The association between performance parameters of physical fitness and postoperative outcomes in patients undergoing colorectal surgery: An evaluation of care data

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Abstract

Background: Preoperative cardiorespiratory fitness, as measured by cardiopulmonary testing or estimated using the less sophisticated incremental shuttle walk test, timed up-and-go test or stair climb test is known to be associated with postoperative outcome. This study aimed to evaluate whether parameters of physical fitness are associated with postoperative outcome in patients with colorectal cancer scheduled for elective resection.

Patients and Methods: Perioperative data of patients who underwent colorectal resection at Maastricht University Medical Center were retrospectively analyzed. Preoperative variables (e.g., age, body mass index, comorbidities, physical fitness, tumour characteristics, neoadjuvant treatment, American Society of Anesthesiologists score, level of perceived fatigue and nutritional status) were compared with postoperative outcomes.

Results: Out of 80 consecutive cases, 75 (93.8%) were available for analysis (57.3% male, median ± interquartile range age 69.2 ± 11.7 years). A higher Charlson comorbidity index (odds ratio (OR) of 1.604, 95% confidence interval (CI) 1.120–2.296), worse functional exercise capacity (in meters, OR of 0.995, 95% CI 0.991–1.000), a lower physical activity level (in min/day, OR of 0.994, 95% CI 0.988–1.000), and a higher level of perceived fatigue (OR of 1.047, 95% CI 1.016–1.078), were associated with a slower time to recovery of physical functioning. A better functional exercise capacity was associated with a lower OR (OR of 0.995, 95% CI 0.991–1.000) for non-surgical complications.

Conclusion: There is an association between preoperative parameters and postoperative outcomes in patients with colorectal cancer scheduled for resection. Patients benefit from an optimal preoperative physical fitness level. Specific interventions can target this physical fitness level.

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Keywords: Physical fitness; Exercise testing; Risk stratification; Colorectal cancer; Colorectal resection

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Introduction

In the Netherlands, patients with signs of colorectal cancer are identified via the national screening program for colorectal cancer (see www.bevolkingsonderzoekzuid.nl) or after referral of the general practitioner. After confirmation of the diagnosis and the decision for surgery, most of

the patients (rectal cancer; 99.0%, colon cancer; 87.0%) undergo elective colorectal resection [1]. A smaller proportion of patients (rectal cancer; 1.0%, colon cancer; 13.0%) requires acute surgery [1]. After the decision for elective surgery, pre-assessment by the anesthesiologist and the physical therapist for medical conditions and physical fitness is scheduled (see Fig. 1 that illustrates the *patient journey* at the Maastricht University Medical Center).

Major colorectal surgery is significantly associated with morbidity and even mortality [2,3]. Outcome after major surgery depends on several factors such as perioperative care, neoadjuvant treatment, and also physical fitness. Preoperative cardiorespiratory fitness has been reported to have a consistent positive relation with postoperative outcome in abdominal surgery [4−8]. A poor cardiorespiratory fitness, as measured by a maximal cardiopulmonary exercise test, indicates a reduced physiological reserve, which can contribute to a complicated postoperative time course including morbidity and mortality in patients with lower and upper gastrointestinal cancer, respectively [5,9]. Patients with an increased preoperative level of cardiorespiratory fitness may have a greater physiological reserve to better cope with surgical stress that significantly increases the metabolic demand after surgery [7].

In most Dutch hospitals, performing a preoperative cardiopulmonary exercise test for risk stratification is not part of standard care for patients undergoing major abdominal surgery. However, performance at less sophisticated physical fitness tests has been found to be related to postoperative outcomes as well. Studies of Nutt et al. [10] and Struthers et al. [11] showed that the incremental shuttle walk test (iSWT) can serve as an indicator of postoperative risk in patients undergoing abdominal surgery. The timed up-and-go (TUG) test [12] is identified as a predictor for postoperative complications in patients undergoing elective surgery (for breast cancer and gastrointestinal malignancies). Other studies identified the stair-climbing test as predictor for postoperative complications in elective abdominal surgery [13] and in surgical resection for non-small cell lung cancer [14]. Alternative physical performance tests that provide information about the patient's physical fitness may therefore also be appropriate tools to perform preoperative risk stratification in several surgical populations.

The aim of this study was therefore to evaluate whether preoperative performance parameters of physical fitness are associated with postoperative outcomes in patients with colorectal cancer scheduled for elective colorectal resection. If specific preoperative parameters are associated with postoperative outcome, these variables may be targeted with preoperative interventions in order improve postoperative outcome, trajectories that were already executed by others [15,16].
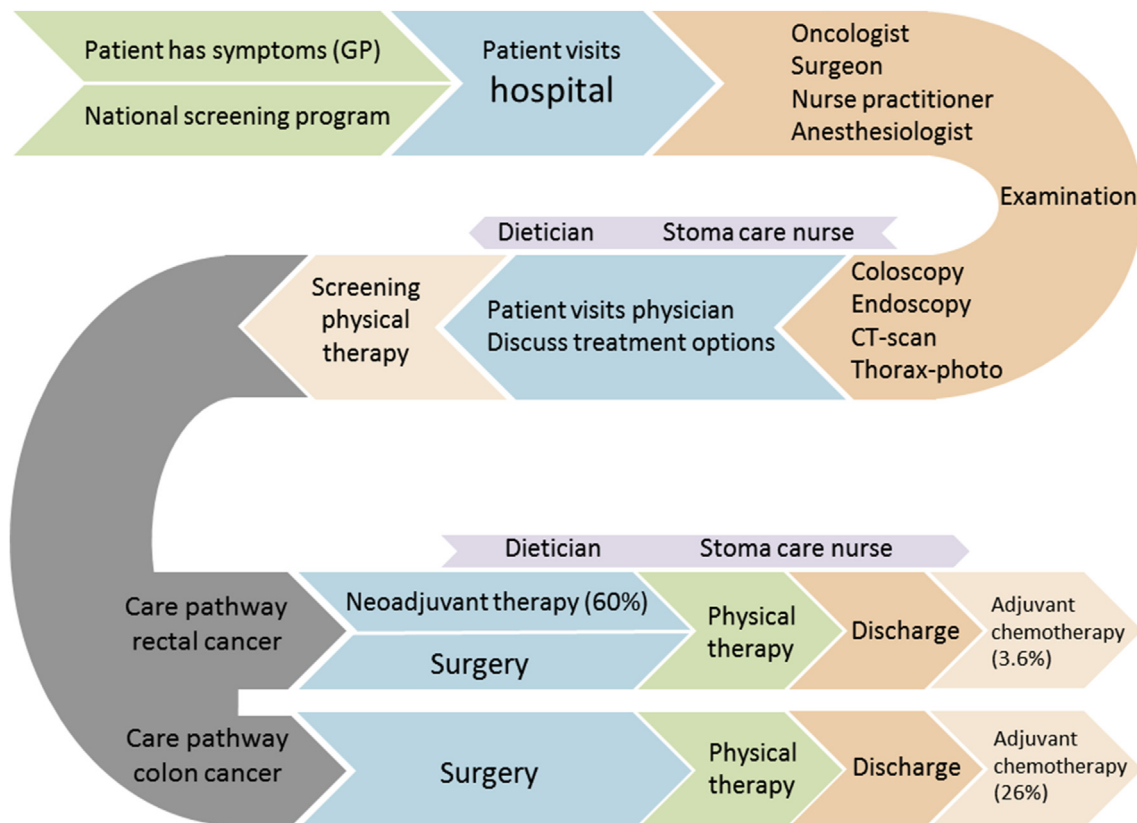

Fig. 1. Patient journey for colon and rectal cancer at our hospital.

Patients and methods

Participants

Patients diagnosed with colorectal cancer planned for elective colorectal resection at the Maastricht University Medical Center (Maastricht UMC+) are being monitored pre- and postoperatively for their physical fitness as part of usual care. For this study, data sampling was performed between January 2015 and December 2015. All consecutive patients >18 years of age who underwent elective colorectal resection for cancer and who had no objection for the use of their usual care data for research purposes were included. When essential data about postoperative outcomes was missing, the data of that patient was excluded from analysis. The medical ethical committee of the Maastricht UMC + decided (15-4-234) that this study met the ethical policies of the Maastricht UMC+ and the regulations of the Dutch government.

Preoperative screening

After the decision for elective colorectal resection, patients consulted the hospital physical therapist as soon as possible for a preoperative screening of physical fitness. During the consultation, patients were educated about the importance of adequate physical fitness to better meet the metabolic demands of major surgery. Patients received standard advice about physical activity throughout the preoperative period. Additionally, patients received information about the content and expectations of postoperative physical therapy treatment during hospitalization.

Outcome variables

Time to recovery of physical functioning (measured by the modified Iowa levels of assistance scale – mILAS [17]) and data on surgical complications (surgical and non-surgical) were collected from patient files. Time to recovery of physical functioning was defined as the time between the day of surgery and the day at which patients reached a mILAS score of 0 (in days). Data on postoperative complications were registered with the use of the Clavien-Dindo classification [18].

Predictive variables

Patient characteristics at time of surgery and treatment details were obtained from electronic patient files. The potential predictors age, body mass index, identification via the national screening program or general practitioner, Charlson comorbidity index, tumour, node, metastasis stage, additional neoadjuvant treatment, American Society of Anesthesiologists score, smoking status, nutritional status (short nutritional assessment questionnaire), level of perceived fatigue (multidimensional fatigue index), and

operation type were collected. Data from the preoperative screening of physical fitness (functional exercise capacity, muscle strength, functional mobility, and the level of physical activity) were also included.

Functional exercise capacity

To measure functional exercise capacity, the modified protocol of the iSWT was used [19], with the maximum walking distance as primary outcome measure. The modified protocol of the iSWT is an extension of the original twelve-level iSWT, with the exact same instructions as the original test [20]. The test starts with a walking speed of 1.8 km/h. Every level has a duration of 1 min and the walking speed increases with 0.6 km/h per level. The maximum walking speed is 10.3 km/h during level 15, in which subjects are allowed to run. Prior to the walking test, standardized instructions were given and the patients were encouraged to walk as long as possible. Heart rate was monitored during the test. The participants had to move around two markers over a 10-m course in time with audio signals from a pre-recorded tape. The test was terminated when the patient could not reach the markers on time on two consecutive audio signals. The use of a walking aid, orthopedic shoes or orthoses was permitted. The test was performed under the close surveillance of an experienced hospital physical therapist. The test-retest reliability for the shuttle walk test varies from 0.760 to 0.990 [21].

Muscle strength

Handgrip strength as measured with a hand held dynamometer (JAMAR® Hydraulic Hand Dynamometer, JAMAR, Patterson Medical Holdings, Inc., Illinois, USA) was used to provide an indication of the patient's overall muscle strength. Patients were seated in a chair with their elbow flexed at 90° and the forearm in the neutral position without any arm support from the chair. The patient performed the test three times with the dominant hand, of which the highest value (kg) was reported [22]. The assessment of handgrip strength measured with the Jamar dynamometer is a reliable method (intraclass correlation coefficient values 0.85–0.98) [23].

Functional mobility

Functional mobility was measured with the TUG test, in which the time needed to rise from a chair, walk 3 m, walk back to the chair, and sit down again, was measured [24]. After one practice trial, the patient was asked to perform the test three times, of which the fastest time (s) was reported.

Level of physical activity

Patients were asked about the frequency, duration, and intensity of various physical activities (total minutes of walking, cycling, gardening, household activities, and sport activities) during the two weeks before the preoperative screening with the LASA Physical Activity Questionnaire

(LAPAQ) [25]. The total amount of physical activity was converted in minutes of physical activity per day (min/day).

Usual care pathway

Postoperative care was similar for all patients, regardless of the surgical procedure. All patients participated in postoperative physical therapy (started at postoperative day 1), in which recovery of physical functioning was monitored using the mILAS [17]. The mILAS assesses the capability of patients to perform several activities of daily living (transfer from supine position to sitting and vice versa, sit-to-stand, walking, and stair climbing) and rates the amount of assistance needed. Postoperative physical therapy consisted of airway clearing exercises, strength exercises, practicing transfers, walking, stair climbing (when necessary for independent functioning at home), and improving muscle function and cardiorespiratory capacity.

Data analysis

The Statistical Package for the Social Sciences for Windows (version 23.0; IBM, SPSS Inc., Chicago, IL, USA) was used for statistical analysis. For all variables, normality was tested with the Kolmogorov-Smirnov test. Data were presented as median and interquartile range (IQR), when the data were not normally distributed. Data on postoperative complications were divided into subgroups (total complications, surgical complications, and non-surgical complications) and dichotomized (0 = absent, 1 = present). Data on time to recovery of physical functioning was also dichotomized (0 = recovery of physical functioning in ≤4 days, 1 = recovery of physical functioning in ≥5 days; as the median time to recovery of physical functioning in the patient population of the current study equaled four days). Additionally, potential predictors were added in univariate logistic regression analysis (enter method) to explore the association between individual independent predictors and postoperative outcome variables. Receiver operating characteristic (ROC) analysis was used to establish optimal threshold values of functional exercise capacity as measured with the iSWT distance to predict non-surgical complications. Finally, a multivariate logistic regression analysis was performed to construct a model which explains the variance in outcome variables. To select potential predictor variables for the regression model, a *P*-value of 0.200 was used. For the other statistical analyses a *P*-value <0.05 was considered statistically significant.

Results

Preoperative data of 80 patients with colorectal cancer were available for analysis. Of these patients, five (6.3%) were excluded because of missing postoperative data (data not available in the database because the nature of the tumour; n = 4, and missing data about the physical

therapy treatment; n = 1). This left 75 cases (93.8%) for analysis, 43 men (57.3%) and 32 women (42.7%) with a median ± IQR age of 69.2 ± 11.7 years. Of these patients, 39 (52.0%) were identified via the Dutch national screening program for colorectal cancer. These patients had a statistically significant higher muscle strength (39.3 ± 18.4 vs 30.0 ± 22.7 kg; *P* = 0.032) and a statistically significant lower level of perceived fatigue (27.0 ± 20.0 vs 41.0 ± 34.8; *P* = 0.005). There was also a statistically significant difference in clinical tumour stages (cT1, cN1 and cN2) between these groups. Table 1 shows patient characteristics and baseline values. Treatment details and postoperative outcomes are summarized in Table 2.

Postoperative complications

Postoperatively, 27 complications (36.0%) were registered, of which 20 (74.1%) were surgical (e.g., anastomotic leakage) and seven (25.9%) were non-surgical (e.g., pulmonary complications). Five patients (6.7%) suffered from anastomotic leakage, of which one patient received preoperative radiation (in combination with chemotherapy) and two patients had preoperative anemia. Redo-surgery was necessary in 9 of the 20 patients with surgical complications (45.0%). According to the Clavien-Dindo classification there were sixteen (59.3%) grade I, one (3.7%) grade II, seven (25.9%) grade III, one (3.7%) grade IV and two (7.4%) grade V complications. The latter two patients died at the hospital due to complications following redo-surgery for anastomotic leakage (overall mortality rate of 2.7%). Eight (10.7%) readmissions were reported.

Time to recovery of physical functioning

Median ± IQR time to recovery of physical functioning was 4.0 ± 3.0 days. When data were clustered according to type of surgical procedure, transabdominal laparoscopic surgery (n = 61) versus transabdominal open surgery (n = 14), a statistically significant difference in time to recovery of physical functioning (4.0 ± 2.0 versus 8.0 ± 8.25 days; *P* < 0.001) was observed. Additionally, patients that were identified via the national screening program had a statistically significant faster time to recovery of physical functioning (4.0 ± 2.0 vs 5.5 ± 5.8 days; *P* = 0.011). A separate analysis showed no difference in time to recovery of physical functioning between laparoscopic and open surgery in the group of patients that was identified via the national screening program. In the group of patients that was identified via the general practitioner there was a statistically significant difference found between laparoscopic and open surgery (time to recovery of physical functioning of 10.0 ± 8.5 vs 4.0 ± 3.0 days; *P* = 0.006).

Results of the univariate logistic regression are shown in Table 3. Logistic regression analysis showed that functional exercise capacity, nutritional status, level of

Table 1
Participant characteristics.

		Total population (n = 75)		Identification via national screening program (n = 39)		Identification via general practitioner (n = 36)		P-value
		Median ± IQR		*Median ± IQR*		*Median ± IQR*		
Age (years)		69.2 ± 11.7		68.2 ± 10.6		72.4 ± 19.5		*NS*
BMI (kg/m²)		26.3 ± 4.6		26.9 ± 4.8		25.5 ± 4.1		*NS*
Preoperative physical fitness								
Functional exercise capacity (iSWT, m)		530.0 ± 322.5		530.0 ± 310.0		560.0 ± 420.0		*NS*
Muscle strength (handgrip strength, kg)		34.4 ± 21.3		39.3 ± 21.4		30.0 ± 23.0		*P = 0.032*
Functional mobility (TUG test, s)		5.8 ± 2.0		5.2 ± 1.6		6.0 ± 2.7		*NS*
Level of perceived fatigue (MFI score)		34.0 ± 26.0		27.0 ± 20.0		41.0 ± 25.8		*P = 0.005*
Level of physical activity (LAPAQ, min/day)		112.2 ± 106.8		132.8 ± 113.6		109.3 ± 103.9		*NS*
		n	*%*	*n*	*%*	*n*	*%*	
Sex (male)		43	57.3	25	64.1	18	50.0	*NS*
Smoking (yes)		12	16.0	8	20.5	4	11.1	*NS*
Charlson comorbidity index								
0		1	1.3	0	0.0	1	2.8	*NS*
1		7	9.3	0	0.0	7	19.4	*NS*
2		18	24.0	15	38.5	3	8.3	*NS*
3		24	32.0	16	41.0	8	22.2	*NS*
4		14	18.7	6	15.4	8	22.2	*NS*
5		5	6.7	1	2.6	4	11.1	*NS*
6		2	2.7	0	0.0	2	5.6	*NS*
7		3	4.0	1	2.6	2	5.6	*NS*
8		1	1.3	0	0.0	1	2.8	*NS*
Clinical TNM stage								
T	cT1	16	21.3	14	35.9	2	5.6	*P = 0.003*
	cT2	10	13.3	5	12.8	5	13.9	*NS*
	cT3	27	36.0	13	33.3	14	38.9	*NS*
	cT4	10	13.3	3	7.7	7	19.4	*NS*
	cTx	12	16.0	4	10.2	8	22.2	*NS*
N	cN0	36	48.0	20	51.3	16	44.4	*NS*
	cN1	13	17.3	11	28.2	2	5.6	*P = 0.014*
	cN2	18	24.0	5	12.8	13	36.1	*P = 0.010*
	cNx	8	10.7	3	7.7	5	13.9	*NS*
M	cM0	72	96.0	38	97.4	34	94.4	*NS*
	cM1	2	2.7	1	2.6	1	2.8	*NS*
	cMx	1	1.3	0	0.0	1	2.8	*NS*

Abbreviations: BMI=Body mass index (kg/m²); IQR = interquartile range; iSWT = incremental shuttle walk test; LAPAQ = LASA physical activity questionnaire; MFI = Multidimensional fatigue index; NS = not statistically significant; TNM = Tumour, Node, Metastasis; TUG = timed up-and-go.

perceived fatigue score, and muscle strength were independent predictors of non-surgical complications. The model with functional exercise capacity predicted 14.8% of the variance in non-surgical complications (pseudo R^2). A higher functional exercise capacity and higher muscle strength were associated with smaller odds ratio's (ORs) for non-surgical complications. If walking distance on the iSWT increased by 1 m, the odds of experiencing non-surgical complications decreased by 0.005. Hence, if the preoperative walking distance increased by 100 m, the odds of experiencing a non-surgical complication decreases with 0.5. Patients with a worse nutritional status and a higher level of perceived fatigue were more likely to experience non-surgical complications. ROC analysis depicted in Fig. 2 shows the value of the iSWT to predict non-surgical complications. The area under the curve (95% confidence interval) was 0.755 (0.592−0.918, $P = 0.027$).

Further analysis showed that Charlson comorbidity index, identification via the national screening program, age, functional exercise capacity, functional mobility, level of perceived fatigue, and level of physical activity were independent predictors of a longer time to recovery of physical functioning. The OR for functional mobility was 1.274, which indicates that each 1-s increase in TUG test outcome increased the odds of having a prolonged time to recovery of physical functioning by 0.274. The model with the level of perceived fatigue had a pseudo R^2 of 19.3%. The American Society of Anesthesiologists score was not related to postoperative outcomes.

Multivariate logistic regression analysis gave additional value in the prediction of postoperative time to recovery of physical functioning. The level of perceived fatigue (OR of 1.044, 95% confidence interval (CI) of 1.013−1.076) and physical activity level (OR of 0.995, 95% CI of 0.989−1.002) were associated with 22.8% of the variance

Table 2
Participant treatment details and postoperative outcomes.

		Total population (n = 75)		Identification via national screening program (n = 39)		Identification via general practitioner (n = 36)		P-value
		n	%	n	%	n	%	
Tumour distance from anal verge (cm)								
<5.0		5	6.7	1	2.6	4	11.1	NS
5.1—10.0		15	20.0	5	12.8	10	27.8	NS
>10.1		55	73.3	33	84.6	22	61.1	NS
Operation type								
Transabdominal laparoscopic		61	81.3	35	89.7	26	72.2	NS
Transabdominal open		14	18.7	4	10.3	10	27.8	NS
Surgery								
Extended right hemicolectomy		19	25.3	8	20.5	10	27.8	NS
Transversum resection		1	1.3	0	0.0	1	2.8	NS
Extended left hemicolectomy		6	8.0	5	12.8	1	2.8	NS
Low anterior resection		44	58.7	24	61.5	21	58.3	NS
Abdomino-perianal resection		5	6.7	2	5.1	3	8.3	NS
Pathological TNM stage								
T	pT0	0	0.0	0	0.0	0	0.0	NS
	pT1	22	29.3	18	46.2	4	11.1	NS
	pT2	21	28.0	9	23.1	12	33.3	NS
	pT3	27	36.0	11	28.2	16	44.4	NS
	pT4	5	6.7	1	2.6	4	11.1	NS
N	pN0	49	65.3	24	61.5	27	75.0	NS
	pN1	23	30.7	15	38.5	8	22.2	NS
	pN2	3	4.0	0	0.0	3	8.3	NS
M	pM0	68	90.7	38	97.4	30	83.3	NS
	pM1	3	4.0	1	2.6	2	5.6	NS
	pMx	4	5.3	0	0.0	4	13.9	NS
Neoadjuvant treatment								
Radiation								
Chemoradiation		15	20.0	4	10.3	11	15.9	NS
Short term radiation		3	4.0	2	5.1	1	2.8	NS
Chemotherapy		10	13.3	3	7.7	7	19.4	NS
ASA score								
I		13	17.3	8	20.5	5	13.9	NS
II		46	61.3	25	64.1	21	58.3	NS
III		16	21.3	6	15.4	10	27.8	NS
Postoperative outcomes								
Complications		27	36.0	12	30.8	15	41.7	NS
Readmission		8	10.7	3	7.7	5	13.9	NS
Mortality		2	2.7	1	2.6	1	2.8	NS
		Median ± IQR		*Median ± IQR*		*Median ± IQR*		
Length of stay (days)		6.0 ± 6.0		5.0 ± 3.0		7.5 ± 6.8		P = 0.009
Time to recovery of physical functioning (days)		4.0 ± 3.0		4.0 ± 2.0		5.5 ± 5.8		P = 0.011

Abbreviations: ASA = American Society of Anaesthesiologists score; NS = not statistically significant; TNM = Tumour, Node, Metastasis.

in time to recovery of physical functioning. Patients with a higher level of perceived fatigue and a lower level of preoperative physical activity were more likely to have a longer time to recovery of physical functioning. Surgical complications and readmissions could not be predicted with the current data set and statistical analyses.

Discussion

The aim of this study was to evaluate the associations between preoperative parameters of physical fitness and postoperative outcome in patients with colorectal cancer

scheduled for elective colorectal resection. The results of this study show that several preoperative parameters are associated with the patient's postoperative outcome. Functional exercise capacity, functional mobility, level of perceived fatigue, and level of physical activity were independent predictors of a shorter time to recovery of physical functioning. Preoperative physical functioning (functional exercise capacity, muscle strength, level of perceived fatigue) and nutritional status were associated with the presence of non-surgical complications. Patients with a better preoperative level of physical fitness are less likely to experience non-surgical complications. In addition, patients

Table 3
Results of univariate logistic regression analysis.

Outcome variable	Predictor variable	B	Wald	P-value	Odds ratio (OR)	Nagelkerke R^2
Non-surgical complications (0 = absent, 1 = present)	Functional exercise capacity (iSWT, m)	−0.005	3.961	0.047	0.995 (0.991−1.000)	0.148
	Nutritional status (short nutritional assessment questionnaire)[a]	0.291	2.118	0.146	1.338 (0.904−1.981)	0.054
	Level of perceived fatigue (MFI score)[b]	0.034	4.006	0.045	1.034 (1.001−1.069)	0.108
	Muscle strength (handgrip strength, kg)	−0.051	2.149	0.143	0.951 (0.888−1.017)	0.069
Time to recovery of physical functioning (0 = recovery of physical functioning in ≤ 4 days, 1 = recovery of physical functioning in ≥ 5 days)	Charlson comorbidity index	0.472	6.655	0.010	1.604 (1.120−2.296)	0.137
	National screening program (yes or no)	0.916	3.720	0.054	2.500 (0.985−6.344)	0.066
	Age (years)	0.060	3.956	0.047	1.061 (1.001−1.126)	0.074
	Functional exercise capacity (iSWT, m)	−0.002	4.577	0.032	0.998 (0.996−1.000)	0.094
	Functional mobility (TUG test, s)[c]	0.242	3.152	0.076	1.274 (0.975−1.664)	0.065
	Level of perceived fatigue (MFI score)[b]	0.046	8.970	0.003	1.047 (1.016−1.078)	0.193
	Level of physical activity (LAPAQ, min/day)	−0.006	3.714	0.054	0.994 (0.988−1.000)	0.075

Abbreviations: iSWT = incremental shuttle walk test; LAPAQ = LASA physical activity questionnaire; MFI = Multidimensional fatigue index; TUG = timed up-and-go.
[a] A higher score means a worse nutritional status.
[b] A higher score means a higher level of perceived fatigue.
[c] A higher score means a worse functional mobility.

with a worse preoperative nutritional status were more likely to experience non-surgical complications.

A ROC analysis of our data showed a value of 290 m on iSWT as the most optimal threshold to predict non-surgical complications with a sensitivity of 0.570 and a specificity of 0.890. Previous literature on the iSWT shows a threshold of 360 m [11] and 250 m [10], respectively to identify patients at risk for postoperative complications in abdominal surgery. A higher sensitivity at the ROC analysis (which is often more desirable in daily practice) provides a value of 515 m on iSWT as threshold to predict non-surgical complications with a sensitivity of 0.857 and a specificity of 0.554. Consequently, postoperative outcomes were better in patients with a preoperative walking distance of 515 m or higher.
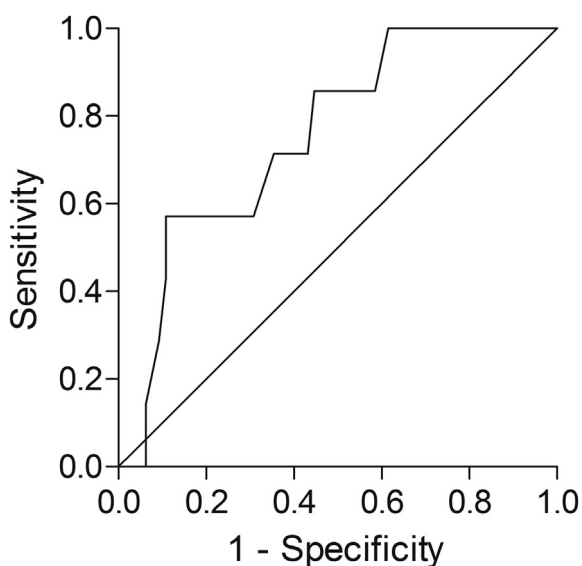

Fig. 2. ROC analysis for predicting postoperative complications from iSWT distance. Abbreviations: iSWT = incremental shuttle walk test; ROC = receiver operating characteristic.

The presence of comorbidities, identification via the general practitioner, a higher age, a lower functional exercise capacity, a lower functional mobility and physical activity level, and a higher level of perceived fatigue were associated with a longer time to recovery of physical functioning ($P < 0.200$). Previous literature already showed the role of preoperative physical fitness and physical activity and its relation with postoperative outcomes [26,27]. Feeney et al. showed that patients who developed a postoperative pulmonary complication after an esophagectomy had a lower preoperative physical activity level (20 ± 13.7 min/day versus 36 ± 20.7 min/day, $P = 0.010$) [26]. The study of Dronkers et al. showed an independent association between adequate preoperative physical activity level (OR of 5.5, 95% confidence interval of 1.400−21.900) and short-term mortality [27].

Our results showed a statistically significant shorter time to recovery of physical functioning for patients that were identified via the national screening program and patients that underwent laparoscopic surgery. Previous literature comparing laparoscopic surgery with open surgery also showed statistically significant differences in length of stay and other postoperative outcomes, with a higher overall morbidity rate, more complications, and a higher mortality rate in patients that underwent open surgery [28,29]. Patients identified via the national screening program (early inclusion) tended to be younger and fitter. Thereby, these patients had less disease-related complaints and a better TNM classification, because of the early stage of the disease. The earlier disease stage increases the options for a laparoscopic procedure, which is usually less invasive and associated with a faster medical and recovery of physical functioning [28,29]. In our patient population, the percentage of laparoscopic procedures was 89.7% in the group of patients that was identified via the national screening program (versus 72.2% in the group identified via the general practitioner).

Lessons learned

We studied patients scheduled for colorectal resection, but the used methods could probably be translated to other surgical populations as well. Our data showed statistically significant associations between functional exercise capacity, Charlson comorbidity index, level of perceived fatigue, and level of physical activity, and postoperative outcomes; however, data could not be used to develop a clear prediction rule that can sufficiently explain the variance in postoperative outcomes. A larger patient population is necessary to make a valid prediction model and this study may be seen as the groundwork hereto. A multicenter study with four hospitals has recently started in the Netherlands.

An additional analysis was performed to explore the association between individual independent variables and *desirable* postoperative outcomes (*no* complications and a *shorter* time to recovery of physical functioning). Analysis showed that a higher body mass index, identification via the national screening program, and a higher preoperative physical activity level were associated with *no* occurrence of surgical complications. A higher functional exercise capacity was associated with *no* occurrence of non-surgical complications. A laparoscopic procedure, a lower preoperative perceived level of fatigue and a higher preoperative level of physical activity were associated with a *shorter* time to recovery of physical functioning (≤4 days).

Conclusion

The current study revealed associations between preoperative physical fitness and postoperative outcome in patients with colorectal cancer scheduled for resection. A complete preoperative evaluation is valuable for patients and their caregivers and can ensure a quick start for appropriate preoperative interventions. Finally, it seems of interest to explore which (preoperative) variables can predict *desirable* postoperative outcomes. If preoperative parameters can distinguish patients not at risk from the total population, this group can be in- and/or excluded from additional preoperative interventions.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.ejso.2017.08.012.

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Conflict of interest

The authors declare no conflict of interest.

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