Effects of Telerehabilitation on Functional and Other Health-Related Outcomes in Colorectal Cancer Patients and Survivors: A Systematic Review and Meta-Analysis

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Abstract

Background: Colorectal cancer is the third commonest cancer worldwide, and its prevalence is increasing. Cancer rehabilitation plays a crucial role in patients with treatment-related complications, but its efficacy is often limited by logistical barriers and patient preferences. Telerehabilitation has emerged as a promising alternative to conventional rehabilitation.

Objective: This systematic review and meta-analysis evaluated the effects of telerehabilitation interventions on functional and health-related outcomes, and physical activity levels in individuals diagnosed with colorectal cancer.

Methods: A systematic literature search, adhering to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines, was performed from inception to September 11, 2024. The search encompassed PubMed, Embase, and CINAHL electronic databases. The methodological quality of included studies was evaluated using the Cochrane Risk of Bias Tool 2.0 (RoB 2). Quantitative synthesis, employing meta-analysis, was conducted utilizing Cochrane Review Manager software (RevMan 5.4).

Results: Eleven randomized control trials (RCTs) with total 844 participants were included in this analysis. The mean participant age was 58 years. Telemonitoring using pedometer or accelerometer was the commonest intervention used. Variation in intervention designs preclude the identification of most effective telerehabilitation program. Meta-analysis showed that telerehabilitation improved quality of life (QoL) more than control (Standard Mean Difference [SMD] = 0.33; 95% confidence interval [CI] = 0.01 to 0.64; p = 0.04; I2 = 14%). However, there was no significant difference in physical function, physical activity, fatigue, and depression between the telerehabilitation group and the control group.

Conclusions: Telerehabilitation significantly enhances the quality of life of colorectal cancer survivors. Heterogeneity in intervention designs, outcome measures, along with potential biases, hinder its impact on physical function. Given the safety and feasibility of telerehabilitation, more future robust study is needed to confirm its potential benefits for colorectal cancer patients.
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Introduction

Colorectal cancer (CRC) represents the third most prevalent malignancy globally, affecting both male and female populations. In 2022, an estimated 1,926,425 new cases were diagnosed (9.6% of all new cancer diagnoses), with 904,019 CRC-related deaths reported [1]. Projections indicate a continued upward trajectory in CRC incidence, with estimates suggesting approximately 3.2 million new cases by 2040 [2]. Disease stage at diagnosis is a critical prognostic factor for CRC, with early-stage detection associated with significantly improved survival outcomes [3]. Specifically, the 5-year survival rate for localized CRC exceeds 90% [4]. The implementation of CRC screening programs has facilitated early disease detection, contributing to a reduction in CRC-related mortality [5]. Furthermore, advancements in targeted therapies have demonstrated improvements in CRC survival rates [6, 7]. However, despite these advancements, CRC patients and survivors frequently report diminished quality of life (QOL), encompassing both physical and psychological domains, with younger individuals experiencing a disproportionately greater impact compared to older patients [8, 9].

Treatment modalities for colorectal cancer (CRC) encompass surgical intervention, systemic chemotherapy, and radiation therapy. Both CRC itself and its associated therapies contribute to adverse effects in patients and survivors. Oxaliplatin-based chemotherapy regimens represent a standard approach for CRC management. Oxaliplatin, a platinum-based alkylating agent, is recognized for its dose-limiting neurotoxicity. Chronic oxaliplatin-induced peripheral neuropathy commonly manifests following cumulative doses exceeding 540 mg/m² [10]. Similarly, fluorouracil (5-FU), a pyrimidine analogue, is associated with cardiotoxicity, with reported incidence rates ranging from 1.2% to 18% [11]. Additional complications reported by CRC patients include cancer-related fatigue (CRF), with a prevalence of 52% [12], cognitive impairment (45%) [12], anxiety (31%) [13], depression (55%) [13], and diminished physical fitness and endurance [14]. These sequelae collectively contribute to a reduction in quality of life (QOL) among CRC patients and survivors [15]. The presence of psychological stress and CRF has been associated with delays in returning to work post-treatment [16]. Furthermore, CRC survivors exhibit a 1.56-fold increased risk of paid employment loss due to work disability compared to the general population [17]. These findings underscore the significant impact of CRC and its treatment, highlighting the critical need for comprehensive rehabilitation strategies in this patient population.

A systematic review examining the effects of exercise in colorectal cancer (CRC) patients and survivors demonstrated improvements in physical strength, aerobic fitness, cancer-related fatigue (CRF), depression, quality of life (QOL), and sleep [18]. Furthermore, studies have indicated that exercise interventions can enhance strength and balance in patients experiencing chemotherapy-induced peripheral neuropathy [19]. CRC patients and survivors have demonstrated receptiveness to exercise programs. Singh et al. [18] reported a low withdrawal rate (12%) and a high exercise adherence rate (86%), establishing the feasibility of exercise interventions in this population. In addition to enhancing functional outcomes, increased physical activity has been associated with a reduced mortality risk among CRC survivors, with a hazard ratio of 0.79 per metabolic equivalent task-hour/week [20]. Despite the established safety and benefits of exercise for CRC patients, participation in cancer rehabilitation remains suboptimal. Identified barriers include limited accessibility to facility-based exercise programs, associated costs, and patient preference for home-based physical activity over gym- or facility-based interventions [21, 22]. Telerehabilitation presents a potential solution to mitigate these barriers.

Telerehabilitation is defined as the utilization of Information and Communication Technologies (ICT) to deliver rehabilitation services remotely to individuals in their home or other environments [23]. The advancement of digital communication technologies has facilitated the delivery of telerehabilitation via various modalities, including telephone, videoconferencing, internet platforms, and wearable devices incorporating sensor and remote monitoring capabilities. Telerehabilitation has demonstrated efficacy across diverse disease populations and is recommended by the European Union of Medical Specialists in Physical and Rehabilitation Medicine (UEMS PRM) in their recently published evidence-based position paper. The UEMS PRM recommends that rehabilitation physicians prescribe telerehabilitation within cancer rehabilitation protocols [24]. Batalik et al. [25] reported that telerehabilitation improved cardiorespiratory fitness and reduced fatigue; however, the study population comprised predominantly female participants, with a majority of breast cancer patients or survivors. Peng et al. [26] reported similar findings in a breast cancer population. Nevertheless, the specific effects of telerehabilitation in colorectal cancer (CRC) patients and survivors have not been investigated separately. Therefore, this systematic review aims to evaluate the impacts of telerehabilitation on functional and other health-related outcomes, as well as physical activity, among CRC patients and survivors. Furthermore, this review will assess the feasibility of telerehabilitation in this patient population.

Methodology

Protocol and registration

A comprehensive literature search was conducted adhering to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) Guideline 2020 [27]. The review protocol was registered in the Prospective Register of Systematic Reviews (PROSPERO) registry (PROSPERO ID: CRD42024584711).

Eligibility criteria

The eligibility criteria were defined using the Population, Intervention, Comparison, Outcome, and Study design (PICOS) framework. The inclusion criteria were as follows:

Population (P): Patients diagnosed with colorectal cancer (CRC), including individuals undergoing active cancer treatment (e.g., chemotherapy, radiation therapy, immunotherapy, hormonal therapy) and those who had completed treatment.

Intervention (I): Telerehabilitation interventions, defined as physical rehabilitation programs delivered via Information and Communication Technologies (ICT), including telephone, smartphone applications, virtual or online platforms, and wearable sensor-based technologies.

Comparison (C): A control comparator group receiving conventional treatment, such as face-to-face rehabilitation or standard care.

Outcomes (O): Reported outcomes pertaining to functional fitness, physical activity levels, quality of life (QOL), and psychological well-being.

Study design (S): Randomized controlled trials (RCTs) involving participants aged 18 years or older.

The exclusion criteria were:

1.Studies presented solely as conference proceedings, poster abstracts, case reports, or study protocols.

2.Animal studies.

Search methods

A systematic literature search was conducted from inception to September 11, 2024, utilizing the electronic databases PubMed, Embase, and CINAHL. The search strategy was designed to identify English-language studies involving human participants. No limitations were imposed regarding the publication period. Duplicate records were identified and subsequently removed. Two independent reviewers (YH and FQ) performed a manual screening of titles and abstracts to assess article relevance. Following this initial screening, full-text articles were evaluated against the predetermined inclusion criteria. Discrepancies in article selection were resolved through consensus, with a third reviewer (SS) consulted to adjudicate unresolved disagreements. Authors of included studies were contacted to request supplementary information or raw data when necessary.

The search strategy incorporated the following keyword string: (cancer OR malignancy OR tumour OR neoplasm OR tumor OR carcinoma) AND (Colorectal OR colon OR rectum) AND (rehabilitation OR rehab OR exercise OR physical therapy) AND (technology OR digital OR virtual OR robotics OR mHealth OR eHealth OR mobile OR tele*).

Study quality and risk of bias

The methodological quality of included studies was independently assessed by two researchers (YH and FQ) utilizing the Cochrane Risk of Bias Tool 2.0 (RoB 2) [28]. Study quality was evaluated across five domains: selection bias, performance bias, detection bias, attrition bias, and reporting bias. Each domain was categorized as exhibiting ‘low risk of bias’, ‘high risk of bias’, or ‘some concerns’.

Outcome measures

The primary outcome of interest was physical function (such as the 6-minute walk test [6MWT]). Secondary outcomes included physical activity levels, assessed using instruments such as the 7-Day Physical Activity Recall (PAR), Godin Leisure-Time Exercise Questionnaire (GLTEQ), duration of moderate- to vigorous-intensity physical activity (MVPA), duration of 10-minute bouts of moderate-intensity physical activity, International Physical Activity Questionnaire (IPAQ), and step count. Quality of life (QOL) was evaluated utilizing tools including the European Organisation for Research and Treatment of Cancer Quality of Life Questionnaire (EORTC-QLQ-C30), Functional Assessment of Cancer Therapy-Colorectal (FACT-C), FACT-Fatigue (FACT-F), Functional Assessment of Chronic Illness Therapy-Fatigue Scale (FACIT-FS), and the 36-Item Short Form Health Survey (SF-36). Psychological outcomes were assessed using the Patient Health Questionnaire (PHQ) and the National Comprehensive Cancer Network (NCCN) Distress Thermometer. Feasibility outcomes, including adherence rates, intervention completion rates, service satisfaction, and adverse events, were analysed where data were available.

Data analysis

Statistical analyses and meta-analyses were conducted by two researchers (YH and FQ) utilizing RevMan 5.4, the Cochrane software review manager [29]. For studies incorporating mixed cancer diagnoses or presenting incomplete data, corresponding authors were contacted via email to request raw data, with one-month response period allotted.

The overall effect size was estimated using mean difference (MD) and 95% confidence intervals (CI) for studies employing identical measurement tools. For studies utilizing disparate measurement tools, standardized mean difference (SMD) was employed. The data point for meta-analysis of process outcomes was standardized to a 12-week time frame. Random-effects models were selected to account for anticipated clinical and methodological heterogeneity across trials, particularly when comparing diverse telerehabilitation interventions against a common comparator group (e.g., usual care, waiting list).

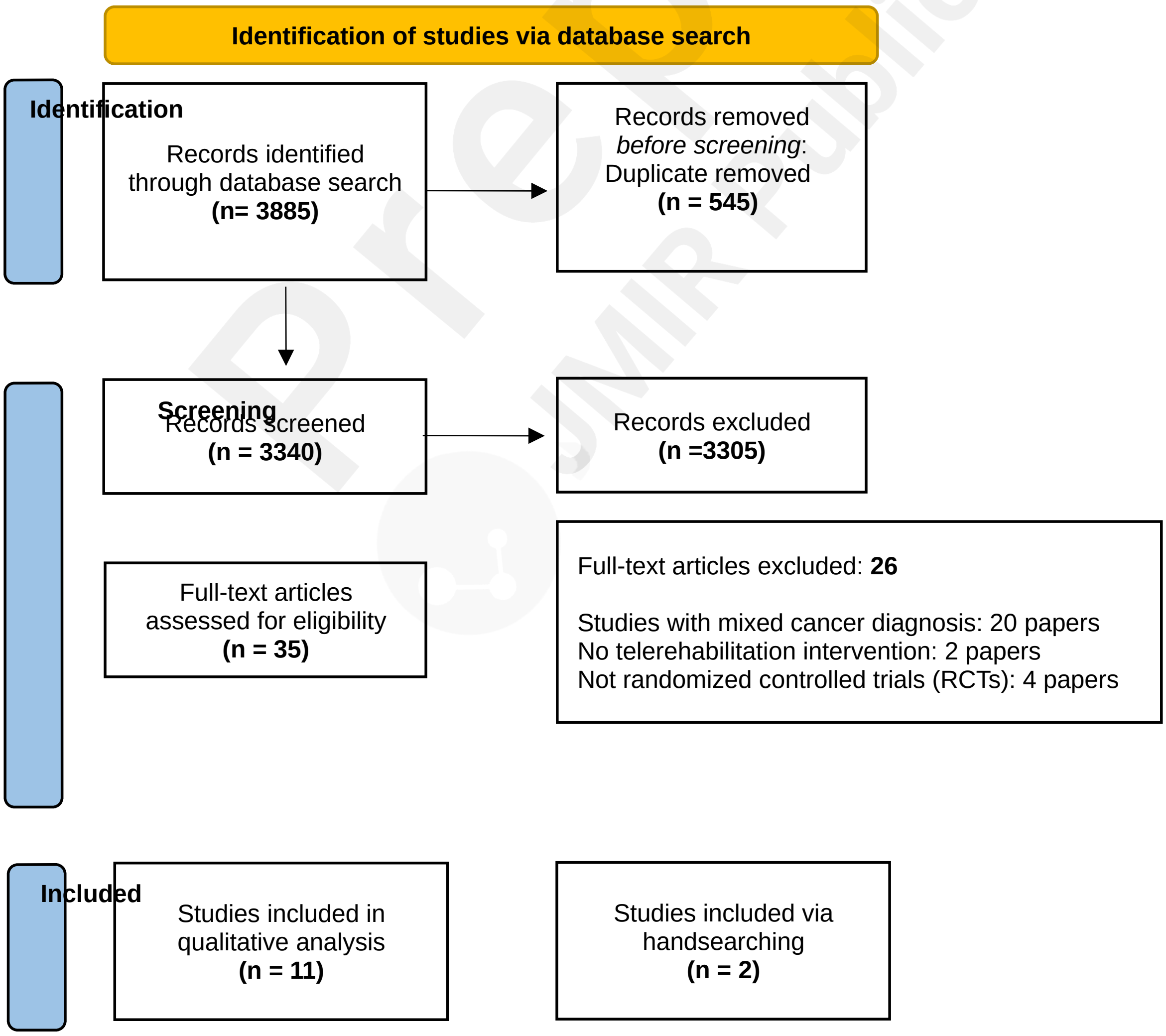
Where feasible and when outcome data were not directly reported, MD and standard deviation (SD) were estimated from the standard error (SE) of the mean or median and interquartile range using a web-based meta-analysis accelerator calculator [30]. In studies lacking reported correlation coefficients, a correlation coefficient of 0.2, representing the minimum clinically important correlation, was imputed for mean change estimation. Forest plots were generated to visualize the pooled effect sizes. Heterogeneity was quantified using the I^2 statistic and categorized as follows: low ($I^2 < 25\%$), moderate ($25\% \leq I^2 \leq 50\%$), and high ($I^2 > 50\%$).

Results

Study screening and selection

The initial literature search yielded 3885 records. Following the removal of 545 duplicates, 3340 records underwent screening based on titles and abstracts. Of these, 3305 records were excluded as they did not meet the pre-specified inclusion criteria. Full-text reviews were conducted for 35 records. Eighteen studies were subsequently excluded due to mixed cancer diagnoses within their study populations, where subgroup analyses were unavailable despite contacting the corresponding authors. Nine randomized controlled trials (RCTs) [31-39] were included. Additionally, 2 eligible studies were identified through handsearching reference lists, resulting in a final inclusion of 11 RCTs [40, 41]. The study selection process is depicted in a PRISMA 2020 flow diagram (Figure 1).

Figure 1 – PRISMA flow diagram



Characteristics of the included studies

The publication years of the 11 included randomized controlled trials (RCTs) ranged from 2013 to 2024. A total of 844 adult participants (50.36% female) with a diagnosis of colorectal cancer were investigated, with 422 participants allocated to the intervention group. The mean age of 779 participants (92.30%) was 58 years. All trials employed a two-arm parallel design.

Intervention characteristics

The telerehabilitation programs exhibited substantial heterogeneity. One trial was conducted in an inpatient setting [33], while the remaining trials were conducted in community or home settings. Telemonitoring, utilizing either pedometers or accelerometers, was the most prevalent telerehabilitation intervention, implemented in 8 RCTs (n = 706) [31, 32, 34, 35, 36, 39, 40, 41]. Telecoaching was incorporated into the intervention protocols of 7 trials (n = 590) [33, 35, 36, 37, 38, 40, 41].

The duration of telerehabilitation interventions varied from 6 weeks to 6 months. A 12-week program duration was most common, as observed in 6 studies [31, 32, 34, 35, 37, 40], while 2 trials employed 6-week programs [38, 41]. Adherence to telerehabilitation programs exceeding 12 weeks was a primary concern. Mayer et al. [36] reported a decline in adherence rates throughout the study period, with a plateau observed from weeks 5 to 24.

Short message service (SMS) or text messaging was the most frequently utilized interface for telerehabilitation delivery, employed in 5 trials (n = 269) [31, 34, 35, 40, 41]. This was followed by telephone calls and smartphone mobile applications, each utilized in 3 trials (telephone calls: n = 189 [32, 40, 41]; mobile applications: n = 360 [36, 37, 38]). Exercise videos were used in 2 trials (n = 143) [40, 41]. In one study [31], participants in the intervention group were provided with a list of home-based exercise videos and a smartphone application, without further instruction or detailed description from the authors. Schrempf et al. [33] utilized immersive virtual reality (VR)-based, activity-promoting games as the intervention.

Five trials prescribed exercises, specifying aerobic and resistance exercises [32, 36, 38, 40, 41], with 3 of these trials incorporating exercise progression (intensity or duration) [32, 40, 41]. Two trials emphasized the adoption of an active lifestyle and encouraged participants to increase physical activity without specific exercise prescriptions [34, 39].

Characteristics of the included trials are detailed in Table 1.

Table 1 – Summary of included studies

er; ntry	**Sample Size; Gender**	**Type of Study; Mode of Delivery**	**Intervention**	**Feasibility / Outcome Measures**	**Results**
an igan al. 22); SA 1]	N = 44; 19 Male; TG* = 22	2-arm RCT, non-blinded; Accelerometer, SMS, exercise applications and videos.	**TG:** 12-week duration. Daily automated encouragement SMS. Target 150mins/week of MVPA. Printed booklet about PA after cancer, a list of home-based exercise apps and videos. **CG:** Usual care with printed booklet about PA after cancer.	**Primary outcomes:** adherence, self-assessed acceptability **Secondary outcomes:** MVPA, 6MWT	TG: Weight loss (mean changes -0.8kg) VS. stable weight in CG (mean changes +0.1kg) Decreased MVPA and increased 6MWT in both TG and CG. P-value not reported. Completion rate: 91%. Compliance rate: 79.37%. No serious adverse events related to the intervention. Fatigue was the most reported non-serious adverse event during enrolment, but it did not increase during the intervention period.
o at l. 13); SA 2]	N = 46; 20 Male; TG = 20	2-arm RCT, single-blinded (assessor); Accelerometer	**TG:** 12-week duration. Home-based moderate-intensity PA program, gradually increased from 10min/day at least 2days/week to 30min/day at least 5days/week. Weekly phone PA	**Primary outcomes:** 7-day PAR, CHAMPS, 1-mile Treadwalk test	TG: Increased 7-day PAR (d=1.93, P= 0.021) and energy expenditure (d=0.84, P=0.009), but effect attenuated at follow up. Increased VO2 peak at the end of study (d=0.37. P=0.017), and effect maintained at 6 months

		, telephone.	counselling. **CG:** Usual care. Weekly phone call with Symptom Questionnaire.	**Secondary outcomes:** FACT-F, SF-36 PF, FACT-C	(d=0.38. P=0.017) and 12 months follow up. (d=0.49, P=0.002). No significant differences in fatigue, self-reported physical functioning, and QoL at 3, 6, and 12 months.
rem t al. 23); man / 3]	N = 62; 37 Male; TG = 31	2-arm RCT; single-blinded (assessor); Immersive Virtual Reality (VR).	**TG:** Inpatient setting, from post-operative day 1 till discharge. 30-min of VR-based fitness session on weekdays in addition to standard physiotherapy. **CG:** Standard physiotherapy	**Primary outcomes:** Feasibility **Secondary outcomes:** Peri-operative surgical outcomes, LOS, EQ-5D-5L, NCCN Distress Thermometer, EORTC	TG: Improved overall mood (mean difference 0.76, P<0.001) No significant difference in LOS, surgical outcomes, health status, and measures of distress between groups. Participation rate: 71%. Compliance rate: 83%. No adverse events.
n et l. 22) SA 4]	N = 41; 17 Male; TG = 20	2-arm RCT; non-blinded Accelerometer, SMS	**TG:** 12-week duration. Daily motivational SMS. **CG:** Usual care.	**Primary outcomes:** FACT-C **Secondary outcomes:** Physical activity	TG: increased FACT-C functional wellbeing at 12-week from baseline (Mean difference 2, P= 0.02), and compared with control group (effect 2.2, P=0.05) No significant change in SF-36.
an igan al. 19); SA 5]	N = 41; 17 Male; TG = 20	2-arm RCT; non-blinded Accelerometer, SMS	**TG:** 12-week duration. Daily SMS to counsel participants to build up to target PA level (150 min/week of moderate PA or 75 min/week of vigorous PA, and 2-3 times/week of resistance exercise.) **CG:** Printed educational materials about PA after cancer.	**Primary outcomes:** Feasibility, acceptability, MVPA **Secondary outcomes:** Satisfaction with the intervention (14-item questionnaire), adverse events	Accelerometer adherence rate: 88% SMS response rate: 74% Attrition rate: 5% in TG VS 10% in CG Satisfaction rate: 88% No significant difference of MVPA and step counts in TG and CG at 12 weeks No serious adverse events reported. Non-serious adverse events potentially related to physical activity were reported, such as low back pain, knee pain, and fatigue, but these were similar between TG and CG.
er et l. 18); SA 6]	N = 284; 139 Male; TG = 144	2-arm RCT; single-blinded Smartphone app, pedometer	**TG:** 6-month duration. Printed educational material, pedometer, and access to SurvivorCHESS mobile app. (Tracks PA, set goal, provide social support, tools and information on coping and adapt to life after cancer, coaching (send motivational messages, answer common fitness questions, provides exercise videos)) **CG:** Printed educational material, pedometer, usual care	**Primary outcomes:** MVPA, GLTPAQ **Secondary outcomes:** FACT-C, NCCN Distress Tool, adherence	TG: Higher mean GLTEQ at 6 months compared with CG (31.4267 VS 25.5090, P=0.045). No difference between 2 groups at 9 months. No significant change in MVPA, FACT-C and distress in both groups, at 6 months and 9 months. Adherence rate was greatest in first week, and declined over 6 months of the study. No injury reported.
ck- erso t al. 18); mar k 7]	N = 42; 21 Male; TG = 20	2-arm RCT; single-blinded (assessor) Smartphone app.	**TG:** 12-week duration. InterWalk application-delivered interval-walking exercise program, targeting total 150min/week. **CG:** Wait-and-see. Usual care during first 12-week (control period), followed by 12-week intervention period.	**Primary outcomes:** change in VO2peak using stationary bicycle. **Secondary outcomes:** feasibility, FACT-C, PSQI, exercise motivation (BREQ-2)	Adherence rate above 75%
ang al. 24); rea 8]	N = 34; 21 Male, TG = 17	2-arm RCT; single-blinded (assessor) Smartphone app.	**TG:** 6-week duration. App-based physical activity program (types and methods of exercises, exercise goals, exercise reminder, self-monitoring on exercise time). Exercise counselling (exercise precautions, recommended exercise times and instruction on how to maintain exercise diary) **CG:** Printed educational booklet	**Primary outcomes:** Peripheral neuropathy symptoms, interference with activities, QoL **Secondary outcomes:** adherence	TG: Improved QoL (F=7.65, P=.003); reduced peripheral neuropathy symptoms (F=8.93, P=.002); reduced interference with activities (Z= −2.55, P= .011). Higher median intervention adherence score in the TG at 1 to 4-week (Z= −2.10, P=.026), 5 to 6-week (Z= −4.02, P<.001), and 1 to 6-weekn (Z= −3.40, P=.001).

			(comprise a section about peripheral neuropathy and exercise guide for alleviating symptoms of peripheral neuropathy with exercise pictures and exercise diary) and exercise counselling (exercise precautions, recommended exercise times and instruction on how to maintain exercise diary)		
o et l. 24); wan 9]	N = 107; 58 Male; TG = 53	2-arm RCT; non-blinded Pedometer	**TG:** 7-day before surgery to 3-month after discharge from hospital. Participants were contacted by telephone if no data was available for more than 7 days. **CG:** Usual care.	**Primary outcomes:** compliance rate **Secondary outcomes:** weekly step counts, LOS	Compliance rate: 72.6% Weekly step counts of less than 4000 or more than 10,000 in the first postoperative week were negatively associated with a longer postoperative LOS (β = −2.874, p = 0.038). No significant difference in terms of surgical procedure, postoperative recovery parameters, complications, and 30-day readmission rates between 2 groups.
n et l. 18); ea 0]	N = 71; 35 Male; TG = 37	2-arm RCT; non-blinded Exercise DVDs, SMS, telephone, pedometer	**TG:** 12-week duration. First 6 weeks used moderate-intensity exercise DVD (contain 3 sets of 7 core and resistance exercises), aimed 18 metabolic equivalent of task (MET)-hours/week. The following 6 weeks used vigorous-intensity exercise DVD (3 sets of 5 aerobic and resistance combined exercises), target 27 MET-hours/week. Daily SMS to check whether participants completed their exercise. Weekly phone counsel or small group training sessions to reinforce, answer questions/problems related to exercise. **CG:** Usual care.	**Primary outcomes:** FACT-C **Secondary outcomes:** FACIT-FS, PHQ, GLTEQ	TG: Significant improvement in FACT-C (p=0.024) and FACIT-FS (mean change +2.7, P=0.011) compared to baseline. Significant increase in MVPA levels compared to the control group (mean change 235.6min VS 16.3min, p=0.001), and increased total PA from baseline (mean change 235.6min, P<0.001) No significant change in PHQ scores in both groups
e et l. 18); ea 1]	N = 72; 35 Male; TG = 38	2-arm RCT; non-blinded Exercise videos, SMS, telephone, pedometer	**TG:** 6-week duration. Participants provided with exercise videos (two 30-min body-weight exercise), exercise diary and pedometer. Daily SMS to check whether participants completed their exercise. Phone counselling for those with SMS response rate of 50%. **CG:** Usual care.	**Primary outcomes:** GLTEQ **Secondary outcomes:** Tecumseh step test, push-ups.	TG: increased mean MVPA from baseline (378.2 min/week VS 108.8 min/week), increased moderate intensity PA at 6-week compared with CG (mean difference 303.7, P<0.001). Improved Tecumseh step test in TG compared with CG at 6-week. (-3.9 VS 2.6, p = 0.012) and push-ups (3.2 vs. -1.2, p = 0.012). No significant differences in body weight, BMI, waist circumference, and body fat percentage in between groups.

TG: Telerehabilitation group,
CG: Control group,
SMS: short message service
PA: Physical activity
MVPA: Moderate-Vigorous Intensity of Physical Activity
6MWT: 6-Minute Walk Test
7-day PAR: 7-Day Physical Activity Recall
CHAMPS: Community Healthy Activities Model Program for Seniors
FACT-F: Functional Assessment of Cancer Therapy - Fatigue
FACT-C: Functional Assessment of Cancer Therapy - Colorectal
SF-36 PF: 36-Item Short Form Health Survey Physical Function
QoL: Quality of Life
LOS: Length of Stay
EORTC-QLQ-C30: EORTC Quality of Life Questionnaire C30
NCCN Distress Thermometer: National Comprehensive Cancer Network [NCCN] Distress Thermometer

GLTPAQ: Godin Leisure Time Physical Activity Questionnaire
GLTEQ: Godin Leisure Time Exercise Questionnaire
PSQI: Pittsburgh Sleep Quality Index
BREQ-2: Behavioural Regulation in Exercise Questionnaire-2
FACIT-FS: Functional Assessment of Chronic Illness Therapy-Fatigue Scale
PHQ: Patient Health Questionnaire

Risk of bias assessments

The methodological quality and risk of bias for 10 randomized controlled trials (RCTs) [31–36, 38–41] were assessed using the Cochrane Risk of Bias Tool 2.0 (RoB 2) to evaluate the risk of bias in prioritized outcomes. Risk of bias was not assessed for Banck-Petersen et al. [37], as this study did not report any of the prioritized outcomes. Three trials exhibited some concerns regarding the randomization process due to the absence of reported randomization and concealment procedures [32, 34, 41]. Three trials were deemed to have a high risk of bias due to missing outcome data [36, 39, 40]. The majority of studies were judged to have some concerns due to the lack of blinding of participants and the utilization of subjective outcome measures [31, 32, 33, 34, 36, 38, 40, 41]. A risk of bias summary figure, illustrating the review authors' judgments regarding each risk of bias item for each outcome in the included studies, was generated (Figure 2).

Figure 2 – Risk of bias of the included trials

Function	Risk of Bias Domain					
	D1	D2	D3	D4	D5	Overall
Pinto et al. 2013	−	+	+	+	+	−
Lee et al. 2018	−	−	+	+	+	−
Van Blarigan et al. 2022	+	+	−	+	+	−

Physical Activity	Risk of Bias Domain					
	D1	D2	D3	D4	D5	Overall
Pinto et al. 2013	−	+	+	−	+	−
Kim et al. 2018	+	−	×	×	+	×
Lee et al. 2018	−	−	+	−	+	−
Mayer et al. 2018	+	+	×	−	+	×
Van Blarigan et al. 2019	+	−	+	+	+	−
Chan et al. 2022	−	−	+	+	+	−
Van Blarigan et al. 2022	+	+	+	−	+	−
Liao et al. 2024	+	−	×	+	+	×

Quality of Life	Risk of Bias Domain					
	D1	D2	D3	D4	D5	Overall
Pinto et al. 2013	−	+	+	−	+	−
Kim et al. 2018	+	−	+	−	+	−
Mayer et al. 2018	+	+	×	−	+	×
Chan et al. 2022	−	−	+	−	+	−
Schrempf et al. 2023	+	+	+	−	+	−
Hwang et al. 2024	+	−	+	−	+	−

Psychological	Risk of Bias Domain					
	D1	D2	D3	D4	D5	Overall
Kim et al. 2018	+	−	+	−	+	−
Mayer et al. 2018	+	+	×	−	+	×
Schrempf et al. 2023	+	+	+	−	+	−

×	High risk
−	Some concerns
+	Low risk
D1	Randomisation process
D2	Deviations from the intended interventions
D3	Missing outcome data
D4	Measurement of the outcome
D5	Selection of the reported result

Effects of intervention

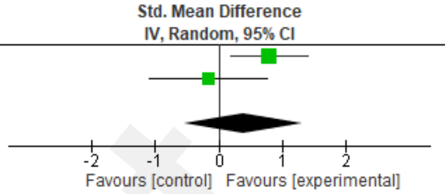
1. Physical Function

Two trials, encompassing 64 participants, were included in the meta-analysis for physical function. Due to the utilization of disparate outcome assessment tools (1-mile treadwalk test [32] and 6-minute walk test [6MWT] [31]), standardized mean difference (SMD) with a random-effects model was employed. The meta-analysis revealed no statistically significant difference between the telerehabilitation and control groups (SMD 0.38; 95% CI -0.54, 1.31; I^2 = 65%; P = 0.42) (Figure 3).

Figure 3 – Forest plot of comparison: Function at 12-week

	Telerehabilitation			Control				Std. Mean Difference
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI
Pinto et al. 2013	3.8	4	20	0.8	3.5	26	57.1%	0.79 [0.18, 1.40]
Van Blarigan et al. 2022	37.1	38.9	8	45.8	58.8	10	42.9%	-0.16 [-1.09, 0.77]
Total (95% CI)			**28**			**36**	**100.0%**	**0.38 [-0.54, 1.31]**

Heterogeneity: Tau² = 0.29; Chi² = 2.83, df = 1 (P = 0.09); I² = 65%
Test for overall effect: Z = 0.81 (P = 0.42)



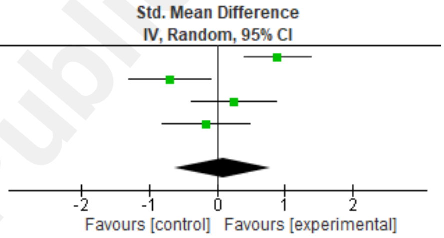
2. Physical activity

Three trials utilized moderate-to-vigorous physical activity (MVPA) [31, 35, 40], while one trial employed the 7-Day Physical Activity Recall (PAR) [31] to assess physical activity levels. A total of 193 participants were included in the meta-analysis. Standardized mean difference (SMD) with a random-effects model was employed. The meta-analysis did not demonstrate evidence supporting the superiority of telerehabilitation compared to usual care (SMD 0.08; 95% CI -0.62, 0.79; I^2 = 83%; P = 0.82) (Figure 4).

Figure 4 – Forest plot of comparison: Physical activity - moderate-vigorous physical activity (MVPA) at 12-week

	Telerehabilitation			Control				Std. Mean Difference
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI
Kim et al. 2018	235.6	280.8	37	16.3	197.1	34	26.5%	0.89 [0.40, 1.38]
Pinto et al. 2013	68.3	151.6	20	176.4	154.5	26	24.9%	-0.69 [-1.29, -0.09]
Van Blarigan et al. 2019	13.7	48.1	20	3.7	29	19	24.4%	0.25 [-0.39, 0.88]
Van Blarigan et al. 2022	-17.4	52.8	17	-8.3	55.6	20	24.2%	-0.16 [-0.81, 0.48]
Total (95% CI)			**94**			**99**	**100.0%**	**0.08 [-0.62, 0.79]**

Heterogeneity: Tau² = 0.43; Chi² = 17.25, df = 3 (P = 0.0006); I² = 83%
Test for overall effect: Z = 0.23 (P = 0.82)



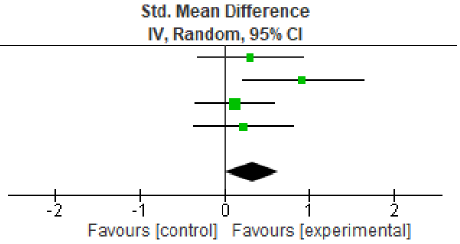
3. Quality of life

Four studies, encompassing a total of 193 participants, were included in the meta-analysis. Due to the utilization of disparate outcome assessment tools across the included trials—Functional Assessment of Cancer Therapy-Colorectal (FACT-C) [31, 34, 40] and European Organisation for Research and Treatment of Cancer Quality of Life Questionnaire (EORTC-QLQ-C30) [38]—standardized mean difference (SMD) with a random-effects model was employed. The pooled results demonstrated a statistically significant difference favoring the telerehabilitation group (SMD 0.33; 95% CI 0.01, 0.64; I^2 = 14%; P = 0.04) (Figure 5).

Figure 5 – Forest plot of comparison: Overall quality of life (QoL) at 12-week.

	Telerehabilitation			Control				Std. Mean Difference
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI
Chan et al. 2022	5.7	16.2	20	-0.3	22.1	21	22.4%	0.30 [-0.31, 0.92]
Hwang et al. 2024	2.7	1.8	17	0.6	2.6	17	17.4%	0.92 [0.21, 1.63]
Kim et al. 2018	2.9	9.2	37	1.6	11.3	34	35.7%	0.13 [-0.34, 0.59]
Pinto et al. 2013	7.5	18.4	20	3.5	17	26	24.5%	0.22 [-0.36, 0.81]
Total (95% CI)			**94**			**98**	**100.0%**	**0.33 [0.01, 0.64]**

Heterogeneity: Tau² = 0.01; Chi² = 3.49, df = 3 (P = 0.32); I² = 14%
Test for overall effect: Z = 2.05 (P = 0.04)



4. Fatigue

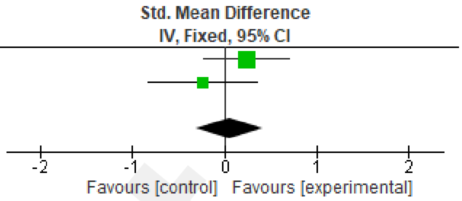
Two trials, encompassing 117 participants, reported data on fatigue. The Functional Assessment of

Chronic Illness Therapy-Fatigue Scale (FACIT-FS) [40] and the Functional Assessment of Cancer Therapy-Fatigue (FACT-F) [32] were utilized in the included trials. Meta-analysis revealed no statistically significant difference between the telerehabilitation and control groups (SMD 0.06; 95% CI -0.31, 0.42; I^2 = 36%; P = 0.76) (Figure 6).

Figure 6 – Forest plot of comparison: Fatigue at 12-week

	Telerehabilitation			Control				Std. Mean Difference
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Fixed, 95% CI
Kim et al. 2018	2.7	6.7	37	1.2	5.4	34	61.0%	0.24 [-0.22, 0.71]
Pinto et al. 2013	1.5	9.5	20	4	11	26	39.0%	-0.24 [-0.82, 0.35]
Total (95% CI)			**57**			**60**	**100.0%**	**0.06 [-0.31, 0.42]**

Heterogeneity: Chi² = 1.57, df = 1 (P = 0.21); I² = 36%
Test for overall effect: Z = 0.30 (P = 0.76)



5. Psychological
Kim et al. [40] reported depression scores, assessed using the Patient Health Questionnaire-9 (PHQ-9), for 71 participants. No statistically significant changes from baseline were observed in either the telerehabilitation or control groups.

6. Feasibility
Five trials reported on the feasibility of telerehabilitation in colorectal cancer (CRC) patients and survivors [31, 33, 35, 36, 39]. Overall, telerehabilitation was deemed feasible. Compliance rates ranged from 71.4% to 83.0% [31, 33, 35, 39]; however, a decline in compliance rates over time was noted [35, 36].

7. Adverse events
Four trials investigated adverse events associated with telerehabilitation [31, 33, 35, 36]. Telerehabilitation was found to be safe, with no serious adverse events reported. Non-serious adverse events potentially related to physical activity, such as knee pain, fatigue, and low back pain, were reported by Van Blarigan et al. [35]; however, these events were observed at similar frequencies in both the telerehabilitation and control groups.

Discussion

This review aimed to evaluate the efficacy of telerehabilitation in colorectal cancer (CRC) patients and survivors. The findings of this review suggest evidence supporting the effectiveness of telerehabilitation in improving overall quality of life (QOL). However, no statistically significant differences were observed for the primary outcome or other secondary outcomes. This may be attributed to the prevalent use of subjective participant-reported outcome measures and the lack of participant blinding across the majority of studies, factors that could have substantially influenced outcome assessment. Furthermore, significant heterogeneity was noted among the included studies with respect to intervention type, duration, frequency, and outcome measures. Consequently, the results should be interpreted with caution.
Advancements in technology have enabled the integration of telemonitoring and telecoaching within a singular setting through the utilization of wearable devices and mobile applications. Furthermore, mobile applications serve as platforms for patient education, counselling, and peer support for colorectal cancer (CRC) patients and survivors, thereby facilitating multidisciplinary telerehabilitation and potentially enhancing patient outcomes by improving exercise adherence [42, 43, 44]. Hwang et al. [38] reported that mobile application interventions significantly improved peripheral neuropathy symptoms and quality of life (QOL) in CRC patients with chemotherapy-induced peripheral neuropathy (CIPN). Conversely, no statistically significant differences in physical

function or QOL were observed in CRC survivors in another study [36]. This can be related to low mobile application adherence in the study, whereby Mayer et al. had to improve their mobile application to reduce the attrition rate. Despite similarities in the primary function of the mobile applications used in these studies, variations in application content, design, and accessibility may have influenced the observed outcomes. Studies showed that customizable functions such as exercise plans, and a communication loop with health care professionals, have been positively linked to physical activity adherence [45, 46].

Pinto et al. [32] used uni-axial accelerometer, which could only detect vertical axis accelerations, has been reported for reduced sensitivity in physical activity detection during vigorous activity, for example running [47]. However, Pinto et al. [32] correlated the objective accelerometer data with self-reported PA data, which provided more comprehensive assessment of the physical activity [48]. Tri-axial accelerometer has better physical activity detection compared with uni-axial accelerometer, with high positive predictive value of 96.29% for step detection in all conditions [49]. Two distinct cut-off points were employed for the classification of physical activity levels across the reviewed studies: Troiano 2008 [35], and Fredson 1998 [31]. Cut-off value of MVPA for Troiano and Freedson was 2020 counts/minute and 1953 counts/minute, respectively. Discrepancy in cut-off value used in different studies potentially affect the outcome [50, 51]. Furthermore, colorectal cancer (CRC) patients and survivors are older, often with multiple comorbidities, and reduced functional capacity. Hence, a set of new cut-off value dedicated for CRC patients are needed [52]. Three studies used Godin's questionnaire to estimate level of physical activity [36, 40, 41]. There was concern of over-estimation of MVPA when using subjective measure to estimate physical activity [53]. It is recommended that outcome measures align with the intervention mode and that further validation of virtual physical assessments be conducted for program pragmatism and timely implementation [54].

Consequently, the results of the meta-analysis for physical activity require cautious interpretation. Overall, telerehabilitation was found to be feasible and safe for colorectal cancer (CRC) patients and survivors, both in inpatient peri-operative and outpatient community settings.

<u>Comparison with other studies</u>

Although similar reviews exist in the literature, none have specifically examined the application of telerehabilitation within a population exclusively comprising colorectal cancer (CRC) patients. Batalik et al. [25] conducted a review on the effects of telerehabilitation in a general cancer population, reporting significant improvements in cardiorespiratory fitness, physical activity levels, and fatigue, but not in quality of life (QOL). This contrasts with the findings of the present review. This discrepancy may be attributed to differences in study populations, including variations in cancer types, treatment modalities, and associated complications. Notably, a substantial proportion of participants in the review by Batalik et al. were breast cancer patients, suggesting that their rehabilitation requirements may differ from those of CRC patients.

van Egmond et al. [55] reported that telerehabilitation improved quality of life (QOL) in post-surgical patients. Given that surgical resection is frequently required in the management of colorectal cancer (CRC), CRC patients may derive substantial benefits from telerehabilitation. Telerehabilitation enables patients to perform exercises at their preferred times and in comfortable environments, while also mitigating travel costs associated with attending rehabilitation centers [56, 57, 58]. These factors may contribute to an enhanced perception of QOL.

<u>Implications for research and practise</u>

This review demonstrates that telerehabilitation interventions, delivered remotely via technology over a relatively short duration (mean 12 weeks), contribute to statistically significant improvements in quality of life (QOL) among colorectal cancer (CRC) patients and survivors. Future studies should prioritize individualized exercise prescriptions, including exercise intensity progression, and implement robust blinding procedures and objective outcome measures whenever feasible.

Strengths and limitations

This review represents the first to specifically focus on telerehabilitation interventions in colorectal cancer (CRC) patients and survivors. Strengths of this study include a comprehensive search across multiple databases and the utilization of the Cochrane Risk of Bias Tool 2.0 (RoB 2) for outcome-specific risk of bias assessment. Heterogeneity in the interventions and outcome measures were limiting factors in arriving in results that would reach statistical significance. The limited number of studies included in the meta-analyses restricts the statistical power to draw robust conclusions.

Conclusions

In summary, this meta-analysis demonstrated that telerehabilitation interventions significantly improved quality of life (QOL) in colorectal cancer (CRC) patients and survivors. However, no statistically significant improvements were observed in physical function, physical activity, or psychological outcomes. Given the inherent limitations of this meta-analysis, the results should be interpreted with caution. Telerehabilitation was found to be safe and feasible, underscoring the need for further high-quality and robust research to advance this field.

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