH, Black N. The feasibility of creating a checklist for the assessment of the methodological quality both of randomised and non-randomised studies of health care interventions. *J Epidemiol Community Health* 1998;**52**:377–384

12. Higgins JP, Altman DG, Gøtzsche PC, Jüni P, Moher D, Oxman AD *et al.* The Cochrane Collaboration's tool for assessing risk of bias in randomised trials. *BMJ* 2011;**343**:d5928

13. Higgins JPT, Thomas J, Chandler J, Li T, Page MJ, Welch VA (eds.), *Cochrane Handbook for Systematic Reviews of Interventions*. (2nd edn). Chichester, UK: John Wiley & Sons, 2019

14. Ahn KY, Hur H, Kim DH, Min J, Jeong DH, Chu SH *et al.* The effects of inpatient exercise therapy on the length of hospital stay in stages I-III colon cancer patients: randomized controlled trial. *Int J Colorectal Dis* 2013;**28**:643–651

15. Bhatt NR, Sheridan G, Connolly M, Kelly S, Gillis A, Conlon KC *et al.* Postoperative exercise training is associated with reduced respiratory infection rates and early discharge: a case-control study. *Surgeon* 2017;**15**:139–146

16. Boerrigter JL, Geelen SJG, van Berge Henegouwen MI, Bemelman WA, van Dieren S, de Man-van Ginkel JM *et al.* Extended mobility scale (AMEXO) for assessing mobilization and setting goals after

gastrointestinal and oncological surgery: a before-after study. *BMC Surg* 2022;**22**:38

17. de Almeida EPM, de Almeida JP, Landoni G, Galas FRBG, Fukushima JT, Fominskiy E *et al.* Early mobilization programme improves functional capacity after major abdominal cancer surgery: a randomized controlled trial. *Br J Anaesth* 2017;**119**: 900–907

18. Fagevik Olsén M, Becovic S, Dean E. Short-term effects of mobilization on oxygenation in patients after open surgery for pancreatic cancer: a randomized controlled trial. *BMC Surg* 2021;**21**:185

19. Fiore JF Jr, Castelino T, Pecorelli N, Niculiseanu P, Balvardi S, Hershorn O *et al.* Ensuring early mobilization within an enhanced recovery program for colorectal surgery – a randomized controlled trial. *Ann Surg* 2017;**266**:223–231

20. Grass F, Pache B, Martin D, Addor V, Hahnloser D, Demartines N *et al.* Feasibility of early postoperative mobilisation after colorectal surgery: a retrospective cohort study. *Int J Surg* 2018; **56**:161–166

21. Koyuncu F, Iyigun E. The effect of mobilization protocol on mobilization start time and patient care outcomes in patients undergoing abdominal surgery. *J Clin Nurs* 2022;**31**:1298–1308

22. Ni CY, Hou GJ, Tang YY, Wang JJ, Chen WJ, Yang Y *et al.* Quantitative study of the effects of early standardized ambulation on sleep quality in patients after hepatectomy. *Front Surg* 2022;**9**:941158

23. Ni CY, Wang ZH, Huang ZP, Zhou H, Fu LJ, Cai H *et al.* Early enforced mobilization after liver resection: a prospective randomized controlled trial. *Int J Surg Lond Engl* 2018;**54**:254

24. Nishijima M, Baba H, Murotani K, Tokai R, Watanabe T, Hirano K *et al.* Early ambulation after general and digestive surgery: a retrospective single-center study. *LANGENBECKS Arch Surg* 2020;**405**:613–622

25. Rosowicz A, Brody JS, Lazar DJ, Bangla VG, Panahi A, Nobel TB *et al.* Early ambulation is associated with improved outcomes following colorectal surgery. *Am Surg* 2022. doi:10.1177/00031348221142590

26. van der Leeden M, Huijsmans R, Geleijn E, de Lange-de Klerk ES, Dekker J, Bonjer HJ *et al.* Early enforced mobilisation following surgery for gastrointestinal cancer: feasibility and outcomes. *Physiotherapy* 2016;**102**:103–110

27. Wiklund M, Sundqvist E, Olsen M. Physical activity in the immediate postoperative phase in patients undergoing Roux-en-Y gastric bypass–a randomized controlled trial. *Obes Surg* 2015;**25**:2245–2250

28. Balvardi S, Pecorelli N, Castelino T, Niculiseanu P, Alhashemi M, Liberman AS *et al.* Impact of facilitation of early mobilization on postoperative pulmonary outcomes after colorectal surgery: a randomized controlled trial. *Ann Surg* 2021;**273**:868

29. Waldhausen JH, Schirmer BD. The effect of ambulation on recovery from postoperative ileus. *Ann Surg* 1990;**212**: 671–677

30. Svensson-Raskh A, Schandl A, Holdar U, Fagevik Olsén M, Nygren-Bonnier M. 'I have everything to win and nothing to lose': patient experiences of mobilization out of bed immediately after abdominal surgery. *Phys Ther* 2020;**100**: 2079–2089

31. Jones ASK, Kleinstäuber M, Akroyd A, Mittendorf A, Bognuda P, Merrie AEH *et al.* Using animated visualization to improve postoperative mobilization: a randomized controlled trial. *Health Psychol* 2019;**38**:748–758

32. Waller GC, Kim TG, Perez S, Esper GJ, Srinivasan JK, Shaffer VO *et al.* Comparing activity trackers with vs. without alarms to increase postoperative ambulation: a randomized control trial. *Am Surg* 2021;**87**:1093–1098

33. Lee SM, Kang SB, Jang JH, Park JS, Hong S, Lee TG *et al.* Early rehabilitation versus conventional care after laparoscopic rectal surgery: a prospective, randomized, controlled trial. *Surg Endosc* 2013;**27**:3902

34. Lee TG, Kang SB, Kim DW, Hong S, Heo SC, Park KJ. Comparison of early mobilization and diet rehabilitation program with conventional care after laparoscopic colon surgery: a prospective randomized controlled trial. *Dis Colon Rectum* 2011;**54**:21–28

35. Svensson-Raskh A, Schandl A, Stahle A, Nygren-Bonnier M, Olsen M. Mobilization started within 2 hours after abdominal surgery improves peripheral and arterial oxygenation: a single-center randomized controlled trial. *Phys Ther* 2021;**101**: pzab094