Meta-analysis and systematic review

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The use of artificial intelligence and wearable devices in enhanced recovery after surgery pathways following radical cystectomy: A systematic review

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Abstract

Objective: Radical cystectomy is associated with relatively high rates of 90-day complications (58%–66%) and readmission (40%). The increasing availability of wearable devices, such as Fitbit devices, Misfit trackers and SenseWear armbands, may offer opportunities to improve postoperative outcomes. This review aimed to explore the roles of wearable devices and artificial intelligence in the perioperative care of patients undergoing radical cystectomy.

Methods: A systematic review (PROSPERO: CRD420261279062) was conducted to investigate the role of wearable devices and artificial intelligence in enhanced recovery protocols following radical cystectomy. A total of 1031 studies were identified from 5 databases, of which 42 underwent full-text screening. Following final eligibility assessment, eight studies were included in the systematic review. Extracted postoperative outcomes included step count, length of stay, readmission, discharge location, body mass index, functional measures and postoperative complications.

Results: Seven studies investigated wearable devices, whereas one study examined the use of artificial intelligence to assess the association between body composition and postoperative complications. Preliminary evidence suggested that wearable devices improve postoperative physical activity and step counts; however, the significance of these associations varied substantially across studies. Evidence regarding artificial intelligence was limited to preoperative planning but indicated potential for identifying patients at high or low risk of complications following radical cystectomy.

Conclusions: Preliminary evidence suggests that wearable devices and artificial intelligence provide useful information to support postoperative recovery. However, the limited number of studies precludes firm conclusions. Randomised trials using standardised parameters are needed to establish the roles of wearable devices and artificial intelligence before their clinical integration into established enhanced recovery after surgery protocols.

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Introduction

Radical cystectomy remains a key treatment for muscle-invasive and high-risk non-muscle-invasive bladder cancer.[1] Despite considerable advances in surgical techniques, including the wider adoption of minimally invasive and robotic approaches, postoperative recovery following cystectomy remains complex.[1,2] Since their introduction in the late 1990s, enhanced recovery after surgery (ERAS) programmes have been increasingly incorporated into perioperative care, with the aim of facilitating recovery, reducing morbidity and shortening hospital stays.[3] This is particularly relevant to cystectomy, as patients are often older and have multiple comorbidities and frailty, making postoperative recovery especially challenging.

Recent studies have increasingly investigated the use of wearable devices and activity trackers in the perioperative setting, with available evidence suggesting high levels of acceptability among patients undergoing urological surgery.[4] By enabling continuous monitoring of parameters such as heart rate and blood oxygen saturation, wearable devices may facilitate earlier prediction of postoperative outcomes.[5] Step count is a parameter of particular interest, as existing literature has explored the use of wearable devices across several surgical specialties to objectively assess postoperative physical activity and recovery.[6] Increasing attention is therefore being given to how these data can be interpreted and translated into clinical practice.

Artificial intelligence (AI) has a broad range of potential applications in the diagnosis and management of various urological conditions. By improving the precision of outcome prediction, AI may support more personalised perioperative care.[7] A review by Khan et al. suggested that integrating AI with wearable devices facilitate earlier detection of clinical deterioration in postoperative surgical patients.[8] Furthermore, AI may support intraoperative decision making by alerting the surgical team to potential complications in real time.[9]

Although early data are promising, the evidence base, particularly in relation to radical cystectomy, remains limited. To the best of our knowledge, no systematic review has comprehensively examined the literature assessing the use of wearable technology and AI-integrated predictive models to evaluate or improve postoperative outcomes following cystectomy. Therefore, this systematic review aimed to evaluate the impact of wearable technology and AI on postoperative outcomes following radical cystectomy.

Methods

This study protocol and search strategy were preregistered on PROSPERO (CRD420261279062).[10] The systematic review was conducted and reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines.[11] The search strategy was developed using a combination of controlled vocabulary and free-text terms and was reviewed in consultation with a medical librarian; the full search strategy is provided in Appendix 1. Searches were conducted in the PubMed, Scopus, Web of Science, Embase and MEDLINE databases to identify original studies published up to 1 February 2026. In addition, the reference lists of relevant articles were manually screened to identify potentially eligible studies; this search yielded no additional studies.

All records were screened against predefined inclusion criteria. Eligible studies were original studies investigating the use of a wearable devices or AI in the postoperative recovery of patients undergoing cystectomy. No additional exclusion criteria were applied based specifically on surgical approach, including robotic cystectomy, or study design, including randomised trials. The full inclusion and exclusion criteria are provided in the supplementary materials (Appendix 1). Records were imported into EndNote, and duplicate records were removed.[12] All records were independently screened by KT and SD, with final decisions regarding study inclusion made by MF and YB.

Risk of bias (RoB)

The methodological quality and RoB of the included studies were independently assessed by two authors (KT and SD). The Risk Of Bias In Non-randomised Studies of Interventions (ROBINS-I) tool was used for observational and

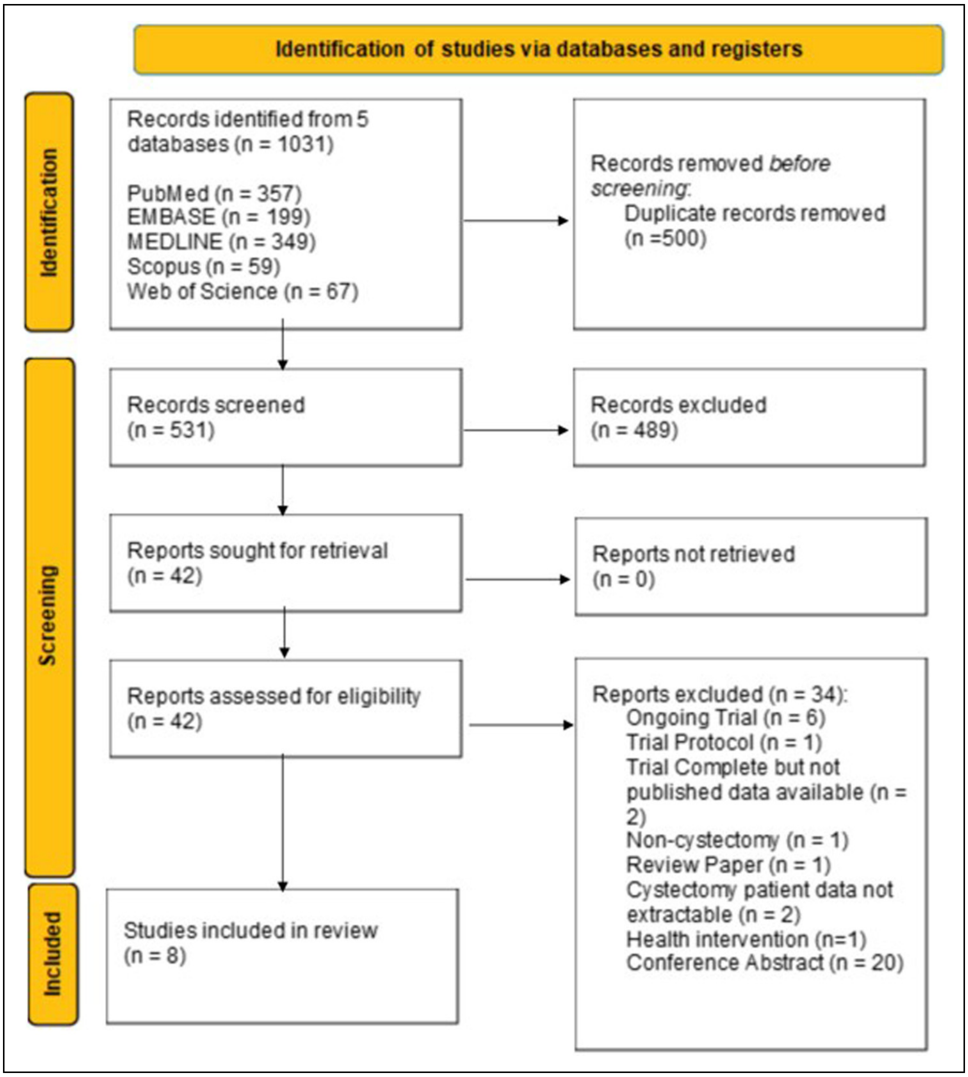

Figure 1. PRISMA flow chart of the systematic review process.
PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analyses.

retrospective studies, whereas the RoB 2 tool was used for randomised clinical trials. Disagreements between the assessors were resolved by a third author (YB).[13,14]

Data extraction and analysis

Two authors (MF and YB) independently extracted data on study design, participant number, wearable device or AI technology used, protocol duration and follow-up period, step count where applicable, length of stay (LOS), complications, readmissions, discharge location, incentives used and functional data. A meta-analysis was planned; however, it could not be conducted because of substantial heterogeneity among the included studies in terms of study design, data presentation and reporting formats. Therefore, the findings were synthesised narratively within the systematic review according to key themes shared across studies, including LOS, complications, incentives, body mass index (BMI) and functional outcomes.

Results

The systematic search identified 1031 records across PubMed, Embase, MEDLINE, Scopus and Web of Science (Figure 1). Following duplicate removal using EndNote and manual review, 531 records remained for title and abstract screening. Of these, 489 were excluded, leaving 42 records for full-text assessment.

Table 1. Summary of included studies.

Study (year)	Patients	Study design	Comparator/control	Technology and intervention
Huelster et al. (2023)[15]	17	Observational	Within-cohort analysis based on postoperative complications (single-arm feasibility study)	Garmin device + app (POSIT platform)
Khetrapal et al. (2024)[16]	308	Secondary analysis of an RCT	Within-cohort analysis	Misfit Shine
Lee D et al. (2025)[17]	61	RCT	Gamification vs. control (all wearable users)	Fitbit + gamification-based mobility intervention
Lee RS et al (2025)[18]	55	Observational	Within-cohort comparison	FitBit Alta HR
Sharma et al (2025)[19]	843	Observational	Within-cohort analysis based on body composition	AI-based CT body composition analysis
Slade et al., (2021)[20]	20	Observational	Within-cohort analysis based on postoperative complications	Garmin Vivofit
Strother et al. (2021)[21]	33	RCT	Financial incentive vs. standard care (all wearable users)	Fitbit Zip + $1.50/day and 20% chance to win $100 for >75% compliance
Zhu et al. (2023)[22]	42	Observational	Within-cohort analysis (single-arm feasibility study)	SenseWear Armband

AI: artificial intelligence; CT: computed tomography; RCT: randomised controlled trial.

Following full-text review, 34 records were excluded for the following reasons: ongoing trial (n = 6), trial protocol (n = 1), completed trial with no published data available (n = 2), non-cystectomy population (n = 1), review article (n = 1), cystectomy patient data not extractable (n = 2), non-relevant health intervention (n = 1) and conference abstract only (n = 20). Therefore, eight studies were included in the final review for data extraction (Table 1).[15–22]

One study was excluded from the systematic analysis despite including patients undergoing cystectomy because cystectomy-specific step count and physical activity data were not explicitly reported; instead, the study presented recovery data across multiple surgical specialties.[23] As noted above, a meta-analysis was not possible because of substantial heterogeneity in study designs and data reporting.

LOS and discharge location

Four studies evaluated the association between wearable-derived physical activity and LOS following radical cystectomy (Appendix 2).[16–18,21] Overall, lower postoperative activity appeared to be associated with longer hospital stays in some cohorts, although findings were inconsistent across studies. Only one study demonstrated a statistically significant association between higher step counts and shorter LOS.[16]

Specifically, Khetrapal et al. reported that every 1000-fewer postoperative steps was associated with an estimated 1.1-day increase in LOS ($p = 0.004$).[16] Furthermore, patients in the lowest postoperative step-count tertile had an approximately 2.2-day longer LOS than those in the higher tertiles ($p < 0.001$).

Lee RS et al. found no statistically significant association between LOS and step counts.[18] Patients with an LOS of less than 5 days had a higher mean daily preoperative baseline step count (6350 vs. 4526 steps/day; $p = 0.418$) and higher inpatient step count (512 vs. 392 steps/day; $p = 0.113$). However, preoperative step count was significantly associated with discharge location. Patients with a higher preoperative step count were more likely to be discharged to their home rather than to a nursing facility (5647 vs. 3764 steps/day; $p = 0.020$). Unlike the other studies included in this review, Lee RS et al. also assessed calorie expenditure. Higher median calorie expenditure was significantly associated with a shorter LOS both preoperatively (1970 vs. 2488 kcal/day; $p < 0.001$) and during inpatient recovery (1846 vs. 2066 kcal/day; $p = 0.022$). This association also extended to discharge location, with patients who had higher preoperative (2261 vs. 1678 kcal/day; $p = 0.016$) and postoperative (1966 vs. 1711 kcal/day; $p = 0.022$) calorie expenditure being more likely to be discharged home rather than to a nursing facility.

In the two studies by Lee D et al. and Strother et al., wearable-assisted strategies did not result in a notable reduction in LOS.[17,21] However, Lee D et al. reported that among patients who participated in a gamification-assisted recovery programme, 100% (8/8) were discharged to their personal residence, compared with 66.6% (10/15) in the control group. In the control group, 5/15 patients therefore required discharge to a skilled nursing or subacute rehabilitation facility.[17]

Complications and readmissions

Six studies examined the association between postoperative activity measured using wearable devices and complications or readmissions following cystectomy (Appendix 3).[15–18,20,22] Overall, lower postoperative activity was associated with poorer outcomes, although findings were inconsistent across studies. One study found a statistically significant association between higher postoperative step counts and lower odds of an adverse event (odds ratio, 0.31; $p = 0.047$), although step counts did not differ significantly between patients with and without complications.[20] Khetrapal et al. reported no association between postoperative step count and the overall complication rate throughout the study period but provided evidence of poorer outcomes among patients with lower step counts.[16] Patients with lower step counts had fewer days alive and out of hospital at 90 days ($p = 0.002$), a higher incidence of pneumonia ($p = 0.02$) and higher complication rates at 5 and 12 weeks postoperatively ($p < 0.009$). This pattern was not observed for cardiovascular complications, venous thromboembolism or death. Both Khetrapal et al. and Lee D et al. reported a statistically significant association between lower step counts and higher readmission rates.[16,17] Interestingly, patients with higher step counts were also more likely to seek medical attention within 5 weeks postoperatively ($p = 0.03$).

Other studies reported similar trends, although the evidence was less conclusive. Huelster et al. assessed complications within the first 30 days after cystectomy and reported lower mean daily distance (1311 vs. 2367 m) and daily step count (1690 vs 3092 steps) among patients who experienced adverse outcomes compared with those who did not.[15] Zhu et al. reported an adverse outcome rate of 57% within the first 90 days postoperatively; however, no statistical analysis was performed to assess the association between postoperative activity and complication rates.[22]

Incentives

Two studies evaluated wearable-assisted interventions designed to increase postoperative activity following radical cystectomy (Appendix 4).[17,21] Strother et al. evaluated a monetary incentive (US$1.50 per day when the step-count target was met), with activity monitored using a Fitbit Zip through postoperative day 30 following radical cystectomy.[21] The intervention did not significantly improve postoperative activity. The median daily step count was lower in the intervention group (979 steps) than in the non-intervention group (1191 steps), which did not receive a financial incentive ($p = 0.59$). The intervention group also had fewer days on which step-count goals were met (4.5 vs. 9.0 days; $p = 0.50$). LOS was similar between the groups ($p = 0.56$). Conversely, Lee D et al. used a text message–based gamification approach in the MoveUp trial to encourage postoperative activity following radical cystectomy.[17] The study assessed the effect of this intervention compared with standard care on daily step count and readmissions. Compared with standard care, the intervention group had higher daily step counts both preoperatively (+689 steps/day) and after discharge (+793 steps/day); however, these differences were not statistically significant ($p = 0.27$ and $p = 0.21$, respectively). The intervention group also had a lower 90-day readmission rate than the control group, although this difference did not reach statistical significance (17% vs. 35%; $p = 0.09$).

Body composition and BMI

Body composition, BMI and functional capacity measures were reported heterogeneously across six studies (Appendix 5).[16,18–22] Khetrapal et al. found no significant association between BMI and overall complication rate ($p = 0.86$), pneumonia ($p = 0.86$), venous thromboembolism (VTE; $p = 0.98$) or death ($p = 0.91$). However, higher BMI was significantly associated with cardiovascular complications following cystectomy ($p = 0.03$).[16]

Similar findings were reported in other studies examining body composition, although higher adipose tissue and lower muscle content was generally associated with higher complication rates. For example, Slade et al. found that patients who experienced adverse events after cystectomy had lower median BMI values than those who did not (22.4 vs. 27.8 kg/m^2; $p = 0.021$).[20] Sharma et al. used AI retrospectively to assess body composition in addition to BMI, including skeletal muscle index (SMI), subcutaneous adipose tissue (SAT), visceral adipose tissue (VAT), intramuscular adipose tissue (IMA) and fat mass index (FMI).[19] None of the body composition parameters was significantly associated with overall 90-day readmission or mortality. However, individual body composition measures showed distinct associations with specific postoperative complications. Higher SMI was associated with lower odds of major complications (odds ratio, 0.75; $p = 0.008$), whereas higher IMA was associated with increased odds of major complications (odds ratio, 1.93; $p = 0.008$). Higher SAT was associated with wound complications (odds ratio, 1.03; $p = 0.007$), whereas higher VAT and FMI were associated with infectious complications (odds ratio, 1.02; $p = 0.008$ and odds ratio, 1.04; $p = 0.002$, respectively). Higher FMI was also associated with wound complications (odds ratio, 1.06; $p < 0.001$).

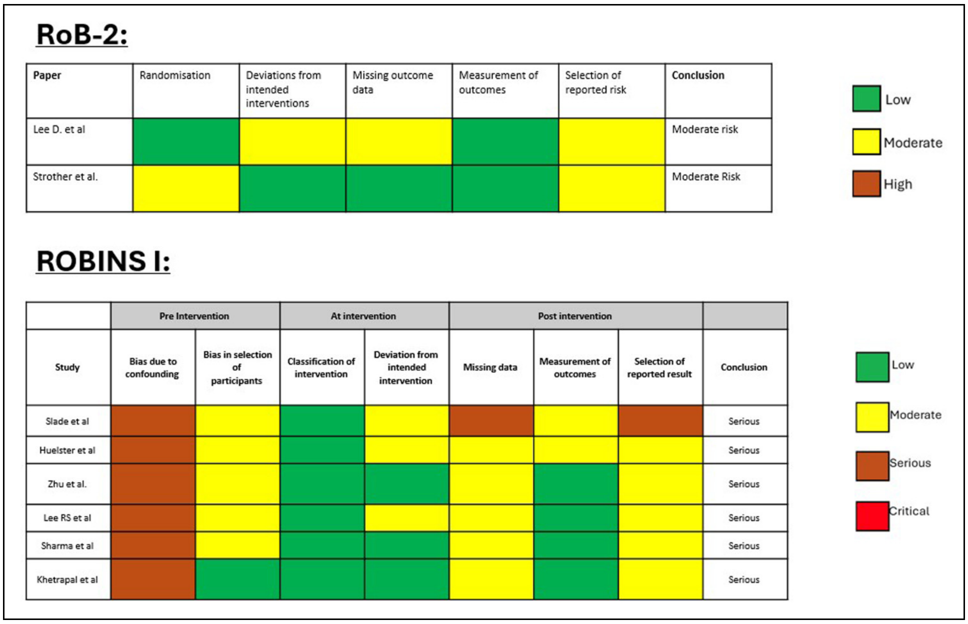

Figure 2. RoB assessment using the RoB 2 and ROBINS-I tools.
ROBINS-I: Risk Of Bias In Non-randomised Studies of Interventions; RoB: Risk of Bias.

Functional activity measures also showed some associations with recovery-related outcomes, although the evidence was limited. Khetrapal et al. reported that poorer performance on the chair-to-stand test was associated with higher rates of cardiovascular complications ($p = 0.03$) and death ($p = 0.023$), but not with the overall complication rate ($p = 0.21$).[16] Zhu et al. reported that moderate- and vigorous-intensity physical activity were associated with higher 36-Item Short Form Health Survey (SF-36) physical component scores ($p = 0.030$ and $p = 0.026$, respectively).[22] They also observed a significant reduction in moderate-intensity physical activity by postoperative day 30 ($p = 0.012$); however, there was no statistically significant difference between baseline and postoperative day 90 activity levels ($p = 0.076$). Strother et al. assessed patient-reported function and activity at 30 days and found no significant differences between the financial incentive and control groups in Health Assessment Questionnaire Disability Index (SHAQ-DI) disability scores, perceived social support or International Physical Activity Questionnaire (IPAQ)–assessed physical activity.[21]

RoB

A summary of the RoB assessment is present in Figure 2. The randomised studies, which evaluated incentive-based interventions by Lee D et al. and Strother et al., were assessed using the RoB 2 tool and were judged overall to have a moderate RoB.[17,21]

The remaining non-randomised or secondary-analysis studies, which were assessed using the ROBINS-I tool, were generally judged to have a serious RoB. This was primarily attributable to their small sample sizes and feasibility or observational designs, with several studies using single-arm designs.[15,16,18,20–22] The main concerns related to confounding and missing wearable device data, which could have resulted from poor compliance or potential data loss surrounding relevant postoperative events. Outcome measurement was considered less concerning when objective metrics were used. Patient selection was problematic across most studies, with five of six studies (83%) judged to have a moderate RoB. Deviations from intended interventions were mixed, with three of six studies (50%) rated as having a low risk and three of six (50%) as having a moderate risk. Selection of the reported result was also a concern, with one study (17%) rated as having a serious risk. Overall, these methodological limitations may reduce the reliability and generalisability of the findings.

Discussion

In urological oncology, radical cystectomy is associated with a relatively high 90-day complication rate (58.5%).[24] Despite the widespread adoption of robotic-assisted radical cystectomy and ERAS protocols, postoperative challenges such as intensive care unit (ICU) admission, prolonged hospital stay and functional deconditioning remain common. The integration of AI and wearable technology into the perioperative pathway represents a promising, although still emerging, adjunct to ERAS, with the potential to enable objective and continuous monitoring of patient recovery both in hospital and at home. As noted previously, to the best of our knowledge, two reviews have investigated the use of AI-driven wearable devices across surgical specialties and reported reductions in LOS and ICU admissions; however, neither specifically examined cystectomy-related outcomes.[5,8]

Across the eight included studies, wearable devices and AI-based tools were associated with several key outcomes, including postoperative LOS, discharge disposition and complication risk. However, the small sample sizes, heterogeneous study designs and predominantly observational evidence base preclude definitive recommendations at this stage and prevented the conduct of a methodologically rigorous meta-analysis. Therefore, the findings were synthesised narratively according to key themes relating to different postoperative outcomes.

This review included a range of wearable devices, from consumer-grade Fitbit and Misfit Shine trackers to research-grade SenseWear armbands, which captured metrics including daily step counts, calorie expenditure, heart rate and physiological stress. The technical differences between consumer-grade devices (e.g. Fitbit and Misfit Shine) and research- or medical-grade devices (e.g. SenseWear) used across the included studies are important to consider. Consumer-grade trackers are relatively inexpensive and generally well tolerated by patients; however, their step-count and calorie-expenditure algorithms have not been independently validated for the low-intensity, altered-gait movements that are typical of early postoperative recovery after cystectomy.[25] Medical-grade devices generally provide more validated and granular physiological data but are associated with greater cost and complexity, which may limit their use outside research settings. This variation in device accuracy and validation represents an important source of heterogeneity across studies and should be considered when interpreting the reliability and clinical applicability of the reported findings.

Three of the eight studies in this review were randomised controlled trials (RCTs) or secondary analysis of RCTs.[16,17,21] In the context of wearable devices and postoperative recovery following cystectomy, the authors consider the MOVEUP study conducted in the United States and the iROC trial conducted across nine UK cancer centres to provide the strongest available evidence.[16,17,26] The iROC trial directly investigated step count in a cystectomy population using prospectively tracked wrist-worn activity data from Misfit Shine devices in 308 participants at 5 time points over 26 weeks. Interestingly, reduced step count was not associated with the overall postoperative complication rate, which contrasts with findings from studies in colorectal and hepatobiliary surgery.[27,28] Nevertheless, the iROC trial found that reduced step count was associated with higher rates of postoperative pneumonia, days alive and outside hospital outcomes at 90 days (DAOH90), complications at postoperative weeks 5 and 12 and presentations to medical professionals following surgery.[16] The MOVEUP trial was a single-centre study investigating a gamification-based wearable intervention after cystectomy and reported that patients using the wearable intervention returned to their preoperative baseline step count by week 5, compared with week 12 among patients in the control group.[17]

Step count and complication risk

The relationship between physical activity and postoperative complications was a recurring theme across the included studies, although most studies did not demonstrate a statistically significant independent association. Zhu et al. found no significant associations between patient demographic or surgical characteristics and daily step counts at postoperative day (POD) 30. They also reported that steps at POD90 (3000 steps/day) remained significantly below baseline levels (3900 steps/day; $p = 0.013$).[22] Slade et al. similarly found no significant associations between heart rate ($p = 0.22$) or sleep duration ($p = 0.47$) and overall complication incidence.[20]

The clearest evidence linking step count with complication risk comes from the subanalysis by Khetrapal et al.[16] Patients who developed any complication after radical cystectomy (RC) had consistently lower step counts at postoperative weeks 5 ($p = 0.009$) and 12 ($p = 0.005$) than those who did not develop complications. The authors also used the baseline 30-s chair-to-stand (CTS) test as a marker of functional capacity alongside step-count data and identified associations between functional capacity and postoperative cardiovascular adverse events ($p = 0.03$) and death ($p = 0.023$). These findings suggest that functional capacity measures provide greater value than raw step counts for risk stratification. This is further supported by Zhu et al., who reported significantly higher SF-36 physical component scores among patients with metabolic equivalent of task (MET) scores >3 ($p = 0.026$ and $p = 0.030$). They also reported a 7.3-unit reduction in Charlson Comorbitidity Index scores among patients with MET scores >1.5, although this association was not statistically significant ($p = 0.24$).[22] In a secondary analysis of the iROC trial, pneumonia occurred more frequently among patients with lower step counts, consistent with the recognised association between postoperative immobility and pulmonary atelectasis.[16] These detailed analyses by complication type provide some of the most informative evidence currently available in the literature.

Activity, discharge disposition and LOS

Lee RS et al. prospectively monitored Fitbit Alta HR devices in 55 patients undergoing RC at a tertiary centre.[18] Patients discharged to a nursing facility had significantly lower preoperative daily step counts than those discharged home (3760 vs. 5650 steps/day; $p = 0.02$) as well as lower preoperative calorie expenditure (1678 vs. 2261 kcal; $p = 0.016$). Prolonged LOS ($\geq$5 days) was associated with lower preoperative calorie expenditure (1970 vs. 2490 kcal; $p = 0.001$) and lower inpatient calorie expenditure (1850 vs. 2070 kcal; $p = 0.009$). Patients who underwent neobladder (NB) reconstruction had significantly higher preoperative ambulation than those who received an ileal conduit (IC) (6060 vs. 4430 daily steps; $p = 0.02$), whereas patients discharged to a nursing facility had significantly lower preoperative step counts than those discharged home (both $p < 0.05$).[18] Although this finding may reflect selection bias, as patients receiving an IC tend to be older and have more baseline comorbidities, it raises the possibility that wearable-derived metrics could inform preoperative counselling regarding diversion type and anticipated discharge needs. The MOVEUP RCT similarly demonstrated that no intervention patients were discharged to skilled nursing facilities, compared with five patients in the control group, although this difference did not reach statistical significance in the small pilot sample.[17]

The role of incentives and gamification

Efforts to modify postoperative behaviour through wearable-integrated incentive programmes have produced mixed results. Strother et al. (2021), the only RCT specifically examining financial incentives in this population, found no statistically significant increase in step-count goal attainment with daily monetary rewards (US$1.50/day plus a 20% chance of a US$100 bonus) compared with standard care (median, 4.5 vs. 9 days meeting goals; $p = 0.53$).[21] Interestingly, the control group numerically outperformed the incentive group, suggesting that modest financial rewards are insufficient to overcome the physical and motivational barriers encountered during the immediate postoperative period after cystectomy. However, the limited value of a small monetary incentive such as US$1.50/day should also be considered, as the reward may not be sufficiently meaningful to motivate behavioural change in some patients. This interpretation is consistent with the qualitative findings reported by Strother et al., which identified surgical pain, restrictions imposed by medical devices, cognitive burden and preoccupation with a cancer diagnosis as barriers that may not be overcome by small financial incentives.

It would be interesting to determine whether larger financial rewards could more effectively encourage participants to meet target step counts. However, obtaining ethical approval for a study of this nature and implementing such an intervention within healthcare systems that often face financial constraints may be challenging. These considerations could ultimately limit the real-world applicability of findings derived from interventions involving substantial monetary incentives. Nevertheless, previous trials have demonstrated significant improvements in weight loss and smoking cessation using similar financial incentive schemes.[28,29]

Gamification, however, appears more promising. The MOVEUP RCT randomised 61 patients to a text message–based mobility game with a support partner or standard care.[17] Although the primary outcome, the increase in daily in-hospital step count, was not statistically significant (adjusted difference, 689 steps; $p = 0.27$), the intervention group demonstrated a faster recovery trajectory. Participants in the intervention group returned to their preoperative baseline step count by week 5 after discharge and continued to increase their activity thereafter, whereas those in the control group had not returned to baseline by week 12. The intervention group also had a numerically lower 90-day readmission rate than the control group (17% vs. 35%; $p = 0.09$), although this difference did not reach statistical significance, potentially owing to the small sample size. These findings suggest clinically meaningful benefits that warrant further evaluation in a larger, adequately powered RCT. Unlike financial incentives, gamified approaches in our review appeared to have a more tangible impact on patients recovering from cystectomy. They may also offer a more practical approach to promoting enhanced recovery without requiring hospitals to provide direct financial rewards for achieving activity goals, an approach that raises several ethical considerations. Furthermore, social motivation strategies have been shown to improve step counts and may be less costly and more sustainable to implement than financial incentive schemes.[29]

Preoperative body composition and AI

Sharma et al. represent the AI component of this review's evidence base, using a validated convolutional neural network to automate CT-based body composition analysis in 843 patients undergoing RC.[19] Higher preoperative SMI was independently associated with lower odds of major complications (odds ratio, 0.75 per 10 cm^2; $p = 0.008$), whereas higher IMA and FMI were associated with increased risks of major, wound and infectious complications. BMI explained only 20% of the variance in SMI, further highlighting the limitations of BMI alone as a preoperative risk-stratification tool. The AI algorithm completed segmentation in less than 1 s per scan, compared with approximately 15 min for manual segmentation, demonstrating potential for clinical scalability. This approach could potentially be integrated with wearable-derived prehabilitation metrics to generate individualised preoperative risk profiles and identify patients at greater risk of major postoperative complications. Such an approach could theoretically support more targeted allocation of limited hospital resources, including high-dependency and ICU beds, while complementing established evidence-based enhanced recovery programmes. However, prospective studies are needed to determine whether integrating AI-derived body composition measures with wearable-derived activity data improves clinical outcomes and resource utilisation.

Limitations and future directions

This review has several important limitations. The included studies were heterogeneous in terms of wearable device type, follow-up duration, outcome definitions and patient populations, precluding a formal meta-analysis. The available evidence was therefore limited to narrative synthesis, restricting the strength of the conclusions that can be drawn. Similar heterogeneity preventing meta-analysis has also been reported in previous reviews of AI- and wearable device–based interventions.[8] Furthermore, the lack of defined control groups and the frequent use of within-cohort comparisons weaken the overall evidence base because of the substantial RoB identified across the observational studies using the ROBINS-I tool.

Nevertheless, the existing conference literature and clinical trial registries contain several promising but unpublished studies examining wearable-integrated ERAS pathways in cystectomy, including remote monitoring programmes after discharge. These studies were excluded from the present review in accordance with the prespecified eligibility criteria because insufficient data were available for synthesis.[30–37] Taken together, although the current evidence is insufficient to support definitive clinical recommendations, it identifies wearable-derived postoperative step counts and AI-based body composition analysis as biologically plausible and technically feasible adjuncts to ERAS in patients undergoing RC. Future research should prioritise the development of standardised, validated outcome measures and common wearable-derived endpoints (e.g. step-count thresholds and activity-intensity metrics) to facilitate comparison and pooling of data across studies.[38] Adequately powered, multicentre RCTs are also needed to validate the preliminary associations identified in this review and establish causal relationships between wearable-derived activity, AI-based risk prediction and postoperative outcomes.

Looking ahead, multimodal AI approaches that integrate wearable-derived activity data with imaging, laboratory parameters and electronic health record data may offer substantial potential for individualised perioperative risk prediction. Combining these complementary data streams could enable more accurate and dynamic risk stratification than any single modality alone, potentially supporting more personalised ERAS pathways. Similar multimodal AI approaches are increasingly being explored in other areas of urological oncology, including the integration of AI into robotic surgery for genitourinary cancers.[39]

Beyond the methodological limitations of the current evidence base, several practical barriers may limit the routine integration of wearable technology and AI into ERAS pathways. Patient adherence remains variable, particularly among older or unwell patients who may find continuous device use burdensome during the early postoperative period. Cost-effectiveness has not been formally evaluated in this population, and the resources required for device provision, data monitoring and staff training may be difficult to justify in the absence of demonstrated clinical benefit. Interoperability between wearable platforms and existing electronic health record and hospital information technology (IT) systems is also limited, often requiring manual data transfer that reduces the feasibility of large-scale implementation.[40] Finally, the continuous collection of physiological and activity data raises important data privacy and governance considerations that will need to be addressed before widespread clinical adoption.

Conclusion

Preliminary evidence suggests that the use of wearable devices following cystectomy help patients return to preoperative activity levels and step counts sooner and may be associated with shorter hospital stays and lower complication rates through increased postoperative activity. There is also emerging evidence that AI-based assessment of body composition beyond simple measures such as BMI may help clinicians identify patients at greater risk of postoperative complications and could therefore support preoperative risk stratification. However, substantial heterogeneity across studies, a high RoB and the frequent use of within-cohort analyses rather than independent, prespecified control groups limit the strength of the current evidence. Before wearable devices and AI are routinely integrated into established ERAS protocols, further high-quality RCTs are needed to establish their clinical effectiveness and inform implementation.

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MF and NV developed the study protocol. MF, YB and BA contributed to manuscript preparation. MF and YB performed data extraction. YB, SD and KT conducted the risk-of-bias assessment. NR, KT, YP, RO, MM, PK, JC, JK, MC and NV contributed to manuscript editing and review.

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Data availability statement

All data generated or analysed in this study are included in the manuscript and supplementary files.

Supplemental material

Supplemental material for this article is available online.

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