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Physical functioning and physical activity after gastrointestinal or bladder oncological surgery: An observational cohort study

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Abstract

Objective: The aim of this study was to investigate the recovery of physical functioning and objective physical activity levels up to 3 months after oncological surgery and to determine the association between physical activity levels and the recovery of physical functioning.

Methods: A longditudinal observational cohort study was conducted in patients who underwent gastrointestinal or bladder oncological surgery. Recovery of physical functioning was measured preoperatively, and 1 and 3 months after discharge. Physical activity was objectively measured with an accelerometer during hospitalisation, and 1 and 3 months after discharge.

Results: Between February and November 2019, 68 patients were included. Half of the patients (49%) were not recovered in physical functioning 3 months after surgery. During hospitalisation, physical activity increased from 13 to 46 median active minutes per day. At 1 and 3 months after discharge, patients were physically active for 138 and 159 median minutes per day, respectively. Patients with higher levels of physical activity 1 month after discharge showed to have higher levels of physical functioning up to 3 months after discharge.

Conclusion: At 3 months after surgery, physical functioning is still diminished in half of the patients. It is important to evaluate both physical activity levels and physical functioning levels after surgery to enable tailored postoperative mobility care.

KEYWORDS
accelerometer, oncological surgery, physical activity, physical functioning, recovery of function

1 | INTRODUCTION

Undergoing oncological surgery is a major life event. Studies evaluating postoperative recovery in patients who underwent oncological surgery mostly evaluate medical outcomes, such as length of hospital stay or complications (Neville et al., 2014). However, other outcomes may be more relevant for patients as they want to return to normal physical functioning in daily life as soon as possible after surgery (Lee et al., 2014; Miller & Mythen, 2014) Physical functioning is described as the ability to perform daily activities required to participate in the society and is a patient-reported outcome measure (PROM) (Coster et al., 2006). Other relevant PROMs are levels of fatigue and a patients' life-space (Prue et al., 2006; Stewart et al., 2009). More insight into PROMs after oncological surgery is needed to identify

patients with an increased need for support after surgery and to optimise postoperative care (Jakobsson et al., 2017).

One of the factors of influence on the level of physical functioning, is the level of physical activity (Abeles et al., 2017; Castelino et al., 2016; Lawrence et al., 2004). Elderly patients with low levels of physical activity during hospitalisation have a high risk of functional decline and loss of independence (Brown et al., 2004; Covinsky et al., 2011; Zisberg et al., 2011). Several studies suggest that physical activity levels both during and after hospitalisation are an important predictor for the recovery of physical functioning after oncological surgery (Abeles et al., 2017; Castelino et al., 2016; Lawrence et al., 2004). Nevertheless, current studies evaluating physical activity after oncological surgery did not measure physical activity with objective measures like an accelerometer, or did not include physical functioning measures as well (Carmichael et al., 2019; Jonker et al., 2020; van Zutphen et al., 2017).

Therefore, more research is needed to evaluate both physical functioning and physical activity during and after hospitalisation for oncological surgery. The primary aim of this study was to investigate recovery of physical functioning, fatigue levels and life space up to 3 months after oncological surgery. The secondary aim was to assess physical activity during and after hospitalisation and its association with the recovery of physical functioning after surgery.

2 | METHOD

2.1 | Study design and population

A prospective observational cohort study was conducted at the University Medical Centre Utrecht in the Netherlands between February and November 2019. Inclusion criteria were adult patients undergoing gastrointestinal (oesophagus, stomach, colorectal, liver and pancreas) or bladder oncological surgery. Patients were purposefully sampled to achieve an objective reflection of the population on the clinical ward. The number of patients recruited per type of cancer was based on the number of surgeries per type performed at the UMC Utrecht on a yearly basis. Patients were excluded if they had a life expectancy of less than 3 months, if the patient was not able to fill in or sign the informed consent form due to cognitive problems or if the patient was completely dependent on a wheelchair. The study protocol was assessed and approved by the medical ethics committee of University Medical Centre Utrecht (research protocol number 19/026). All participants signed informed consent, and all methods were performed in accordance with the Declaration of Helsinki.

2.2 | Outcome measures

2.2.1 | Primary outcome

Physical functioning was measured using a translated version of the Boston University Measure for Post-Acute Care (AM-PAC) Basic Mobility Outpatients Routine Short Form (Jette et al., 2016). This questionnaire consists of 18 questions about the difficulty to perform a specific activity in the outpatient setting on a scale from 1 (*unable*) to 4 (*none*). The total score ranged from 0 to 72 points, whereby a higher score represents less difficulty with performing daily activities. The questionnaire was translated into Dutch by using a forward–backward translation protocol following the guideline for the process of cross-cultural adaption of self-report measures (see Appendix in the supporting information) (Beaton et al., 2000). The AM-PAC has a minimal administration burden and excellent reliability, validity and sensitivity to changes (Coster et al., 2006; Haley et al., 2004). The minimal clinically important change lies between 3.9 and 5 points (Lee et al., 2017). Therefore, in this study participants were labelled as 'recovered' when their postoperative AM-PAC score reached their preoperative score minus 5 points.

2.2.2 | Secondary outcome

Physical activity was measured with the Physical Activity Monitor (PAM) version AM400. The PAM-AM400 (PAM B.V. Doorwerth, the Netherlands) is a small three-axial accelerometer. The PAM was attached around the ankle and measures active minutes per day. The threshold for the detection of physical activity was set at 1.4 MET. The activity monitor only registers movement above this threshold, defined as active minutes (Valkenet et al., 2022). The PAM was connected by the researcher to a smartphone application called 'AtrisZorg' via Bluetooth by which the data were sent to a data cloud. During hospitalisation, the participants were not able to see their physical activity levels. Postoperatively, patients had to synchronise the data with the 'AtrisApp' (Peercode B.V. Geldermalsen, the Netherlands), whereby active minutes became visual for the patient and data were stored in the data cloud. The PAM registers active minutes categorised into three subgroups based on metabolic equivalent of task (MET) values: light 1.4–2.4 MET, medium 2.5–5.9 MET and heavy ≥6.0 MET. The concurrent validity of the PAM was evaluated in 19 hospitalised patients admitted to different wards (gastrointestinal surgery, internal medicine, cardiology, oncology and lung disease) of the University Medical Centre Utrecht. The level of agreement between the PAM and the ActiGraph (wGT3X-BT) was strong with an Intraclass Correlation Coefficient of 0.849 indicating that the PAM is a suitable device to validly measure active minutes in hospitalised patients (Valkenet et al., 2022).

Other secondary study parameters were fatigue, life-space and perceived recovery. Furthermore, it was recorded if patients met the Dutch physical activity guideline and if patients trained under supervision of a physiotherapist postoperative. Fatigue was measured with the shortened fatigue questionnaire and consists of four questions ('I feel tired', 'I tire easily', 'I feel fit' and 'I feel physically exhausted'), which were answered on a 7-point scale. The total score ranged from 4 to 28, with higher scores representing higher levels of fatigue (Alberts et al., 1997). The life-space was assessed with the Life Space Assessment (LSA), which evaluates the mobility of the past 4 weeks

by the investigation of five space-levels (bedroom, in and around the house, the neighbourhood, inside the city and outside the city) (Peel et al., 2005). The total score ranges from 0 to 120, with a higher score representing a higher level of patients' mobility within their home and community (Baker et al., 2003). The perceived recovery was obtained by answering the question; 'to what extent are you recovered from the surgery' on a 10 point scale (0 = *not at all*, 10 *fully recovered*). The Dutch physical activity guideline was assessed by asking the question 'on how many days a week are you physically active for more than 30 consecutive minutes, on a moderate intensity' and 'on how many days a week do you perform muscle strength exercises'. Participants met the Dutch physical activity guideline if they engaged in moderate physical activity for more than 30 consecutive minutes a day on five or more days a week and if they performed muscle strengthening exercises at least twice a week (Weggemans et al., 2018). Additionally, patients were asked if they received postoperative physical therapy treatment to improve their physical functioning levels.

2.2.3 | Baseline and clinical data

Baseline and clinical data were retrieved from the electronic patients file. Baseline data included gender, age, body mass index (BMI), living situation, comorbidities (pulmonary, cardiovascular disease and diabetes mellitus), tumour location, operation technique (open versus laparoscopic) and the American Society of Anesthesiologists classification of physical health (ASA classification). Clinical data included the number of complications and the severity of the complication, graded with the Clavien Dindo Score (Clavien et al., 2009). Additionally, (neo)adjuvant therapy with chemo- and/or radiotherapy, length of hospital stay and destination after discharge were collected.

2.3 | Procedures

The assessments took place during hospitalisation and 1 and 3 months after discharge.

2.3.1 | Procedure during hospitalisation

Within 72 h after surgery, patients received information about the research and were asked to participate. If patients were eligible for the study and signed informed consent, the participants were asked to wear the PAM 24 h a day during their hospital stay. Furthermore, the participants were asked to retrospectively fill in the questionnaires within 1 week after surgery about their physical status in the last week before surgery.

2.3.2 | Procedure after discharge

At 1 and 3 months after discharge the participants received a digital questionnaire via e-mail. The PAM was sent by post, and the participants were asked to wear the PAM 24 h a day for a period of seven consecutive days. After 1 week, the participants were contacted by phone by the researcher to connect the PAM with the AtrisApp to synchronise the data with the data cloud.

2.4 | Data analysis

SPSS statistics software (IBM statistics version 25) was used for statistical analysis. Data were checked for outliers, data-entry errors and missing data. Patterns of missing data were analysed. Multiple imputation with Predictive Mean Measurements was used for imputation of all data with patient characteristics and pre- and postoperative measurements as predictors for imputation (Groenwold et al., 2012; Moons et al., 2006).

Categorical data are presented as numbers and percentages (%). Normally distributed continuous data are presented as means with standard deviations (SD) and non-normally distributed continuous data as medians with interquartile ranges [IQR]. To determine differences between preoperative levels of physical functioning and after 3 months statistical analyses were performed. For not normally distributed continuous data, a Wilcoxon sign-rank test was performed and for dichotomous data a McNemar test was performed. A linear mixed model analysis was performed to explore the association of physical activity levels (during hospitalisation and 1 month after discharge) with the level of physical functioning. Since ASA-classification is associated with postoperative physical functioning, this variable was entered in the mixed model analyses as covariate (Jakobsson et al., 2017).

3 | RESULTS

3.1 | Baseline and clinical data

A total of 68 patients were included in this study. Figure 1 provides the flow chart of the data collection. All patients filled out the preoperative questionnaire, 48 patients after 1 month and 46 patients after 3 months. The reasons for missing physical functioning data were lost to follow up (not willing to participate after discharge and re-admission) and not filled out the questionnaire (1 month after discharge $n = 5$, 3 months after discharge $n = 7$). Physical activity was measured in 48 patients (71%) during hospitalisation, in 41 patients (60%) after 1 months and 33 patients (49%) after 3 months. The main reason for missing physical activity data were non-wear and technical issues. Multiple imputation was used to handle missing data.

Table 1 provides an overview of the patient characteristics, surgical characteristics and postoperative outcomes in patients after oncological surgery. Overall, the mean (SD) age was 63 ± 12 and 63% of the patients were male. Patients had a tumour in the oesophagus ($n = 18$, 27%), stomach ($n = 5$, 7%), colon or rectum ($n = 17$, 25%), liver ($n = 15$, 22%), pancreas ($n = 4$, 6%) or bladder ($n = 9$, 13%). Complications occurred in 16 patients (24%). No statistical significant

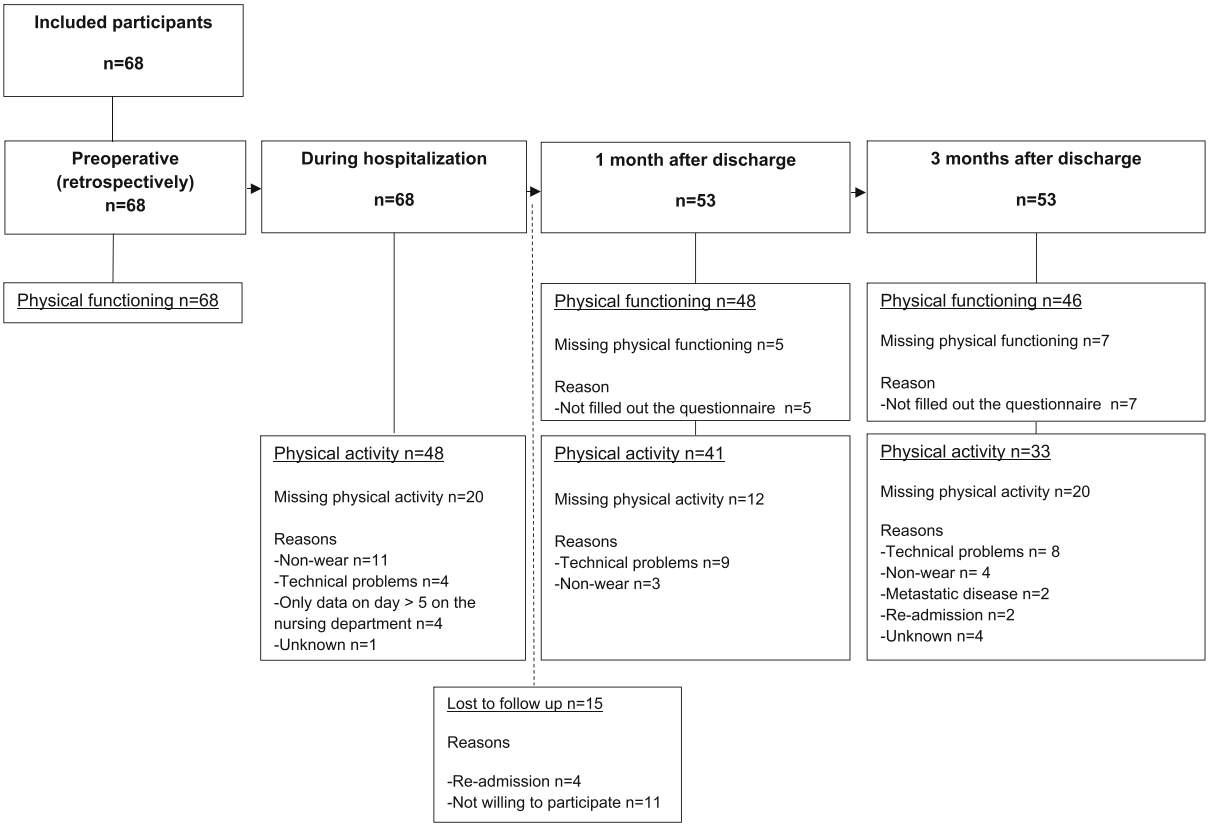

FIGURE 1 Flow chart of the data collection

differences were found in baseline and clinical data between patients with complete ($n = 46$) and incomplete data ($n = 22$) of physical functioning, 3 months after discharge.

3.2 | Recovery of physical functioning

Preoperatively, the median score of physical functioning was 61 (IQR 18) out of 72. One and 3 months postoperatively, patients had a median score of respectively 51 (IQR 11) and 55 (IQR 10). Patients had a significant lower level of physical functioning 3 months after discharge compared to preoperatively (-6, $p < 0.001$). Furthermore, a significant higher level of fatigue and lower level of life-space was seen 3 months after discharge compared to preoperatively (fatigue $+7$, <0.001) (life-space -17, <0.001), see Table 2. No difference in physical activity was found between preoperative levels compared to levels 3 months after discharge (Table 2).

After 1 month, 22 patients (32%) were recovered in physical functioning compared to their preoperative score. After 3 months, 33 patients (49%) were recovered. Physical functioning 1 month after discharge was significantly lower compared to the level of physical functioning 3 months after discharge (β -2.853; 95%CI -4.803 to -0.903, $p = 0.004$) (Table 4).

3.3 | Physical activity levels during and after hospitalisation

Overall, the median number of active minutes during the first 5 days during hospitalisation on the nursing department was 37 (IQR 13) minutes a day (Table 3). An increase in active minutes per day was seen from day 1 to day 5. One and 3 months after discharge, the median active minutes per day was respectively 138 (IQR 11) and 159 (IQR 7) minutes (Table 3).

3.4 | Association between the amount of physical activity and the level of physical functioning after discharge

A higher level of physical activity 1 month after discharge was associated with a higher level of physical functioning between 1 and 3 months after discharge (β 0.151; 95%CI 0.095–0.207, $p < 0.001$) (Table 4).

4 | DISCUSSION

This prospective observational cohort study investigated the recovery of physical functioning in patients undergoing oncological surgery.

TABLE 1 Patients' characteristics, surgical characteristics and postoperative outcomes in patients after oncological surgery

Patient characteristics	$n = 68$
Male, *n* (%)	43 (63)
Age in years, mean ± SD	63 ± 12
BMI, mean ± SD	26 ± 4
Living alone, *n* (%)	11 (16)
Comorbidities, *n* (%)	
• Pulmonary	9 (13)
• Cardiovascular	22 (32)
• Diabetes mellitus	7 (10)
ASA classification, *n* (%)	
• I	4 (6)
• II	44 (65)
• III	17 (25)
• Unknown	3 (4)
Pretreatment, *n* (%)	
• No	36 (53)
• Chemotherapy	13 (19)
• Radiotherapy	4 (6)
• Chemoradiotherapy	15 (22)
Surgical characteristics	
Tumour location, *n* (%)	
• Oesophagus	18 (27)
• Stomach	5 (7)
• Colorectal	17 (25)
• Liver	15 (22)
• Pancreas	4 (6)
• Bladder	9 (13)
Operation technique, *n* (%)	
• Laparoscopic	57 (84)
• Open	7 (10)
• Other (transurethral resection)	4 (6)
Postoperative outcomes	
Complications, *n* (%)	16 (24)
Clavien Dindo classification, *n* (%)	
I/II/III/IV	3 (4) / 5 (7) /5 (7) /3 (4)
Length of stay in hospital, median (IQR)	7 (7)
Destination after discharge, *n* (%)	
• Home	63 (93)
• Rehabilitation centre	5 (7)
Post-treatment, n (%)	
• No	56 (82)
• Chemotherapy	6 (9)
• Missing	6 (9)

Abbreviations: ASA classification, American Society of Anesthesiologists Classification of physical health; BMI, body mass index; IQR, interquartile range.

Half of the patients (49%) were not recovered in physical functioning 3 months after surgery. During the first 5 days of hospitalisation, physical activity increased from 13 to 46 active minutes per day. After discharge, physical activity levels were respectively 138 and 159 active minutes per day 1 and 3 months after discharge. Higher levels of physical activity 1 month after discharge were associated with higher levels of physical functioning up to 3 months after discharge.

For patients it is important to return to their preoperative level of physical functioning as soon as possible. The low percentage of patients that recovered 3 months after discharge is in line with previous studies that evaluated the recovery of physical functioning after colorectal and abdominal surgery (Lawrence et al., 2004; van Zutphen et al., 2017). These findings emphasise the high impact of oncological surgery on physical functioning of patients after oncological surgery, not only during hospitalisation but also in the period after discharge.

In this study, patients were physically active 3% of the day during hospitalisation, which is in line with previous studies who found low physical activity levels during hospitalisation (Brown et al., 2009; Mudge et al., 2016; Ostir et al., 2013; Pedersen et al., 2013). No association was found between the level of physical activity during hospitalisation and the recovery of physical functioning after discharge. This is in contrast with previous published studies who concluded that the level of physical activity during hospitalisation is related to functional decline 1 month after hospitalisation (Brown et al., 2004; Zisberg et al., 2011). The low variety in levels of physical activity in our study could be the reason why no association was found, since outcomes could not be compared to patients with higher levels of physical activity during hospitalisation.

At 1 and 3 months after discharge, patients were on average physically active for 138 and 159 min per day, respectively. The physical activity levels found in this study were lower compared to a previous published study, which showed that patients where 266 min per day physical active 4 weeks after abdominal surgery (van der Meij et al., 2017). However, these patients underwent other types of abdominal surgery (adnexal, inguinal hernia repair, cholecystectomy and hysterectomy), which makes it hard to compare. Our study showed that a higher level of physical activity after 1 month was associated with higher levels of physical functioning after discharge. This is in line with another study in patients with colorectal cancer, which showed that a higher physical activity level 6 months after surgery was associated with enhanced recovery of physical functioning (van Zutphen et al., 2017). However, the question remains if higher activity levels lead to higher physical functioning levels or that patients with higher physical functioning were able to be more physically active.

Nevertheless, a causal relationship between higher levels of physical activity and enhanced postoperative recovery of physical functioning is plausible. A recent published systematic review showed the impact of mobilisation during hospitalisation in medically ill patients on postoperative recovery of physical functioning (Cortes et al., 2019). Additionally, literature shows that better adherence to in-hospital mobilisation protocols after lung cancer surgery is related to improved physical fitness after hospital discharge (van der Leeden et al., 2019). Since physical inactivity is deeply rooted in the hospital culture, it seems important to start promoting physical activity levels early after surgery to optimise recovery after surgery (Cortes et al., 2019; Kolovos, 2020; Smart et al., 2018). A promising and upcoming technology to improve physical activity levels are activity trackers (Cook et al., 2013; Smart et al., 2018; van der Meij et al., 2017). They can provide insight in the trajectory of physical activity levels following surgery for both the patient and healthcare

TABLE 2 Physical functioning preoperative and 1 and 3 months postoperative

	n	Pre-operative	1 month after discharge	3 months after discharge	Differences (preoperative − 3 months after discharge)	*p*-value
Physical functioning, median (IQR)	68	61 (18)	51 (11)	55 (10)	−6	0.000*
Fatigue, median (IQR)	68	11 (16)	17 (4)	18 (4)	7	0.000*
Life-space, median (IQR)	68	90 (26)	56 (19)	73 (13)	−17	0.000*
Dutch guideline of physical activity, *n* (%)	68	17 (25)	13 (19)	20 (29)	3	0.678
Perceived recovery 0–10, median (IQR)	68	N.A.	6 (2)	7 (1)	N.A.	N.A.
Physical therapy treatment, *n* (%)	68	N.A.	7 (10)	11 (16)	N.A.	N.A.

Note: Statistical analysis includes the Wilcoxon signed-rank test for continuous data and the McNemar test for dichotomous data.
Abbreviations: IQR, interquartile range; N.A., not applicable.
*p-value < 0.05.

TABLE 3 Median number of active minutes during hospitalisation and 1 and 3 months after discharge in patient after oncological surgery

Active minutes per day	*n*	Light	Medium	Heavy	Total
During hospitalisation (day 1–5), median (IQR)	68	27 (8)	7 (6)	0 (0)	**37 (13)**
• Day 1		11 (3)	3 (1)	0 (0)	**13 (3)**
• Day 2		24 (6)	5 (4)	0 (0)	**28 (5)**
• Day 3		30 (10)	7 (6)	0 (0)	**37 (11)**
• Day 4		31 (6)	8 (6)	0 (0)	**42 (8)**
• Day 5		33 (6)	12 (9)	0 (1)	**46 (8)**
1 month after discharge, median (IQR)	68	84 (8)	51 (11)	3 (1)	**138 (11)**
3 months after discharge, median (IQR)	68	97 (6)	57 (5)	5 (3)	**159 (7)**

Note: light = 1.4–2.4 MET; medium = 2.5–5.9 MET; heavy = ≥6.0 MET.
Abbreviation: IQR, interquartile range.

TABLE 4 Regression coefficients for the relationship between physical activity, time and the course of physical functioning after discharge

	n	β (95%CI)	*p*-value
Active minutes during hospitalisation (day 1–5)	68	0.056 (−0.048–0.160)	0.286
Active minutes 1 month after discharge	68	0.151 (0.095–0.207)	0.000*
Time[a]	68	−2.815 (−4.846–0.785)	0.007*

Note: Statistical analyses included a linear mixed model analyses, corrected for ASA-classification.
β = regression coefficient; 95%CI = 95% confidence interval.
[a]The reference value is physical functioning at 3 months.
*p-value < 0.05.

professional (Carmichael et al., 2019). Hereby, healthcare professionals can provide more tailored advise to optimise physical activity levels or can identify patients showing signs of inadequate progress of recovery in their home-situation (Carmichael et al., 2019). Therefore, the next step of our research is to implement an activity tracker in usual care to improve physical activity levels after surgery and to explore the effect on the recovery of physical functioning.

4.1 | Strengths and limitations

This study showed that oncological surgery has a high impact on daily functioning up to 3 months after discharge. In addition, physical activity was objectively measured. This insight might contribute to initiatives to improve postoperative physical activity levels in the future. There were also some limitations in this study. First of all, preoperative physical functioning was measured retrospectively. This might have caused recall bias. However, literature suggests that a short recall period reduces the chance of recall bias (Althubaiti, 2016). Second, there was a large amount of missing data. No statistical differences were found in baseline characteristics between patients with complete follow-up data and patients with missing data. However, it is possible that frailer patients had a higher drop-out rate. Although not all the missing data was at random, imputation gives less biased estimates in comparison to not addressing the missing data at all (Groenwold et al., 2012; Madley-Dowd et al., 2019). Third, the

researchers observed that the participants with more complications were more often not willing to participate in this study, which might have led to selection bias and potentially to an overestimation of physical activity and physical functioning levels. Fourth, this study evaluated physical functioning up to 3 months after discharge. More than half of the patients was not recovered within this timeframe. Therefore, a longer follow up is needed to explore whether patients return to baseline functioning. Fifth, physical activity was measured with an activity tracker. Despite the fact that patients were blinded for their active minutes, wearing an activity tracker might have had positive influence on patient's physical activity level. Therefore, patients' physical activity level both during and after hospital stay might have been even lower. Sixth, as this study included a heterogeneous population in terms of operation type, the ability to determine patient recovery trajectories to specific patients' populations is limited. Finally, Enhanced Recovery After Surgery (ERAS) protocols including early mobilisation are widely implemented after surgery. As each patient population has its own ERAS protocol, differences in postoperative care possibly led to differences in physical activity levels and postoperative recovery between patient populations.

5 | CONCLUSION

Physical functioning 3 months after oncological surgery is diminished in half of the patients emphasising the high impact of oncological surgery on patients. Higher physically activity levels 1 month after discharge were associated with higher levels of physical functioning up to 3 months after discharge. Therefore, it is important to evaluate both physical activity levels and physical functioning levels after surgery to enable tailored postoperative mobility care to optimise recovery after oncological surgery.

CONFLICT OF INTEREST

None.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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