Surgery in Practice and Science 15 (2023) 100227

Contents lists available at ScienceDirect

Surgery in Practice and Science

journal homepage: www.sciencedirect.com/journal/surgery-in-practice-and-science

Review Article

# The effect of exercise in patients with colorectal cancer surgery: A systematic review

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ARTICLE INFO

*Keywords:*
Colorectal surgery
Exercise training
Physiotherapy
Rehabilitation

ABSTRACT

*Background:* Current reviews have primarily focused on the effect of exercise on colorectal cancer patient's functional abilities and cardiorespiratory performance. There is a need for more comprehensive studies to determine the effects of exercise on different components. We aimed to investigate recent pre-operative and post-operative exercise interventions conducted in patients undergoing or scheduled for colorectal cancer surgery.
*Methods:* The PRISMA guidelines were followed. PubMed, Web-of-Science (WoS) and Scopus databases were searched. The Physiotherapy Evidence Database (PEDro) tool provided the methodological quality and risk of bias for the included trials. The review findings are presented using the principles of narrative synthesis. The synthesis process encompasses steps such as "developing a preliminary synthesis, exploring relationships within and between studies, and assessing the robustness of the synthesis."
*Results:* The combined use of aerobic and resistance exercises reduces hospital stay in the preoperative period, long-term exercise interventions significantly improve functional parameters, and progressive relaxation exercises performed during the preoperative and postoperative periods reduce anxiety.
*Conclusions:* Long-term and combined (relaxation, aerobic and resistance) rehabilitation in colorectal cancer surgery is essential to improve the physical and psychological parameters of patients. Further studies should focus on more comprehensive, long-term exercise programs and separately investigate the effects of each exercise type.

## Background

Colorectal cancer is the third most common type of cancer worldwide, with an increasing incidence due to changing lifestyles [1,2]. Colorectal cancer can manifest with many symptoms, including rectal bleeding, changes in bowel habits, weight loss and abdominal pain. The link between dietary habits and the risk of colorectal cancer is widely comprehended. Studies have shown that the consumption of red meat, alcohol, and processed foods, in particular, increases the risk of colorectal cancer [3].

Another risk of colorectal cancer is physical inactivity. Due to the fast-paced and intense work routines, individuals have increasingly adopted sedentary lifestyles in recent years. This condition, comprehended for its numerous adverse effects, also contributes to an increased risk of colorectal cancer [4,5]. Over the past few decades, there has been an improvement in the prognosis of individuals diagnosed with colorectal cancer [6]. The main objective following colorectal surgery is the swift restoration of gastrointestinal function and ensuring the person's ability to return to daily life quickly [7]. Colorectal surgery patients were only subjected to pre-operative practices involving nutrition and medication approaches for many years. However, the inclusion of exercise in this approach was recognized through studies demonstrating various benefits of exercise in the pre- and post-operative stages of different surgeries [7–9].

With the increase in types of colorectal cancer occurrence and life expectancy of the patients, there has been a rise in studies aimed at reducing post-operative length of hospital stay [10,11]. Research has shown that extended bed rest leads to muscle atrophy and weakness, raising the chances of post-operative complications such as atelectasis, delayed wound healing, and mortality [12]. Reduced cardiovascular

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https://doi.org/10.1016/j.sipas.2023.100227

Available online 4 December 2023

capacity constitutes a risk factor for many post-operative complications such as thrombosis, infection, and more [13,14].

Studies have indicated that aerobic and resistance training can enhance surgical patients' muscle function and encourage mobility before and after colorectal cancer surgery [14]. While these studies have primarily focused on the patient's functional abilities and cardiorespiratory performance, there is a need for more comprehensive studies to determine the effects of exercise on different components of these patients. Furthermore, due to the limited number of participants and the scarcity of extensive studies, a consensus has not been reached regarding pre-operative and post-operative exercise programs for this patient group.

We aimed to investigate recent pre-operative and post-operative exercise interventions conducted on patients undergoing or scheduled for colorectal cancer surgery. By assessing various approaches and their impact on different parameters, our goal was to contribute to developing an optimal exercise program that could reduce individuals' post-surgical recovery time, enhance their functional level, and decrease complication rates.

## Methods

### *Search strategy*

PRISMA guidelines were used during this systematic review (Appendix 1) [15]. Two researchers in our study group utilized the PubMed, Web-of-Science (WoS) and Scopus databases to conduct a literature search in order to find relevant studies. The inclusion criteria for this study encompassed exercise studies involving patients who underwent bariatric surgery, with a publication date from August 2018 to August 2023. The search for all databases were conducted in August 2023. The keywords used were "colorectal cancer surgery and exercise", "colorectal cancer surgery and aerobic exercise", "colorectal cancer surgery and resistance exercise", "colorectal cancer surgery and endurance exercise" (Appendix 2). During the initial search, a total of 202 studies were reviewed.

**Table 1**
The summary of the included trials.

| Author | PEDro | Time of Intervention | Intervention | Outcomes | Results |
|---|---|---|---|---|---|
| Min et al. [19] | 8 | Post-operative period | **IG:** Stretching, ADL, low intensity RT, balance 15 min twice a day<br>**CG:** Usual care | LOS<br>PT-RHDS<br>Physical characteristics | **IG:** LOS reduced significantly (p:0.021), PT-RHDS scores improved significantly ($p < 0.01$), muscle mass increased significantly (p:0.03) |
| Northgraves et al. [36] | 7 | Post-operative period | **IG:** RT +AT (%40–60 HRR) 3 per week<br>**CG:** Instructed to maintain their normal exercise levels | 6MWT<br>TUG<br>SCT<br>FTSTS<br>HADS<br>EORTCQLQ-C30<br>HGD<br>LOS | **IG:** LOS reduced non significantly; 6MWT, TUG, FTSTS scores improved non significantly |
| Taha et al. [34] | 8 | 3–6 weeks prior to surgery | **IG:** HIIT+RT 2X week<br>**CG:** Physical activity education | HADS-D<br>HADS-A | **IG:** HADS-D and HADS-A improved non significantly |
| Mascherini et al. [38] | 6 | Post-operative period | **IG:** AT(30 min 3 times per week) + RT (3 sets 8–12 rep 2X week) and mixed supervised/home-based exercise program for six months<br>**CG:** Standard care | 6MWT<br>6MWD<br>SRT<br>BM<br>BIA<br>HGD<br>30CST | **IG:** SRT, 30CST, 6MWT significantly increased ($p < 0.01$) 3 m after the surgery and fat mass reached lowest values in 6 m post-op |
| Peng et al. [49] | 8 | Post-operative period | PR-ERAS: RT + Breathing Exercises + Core Exercises | I-FEED<br>QOR-40<br>HGD | PR-ERAS: QOR-40, HGD, I-FEED scores improved significantly |
| Berkel et al. [37] | 7 | Post-operative period | **IG:** HIIT (Moderate İntensity) + RT 3 times per week<br>**CG:** Usual care | $VO_{2\ max}$<br>LOS<br>Complication Rate<br>HGD<br>TUG<br>QF Strength | **IG:** Complication Rate was significantly lower (p:0.024), |
| Onerup et al. [20] | 7 | Pre- and post-operative period | **IG:** Daily medium intensity AT 30 min + IMT<br>**CG:** Usual care | Self-Recovery<br>HbA1c<br>CCI<br>IGF-1<br>IGFBP-3 | No significant effect |
| Karlsson et al. [50] | 6 | Pre-operative period | **IG:** Breathing exercises + RT + AT 2–3 times per week<br>**CG:** Usual care | PRP<br>Adverse events<br>IMS | **IG:** IMS increased significantly (p:0.04) |
| Özhanli et al. [35] | 6 | Pre and Postoperative Period | **IG:** Breathing and relaxation exercises daily<br>**CG:** Usual care | SF-MPQ<br>STAI<br>BP<br>Cortisol level | **IG:** Lower postoperative pain and anxiety levels and a lower rate of using opioid analgesic on postoperative day 0 compared to the control group |

**"IG:** Intervention Group, **ADL:** Activities of Daily Living, **RT:** Resistance Training, **CG:** Control Group, **LOS:** Length of Stay, AT: Aerobic Training, **PT-RHDS:** Patient-perceived readiness for hospital discharge, **6MWT:** 6 Minute Walking Test, **BP:** Blood Pressure, **STAI:** State-Trait Anxiety Inventory, **SF-MPQ:** Short Form of McGill Pain Questionnaire, **PRP:** Postoperative Recovery Profile, **IGFBP-3:** IGF-binding protein 3, **IGF-1:** insulin-like growth factor, **CCI:** comprehensive complication index, **HbA1c:** glycosylated hemoglobin, **HGD:** Handgrip Dynamometer, **TUG:** Timed Up and Go Test, **QOR-40:** quality of recovery score, **I-FEED:** GI function, **6MWD:** 6 Minute Walking Distance, **HADS:** Hospital Anxiety and Depression Scale, **SCT:** Stair Climb Test, **FTSTS:** Five Times Sit To Stand Test, **EORTCQLQ-C30:** EORTC Quality of Life Questionnaire-C30, **HIIT:** High Intensity Interval Training, **IMS:** Inspiratory Muscle Strength, **SRT:** Sit and Reach Test, **BM:** Body Mass, **BIA:** Bioelectrical impedance analysis".

*Eligibility criteria*

The inclusion criteria for this study were (1) studies that included only exercise programs and (2) studies with a randomized controlled design. The exclusion criteria for this study were (1) studies for which only an abstract was available, (2) duplicate studies and (3) studies that include interventions other than preoperative or postoperative exercise approaches.

*Screening*

The datasets from the individual searches conducted by two researchers were imported into the Rayyan software developed by QCRI in Qatar [16]. Rayyan is a practical and automated tool for managing articles in systematic reviews. This software can automatically identify and remove duplicate records. Additionally, it allows for manually categorizing trials as 'yes,' 'no,' or 'maybe' based on their title/summary.

The two screening investigators assessed the eligibility of the trials using Rayyan's features, considering the predefined inclusion and exclusion criteria. In cases where the two investigators had differing opinions on trial selection, a consensus was reached by consulting an expert academic specializing in surgical rehabilitation and experienced in systematic review methodologies.

*Synthesis of evidence*

The review findings are presented using the principles of narrative synthesis (Table 1). The synthesis process encompasses steps such as 'developing a preliminary synthesis,' 'exploring relationships within and between studies,' and 'assessing the robustness of the synthesis.' Subsequently, the results are presented, highlighting the trials' qualitative and quantitative characteristics [17]. The authors note that this systematic review protocol was not registered.

*Assessment of quality and risk of bias*

Quality assessments were carried out by two independent reviewers using PEDro scores. In instances of any discrepancies, a third researcher was consulted to resolve the matter. The PEDro scoring system comprises 11 questions to evaluate specific aspects, including eligibility criteria, randomization, blinding, follow-up procedures, and analysis methods. Each question on the PEDro scale is responded to with either a 'Yes' or a 'No.' The scores acquired from PEDro are used to categorize the study's quality as 'excellent' for scores of 9–10, 'good' for scores of 6–8, 'moderate' for scores of 4–5, and 'poor' for scores of 0–3 (Table 2) [18].

## Results

*Length of hospital stay(LOS)*

A review of screening results provided nine studies. We examined components related to preoperative rehabilitation for patients with colorectal surgery (Fig. 1). In a recent study conducted by Min et al. [19] on a group of patients who underwent colorectal cancer surgery, a comprehensive multimodal rehabilitation program incorporating various exercise approaches (aerobic, resistance, core-focused, balance) was implemented during the postoperative period. This program was divided into several phases. The results indicated that this rehabilitation program significantly reduced the patient's hospital stay compared to the control group and demonstrated the highest adherence to the predetermined length of hospital stay, particularly within this group. In addition to these findings, patients in the exercise group, in the same study, reported feeling more prepared and personally better upon discharge from the hospital compared to patients in the control group. While these results align with many studies, some studies have observed contrasting outcomes. In another study examined in our systematic review conducted by Onerup et al. [20], hospital stay duration was identified as one of the primary outcome measures. However, the exercise program implemented in this study did not significantly impact hospital stay duration. This difference in results could stem from various discrepancies in the interventions. In the study by Min et al. [19], comprehensive, diverse approaches involving exercises supervised by a physiotherapist were employed within a hospital setting. In contrast, the study by Onerup et al. [20] only incorporated aerobic exercises and resistance breathing exercises during hospitalization, followed by post-discharge instructions. The disparity could be attributed to the inclusion of resistance exercises and the functionality-focused exercises used in the Min et al. study [19], potentially accelerating recovery by promoting an increase in the patient's muscle mass.

*Anxiety and depression*

Before surgery, anxiety and depression related to the hospital environment are significant stress factors frequently observed in colorectal cancer surgery and major abdominal surgical procedures [21–23]. Cancer alone is a significant component that generates severe anxiety in an individual, and in addition, recent surgery can affect the patient's mental state [24,25]. Even deterioration in functional status solely due to the effects of surgery on an individual's physical condition can lead to issues such as depression and anxiety [26]. The positive effects of exercise on individuals' emotional and mental well-being are well-known [27–30]. In numerous studies, this effect has been observed not only in healthy individuals but also in individuals with cancer, the geriatric population, women in the postpartum period, and those diagnosed with fibromyalgia [31–33]. Based on these findings, Taha et al. [34] conducted a study involving 23 individuals over 3–6 weeks to determine the effects of a prehabilitation program combining aerobic and resistance

**Table 2**
PEDro scores of the included trials.

| Article | Q-1 | Q-2 | Q-3 | Q-4 | Q-5 | Q-6 | Q-7 | Q-8 | Q-9 | Q-10 | Q-11 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Min et al. [19] | Y | Y | Y | Y | N | N | N | Y | Y | Y | Y | 8 |
| Northgraves et al. [36] | Y | Y | Y | Y | N | N | N | N | Y | Y | Y | 7 |
| Taha et al. [34] | Y | Y | Y | Y | N | N | N | Y | Y | Y | Y | 8 |
| Mascherini et al. [38] | Y | Y | N | N | N | N | N | Y | Y | Y | Y | 6 |
| Peng et al. [49] | Y | Y | N | Y | N | N | Y | Y | Y | Y | Y | 8 |
| Berkel et al. [37] | Y | Y | N | N | Y | N | Y | N | Y | Y | Y | 7 |
| Onerup et al. [20] | Y | Y | N | N | N | Y | Y | N | Y | Y | Y | 7 |
| Karlsson et al. [50] | Y | Y | N | N | N | N | Y | Y | Y | N | Y | 6 |
| Özhanli et al. [35] | Y | Y | N | Y | N | N | N | Y | N | Y | Y | 6 |

"Q-1: Eligibility criteria; Q-2: Random allocation; Q-3: Concealed allocation; Q-4: Baseline comparability; Q-5: Blind subjects; Q-6: Blind therapists; Q-7: Blind assessors; Q-8: Adequate follow-up; Q-9: Intention-to-treat analysis; Q-10: Between-group comparisons; Q-11: Point estimates and variability".

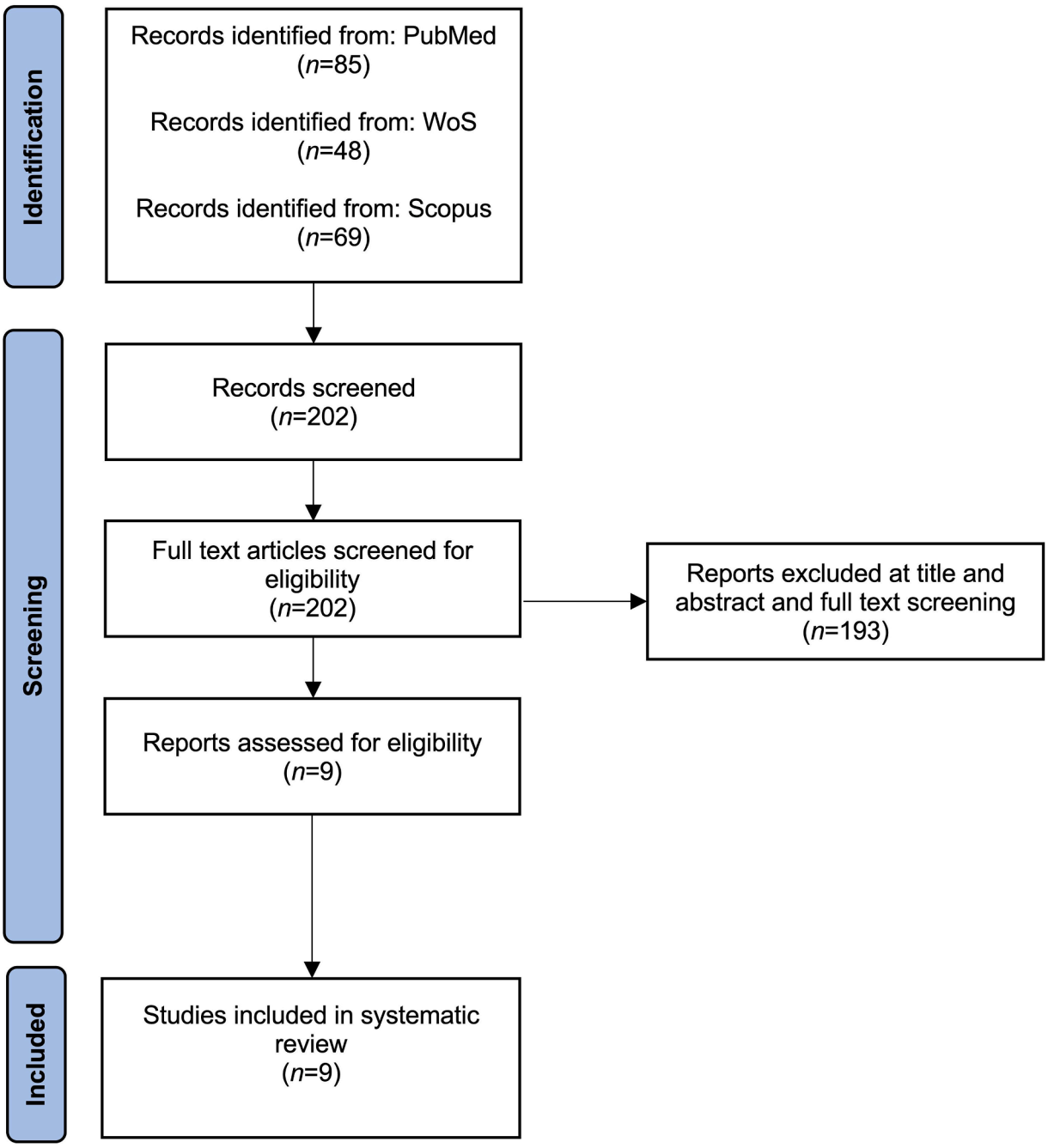


**Fig. 1.** PRISMA flow diagram of the study.

exercises on individuals undergoing surgery for colorectal cancer. However, the results of this study did not show a statistically significant reduction in preoperative anxiety and depression levels among the intervention group individuals, and the change did not surpass the minimal clinically significant difference. The similarity in results between the groups in the study could be attributed to the education provided to both groups about the effects of exercise on anxiety and physical condition before surgery. Other studies in the literature have also obtained similar outcomes in patients undergoing colorectal and abdominal surgery, thus making the effects of exercise on anxiety and depression symptoms in this group a subject of debate. Taking a different perspective, Ozhanlı et al. [35] conducted a study utilizing progressive relaxation exercises during the preoperative and postoperative periods to examine the effects of these exercises on anxiety, pain levels, and vital parameters in this group of patients. The exercises were administered before surgery and on the 1st, 2nd, and 3rd postoperative days. As a result, significant reductions in anxiety, pain levels, and systolic blood pressure, particularly on the 3rd postoperative day, were observed in the exercise group. To determine the effects of these components, longer-term, more comprehensive, and better-structured exercise programs need to be tested on larger patient populations.

*Functional performance*

Among the nine randomized controlled studies examined in our review, 4 of them utilized functional assessments as outcome measures. The functional assessments included 6MWT, 6MWD, TUG, SCT, FTSTS, 30CST and HGD. In the study by Northgraves et al. [36], progressive resistance and aerobic exercise were administered twice weekly in sessions lasting 60 minutes. Following the intervention, improvements

were observed in TUG, SCT, and 6MWT tests within the exercise group, while similar improvements were not observed in the group receiving standard care. In the study by Berkel et al. [37], patients undergoing colorectal resection were given 60 minutes of HIIT thrice a week for three weeks. However, statistically significant results could not be obtained in functional measurements. In another study, Mascherini et al. [38] applied resistance and aerobic exercises to the same group of patients during the postoperative period, consisting of 8 sessions, and patients were encouraged to continue exercises at home after being discharged from the hospital. The patients who continued exercises at home observed improvements in all functional parameters (6MWD, 30CST, SRT) at 3 and 6 months. These improvements peaked at the 6-month mark, suggesting that a combination of home and supervised exercises could be utilized, revealing the long-term effects of exercise. However, when interpreting this study, considering the sample size is essential because it is a preliminary study.

*Complication rate*

Considering that many patients undergoing colorectal surgeries for cancer are at high-risk for complications after the procedure, investigating the effects of exercise in different forms on complication rates is critical. Literature has demonstrated that exercise reduces postoperative complications and side effects resulting from surgery. When examining the effects on the rate of surgery-related complications in patients undergoing colorectal surgery, the study by Berkel et al. showed that the prehabilitation intervention applied to high-risk colorectal surgery patients significantly reduced the risk of complications. In this study, Berkel et al. showed that high-risk patients could perform a more compelling exercise program involving high-intensity interval training without adverse effects and result in a positive outcome for the postoperative period [37].

## Discussion

The primary aim of this systematic review was to document the impact of exercise on individuals who had undergone or were planning to undergo surgery for colorectal cancer. Due to the global rise in the occurrence of colorectal cancer, there has been a growth in scientific research related to the field. Despite the increasing frequency of new treatment methods, surgical operation remains one of the foremost treatment methods for colorectal cancers. Colorectal cancers significantly impact an individual's gastrointestinal system, functional and aerobic capacity, mental state, emotional well-being, and overall quality of life [39–43]. Additionally, complications arising from surgical procedures, increased symptoms due to preoperative fear and stress, and the presence of risk factors for surgical procedures can lead to negative outcomes such as poor postoperative recovery and elongated hospital stay, worsening functional status, and general well-being.

Exercise is a proven preventive and therapeutic approach before and after various surgical interventions. Different forms of exercise reduce preexisting risk factors before surgery, decrease the likelihood or severity of postoperative complications, provide patient education, shorten hospital stays, and facilitate a swift return to daily life activities, ultimately enhancing quality of life. Furthermore, recent studies have reported that exercise may reduce the risk of colorectal cancers and potentially decrease mortality risk among individuals diagnosed with cancer [44]. When we look at a more specific direction, a recent meta-analysis showed that different forms of exercise interventions, when used for 12 weeks or less, are effective on fatigue, quality of life, aerobic fitness, upper body strength, reduction in body fat, also more significant effects were seen if interventions were used for more than 12 weeks in quality of life, cardiovascular fitness and reduction of body fat. In physiotherapist supervision, the effects of exercise on the quality of life and fatigue for these patients are significantly higher than in unsupervised treatment programs [45].

Sarcopenia, commonly observed in individuals with colorectal cancer, is characterized by a reduction in muscle mass and quality [46–48]. Alongside the decrease in muscle mass, these individuals may experience a decline in daily life activities and a reduced functional capacity. As with all patients, surgical interventions bring forth numerous risk factors in this group of patients as well. Completing an individual's recovery post-surgery and becoming active without prolonged bed rest is critical due to the adverse effects of extended bed rest on cancer.

In our systematic review, we conducted research to examine the effects of exercise on individuals who have undergone or are scheduled for colorectal cancer surgery. We focused on randomized controlled studies conducted within the last five years that solely utilized exercise interventions. Many of the trials involved nutrition, behavioral and exercise approaches combined. Therefore, these studies were not examined because they might prevent us from fully observing the effects of exercise on outcome parameters and could create a masking effect of other interventions. We identified nine studies that met our inclusion criteria. Among these nine randomized controlled studies, 6 included prehabilitation interventions, while the other three used postoperative approaches. Most exercise interventions investigated the impact of combined aerobic and resistance exercise programs. The duration of exercise programs varied among the studies, with the duration of exercise programs ranging from 3 days to 6 weeks. In most studies, the same number and frequency of sessions were not applied to all patients, attributed to the differing scheduled surgery dates. In some studies, exercise programs included relaxation exercises, device-assisted resistance breathing exercises, and aerobic and progressive resistance exercises.

When examining the results in terms of outcome measures, we can identify only one study demonstrating a statistically significant reduction in hospital stay, which is one of the crucial points for patients. However, this result might be attributed to the fact that hospital stay was not utilized as an outcome parameter in the other studies, and the exercise programs' duration could be a contributing factor. Functional measurements, one of the most critical components determining patients' quality of life and daily life activities, have not been consistently examined in each study, as mentioned above, and have not been consistently included as outcome parameters in the articles. Among the three studies that examined functional capacities, only the study by Mascherini et al., which employed a long-term exercise program, observed time-dependent positive statistically significant effects in functional tests within the exercise group. Examining the impact of exercise on the control of mental and emotional influences in this patient group, which is another issue deeply affecting daily life, the study by Özhanli et al. that we reviewed utilized progressive relaxation exercises [35]. In a short period, this study demonstrated significant reductions in systolic blood pressure, pain levels, and anxiety within the exercise group during the postoperative period. Symptoms such as anxiety and depression were not used as outcome measures in the other studies.

*Limitations*

Our study has certain limitations. One examined study is a preliminary article, resulting in a small number of participants (3 in each group). Additionally, other studies also have low participant numbers. The variations in exercise program durations and the different methods employed can be another limitation, leading to diverse outcome measures across the studies. Furthermore, in several studies, the need for uniform application duration for each patient in the intervention group complicates interpretation.

*Strengths*

In addition to the limitations, the strengths of our systematic review include the incorporation of highly current randomized controlled comparative studies conducted within the past five years and the

exclusion of studies with additional interventions to assess the pure effect of exercise in the examined studies.

## Conclusion

The parameters analyzed by our study were functional performance, anxiety and depression, LOS and complication rate. For all analyzed parameters, included studies in our review showed conflicting results which made effect of combined exercise on these outcomes debateable. For functional performance and LOS outcomes multimodal exercise programs with longer durations seems to be more effective. In conclusion, the combined use of aerobic and resistance exercises may reduce hospital stay duration when performed in the preoperative period, long-term exercise interventions significantly improve functional parameters, and progressive relaxation exercises performed during the preoperative and postoperative periods may reduce anxiety. However, the limited number of studies, heterogeneity of the analyzed studies and low sample size should be considered when generalizing the results of this systematic review. Future studies should focus on more comprehensive, long-term exercise programs and separately investigate the effects of each exercise type.

## Funding

None.

## Ethical approval

Not applicable.

## Consent to participate

Not applicable.

## Availability of data and material

All data generated or analyzed during this study are included in this published article.

## CRediT authorship contribution statement

**Ece Ekici:** Conceptualization, Data curation, Writing – original draft, Writing – review & editing. **Mehmet Özkeskin:** Conceptualization, Data curation, Writing – original draft, Writing – review & editing. **Fatih Özden:** Conceptualization, Data curation, Writing – original draft, Writing – review & editing.

## Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

## Acknowledgements

None.

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