

# Possible Sarcopenia and Functional Decline After Colorectal or Gastric Cancer Surgery

NAOHIRO FURUYA<sup>1</sup>, JUNICHI ANDO<sup>1</sup>, HINATA MURAKAMI<sup>1</sup>, AOI HASHIMOTO<sup>1</sup>, YUKI TAKANO<sup>2</sup> and DAISUKE SOMA<sup>2</sup>

<sup>1</sup>Department of Rehabilitation, Saitama Sekishinkai Hospital, Saitama, Japan;

<sup>2</sup>Department of Surgery, Saitama Sekishinkai Hospital, Saitama, Japan

## Abstract

**Background/Aim:** While possible sarcopenia may influence short-term outcomes following gastrointestinal cancer surgery, its relationship with physical function at discharge remains poorly characterized. This study investigated the association between preoperative possible sarcopenia and functional decline at discharge.

**Patients and Methods:** This single-center retrospective cohort study included 200 consecutive patients who underwent elective colorectal or gastric cancer resection at Saitama Sekishinkai Hospital between January 2024 and August 2025. Possible sarcopenia was defined according to the Asian Working Group for Sarcopenia 2025 (AWGS 2025) criteria. Functional decline at discharge was defined as a decrease of  $\geq 1$  point in the Short Physical Performance Battery (SPPB) total score from the preoperative assessment to discharge. Modified Poisson regression was used to estimate relative risks (RRs) and 95% confidence intervals (CIs).

**Results:** Of the 200 patients, 54 (27.0%) had possible sarcopenia and 37 (18.5%) showed functional decline at discharge. Functional decline occurred in 19 of 54 patients (35.2%) with possible sarcopenia and in 18 of 146 patients (12.3%) without possible sarcopenia. Possible sarcopenia was associated with functional decline in the crude model (RR=2.85, 95%CI=1.59-5.15;  $p < 0.001$ ), after adjustment for age and sex (RR=2.43, 95%CI=1.30-4.57;  $p = 0.006$ ), and after further adjustment for body mass index, Charlson Comorbidity Index, cancer location, surgical method, and preoperative SPPB scores (RR=2.15, 95%CI=1.09-4.25;  $p = 0.027$ ). Similar results were observed in patients aged  $\geq 65$  years.

**Conclusion:** Preoperative possible sarcopenia was independently associated with functional decline at discharge after colorectal or gastric cancer resection. Handgrip strength assessment may be a practical preoperative screening tool for identifying patients at risk and for planning perioperative rehabilitation or prehabilitation.

**Keywords:** Colorectal neoplasms, gastric neoplasms, sarcopenia, handgrip strength, short physical performance battery.



Naohiro Furuya, 2-37-20, Irumagawa, Sayama-shi, Saitama 350-1305, Japan. Tel: +81 429536611, e-mail: naohiro.furuya.0513@gmail.com

Received April 20, 2026 | Revised May 16, 2026 | Accepted May 18, 2026



This is an open access article under the terms of the Creative Commons Attribution License, which permits use, distribution and reproduction in any medium, provided the original work is properly cited.  
©2026 The Author(s). Published by the International Institute of Anticancer Research.

## Introduction

The incidence of gastrointestinal cancer is increasing among older populations. Colorectal cancer is the third most common cancer, and gastric cancer is the fifth most common cancer globally (1). Surgical resection is the primary curative treatment for these solid tumors (2). Recovery of physical function after abdominal surgery can be delayed, particularly in patients who develop postoperative complications (3, 4). The Short Physical Performance Battery (SPPB) is a validated measure of lower extremity physical function and is widely used in older adults and patients with cancers (5, 6). Lower SPPB scores have been associated with poorer activities of daily living and worse prognosis (7-9). Therefore, simple preoperative indicators that can identify patients at risk of functional decline after surgery are required.

Sarcopenia is characterized by low muscle strength and reduced skeletal muscle mass (10). Previous studies have linked sarcopenia to adverse outcomes, such as postoperative complications, extended hospital stays, and increased mortality (11, 12). The Asian Working Group for Sarcopenia 2025 (AWGS 2025) recently updated its criteria and introduced the concept of “possible sarcopenia,” which is defined by low muscle strength alone. Because handgrip strength can be measured quickly and without specialized equipment, possible sarcopenia has the potential to serve as a practical preoperative screening tool.

Previous studies have primarily focused on the association between sarcopenia defined by low muscle mass and poor prognosis (11, 12). However, the relationship between possible sarcopenia, assessed using handgrip strength measurements, and postoperative physical function has not been investigated. If this association is confirmed, handgrip strength assessment could serve as a convenient tool for preoperative risk stratification. Therefore, we conducted a single-center retrospective cohort study to investigate whether preoperative possible sarcopenia, defined by the AWGS 2025 criteria, is associated with functional decline at discharge in patients undergoing

elective colorectal or gastric cancer resection. We hypothesized that patients with possible sarcopenia would have a higher risk of functional decline, as measured using the SPPB, at discharge.

## Patients and Methods

*Study design and patients.* We present the results of this single-center, retrospective observational study conducted at the Saitama Sekishinkai Hospital, a 470-bed acute-care facility. We included consecutive patients admitted between January 2024 and August 2025 who underwent elective primary resection for colorectal or gastric cancer and were discharged after perioperative rehabilitation. The study was approved by the Institutional Review Board (Approval No. 2025-66) and conducted in accordance with the Declaration of Helsinki. Written informed consent was waived owing to the retrospective design. All physical assessments, including handgrip strength and SPPB, were part of routine clinical care under the standardized perioperative clinical pathway at our institution and were not performed specifically for this study. Reporting followed the STROBE statement (13).

*Perioperative management and rehabilitation.* No structured outpatient or inpatient prehabilitation programs were in place during the study period. Patients were excluded if they lacked preoperative or perioperative rehabilitation records, died during the hospital stay, or had missing data. Early mobilization began on postoperative day 1, and oral intake was initiated on postoperative day 2, following the standardized clinical pathway. Perioperative rehabilitation was standardized in the clinical pathway from September 2024 onward. Rehabilitation was provided by a physical therapist and/or occupational therapist and included muscle strengthening, gait training, and cycle ergometry, with the program adjusted to each patient's condition until discharge.

*Definition of possible sarcopenia.* Possible sarcopenia was defined based on handgrip strength according to the

AWGS 2025 criteria. The cutoff values were <28 kg for men aged  $\geq 65$  years, <34 kg for men aged <65 years, <18 kg for women aged  $\geq 65$  years, and <20 kg for women aged <65 years (10). Participants were classified into groups with and without possible sarcopenia.

**Outcome measure.** Physical function was assessed using the SPPB. The primary outcome was functional decline at discharge, defined as a  $\geq 1$ -point decrease in SPPB sum score between the preoperative assessment and discharge, in line with the substantial meaningful change reported by Perera *et al.* (14). Preoperative SPPB was measured during the preoperative waiting period after admission, and discharge SPPB was assessed within three days before discharge, including the day of discharge. Gait speed was measured over a 4-m timed section within a 6-m walkway; the five-times chair-stand test was performed using a 42-cm armless chair; and balance was assessed in side-by-side, semi-tandem, and tandem stances for up to 10 s each.

**Data collection.** Data extracted from electronic medical records included age, sex, body mass index (BMI), Charlson Comorbidity Index (CCI) (15, 16), tumor location (colorectal or gastric), pathological stage (stage III or higher vs. lower), preoperative treatment, surgical method (open vs. minimally invasive), duration of surgery, blood loss, margin status, postoperative analgesia (patient-controlled epidural analgesia or intravenous patient-controlled analgesia), postoperative day 1 laboratory values (serum albumin, C-reactive protein, white blood cell count, and hemoglobin) (17-19), postoperative intensive care unit admission, postoperative complications (occurrence and severity), Eastern Cooperative Oncology Group Performance Status (ECOG PS)  $\geq 2$  (20), preoperative calf circumference and handgrip strength, pre- and discharge SPPB scores, duration and frequency of postoperative rehabilitation, postoperative day of first gait exercise, and postoperative initial oral intake, and postoperative length of hospital stay (PLOS). Postoperative complications were graded according to the Clavien–Dindo

classification (21). Complications of Grade II or higher were considered clinically relevant, whereas those of Grade III or higher were considered severe. Handgrip strength and calf circumference were recorded as the higher value from either side.

**Statistical analysis.** Continuous variables are expressed as medians (interquartile range; IQR) and categorical variables as counts (percentages). Because functional decline was relatively common in our cohort, we used modified Poisson regression with robust error variance to directly estimate relative risks (RR), avoiding the overestimation that occurs when odds ratios are used as a common outcome (22).

We built several models to examine the association between possible sarcopenia and functional decline at discharge; RR and 95 % confidence intervals (95%CI) were calculated for each. The crude model was a univariate modified Poisson regression. Model 1 was adjusted for age and sex. Model 2 additionally included BMI, CCI, cancer location, surgical method, and preoperative SPPB scores. Model 3 was an exploratory model that further added postoperative complications classified by the Clavien–Dindo classification and PLOS to Model 2. Covariates were chosen beforehand on the basis of clinical reasoning and earlier reports (3, 4, 18, 19, 23).

For sensitivity analysis, the crude and multivariate models were re-run in a subgroup of patients aged  $\geq 65$  years, given their higher susceptibility to geriatric syndromes. Analyses were performed using R (version 4.5.2; R Foundation for Statistical Computing, Vienna, Austria), with a two-sided  $p < 0.05$  considered statistically significant.

## Results

Of the 317 patients who met the eligibility criteria during the study period, 200 were included in the analysis. A total of 117 patients were excluded for the following reasons: 44 had no preoperative rehabilitation, 35 had no perioperative rehabilitation, 35 had missing data, and 3

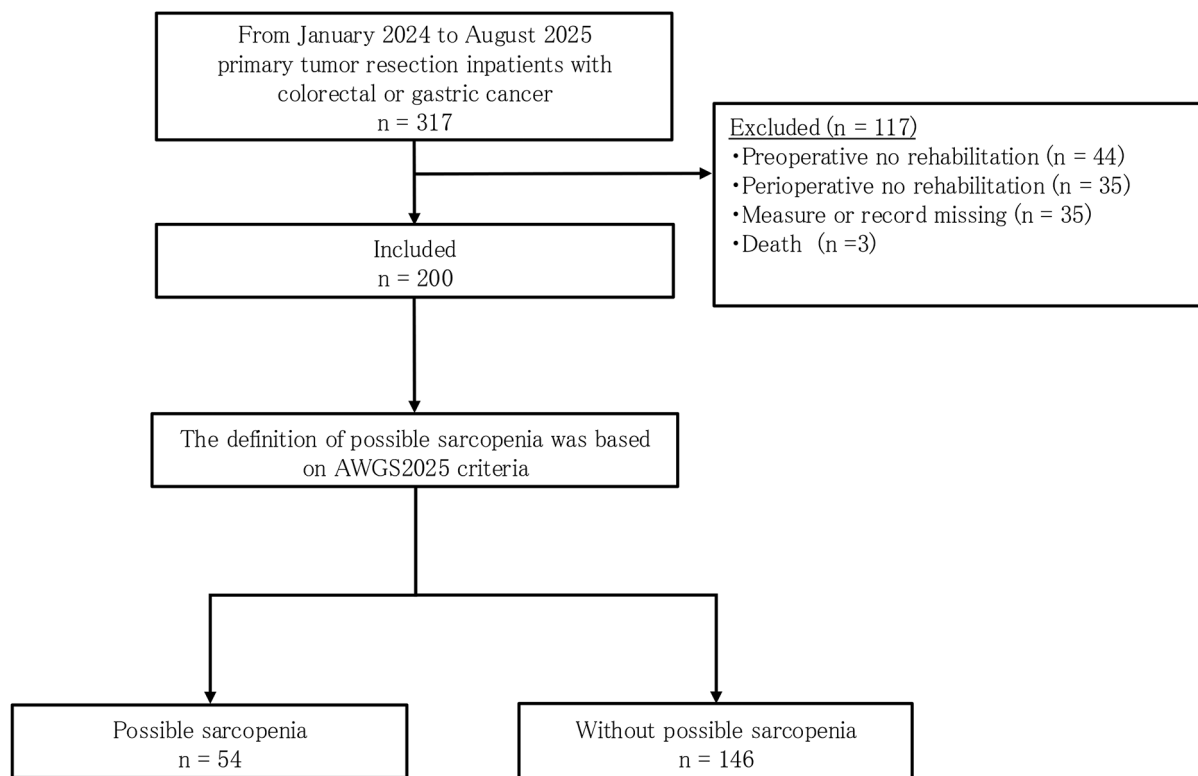


Figure 1. Flow diagram of patients with and without possible sarcopenia.

died during the hospital stay. Among these 200 patients, 54 (27.0%) had possible sarcopenia. Functional decline at discharge was observed in 37 patients (18.5%). Figure 1 shows the flow diagram.

The baseline characteristics of the study population are shown in Table I. The median age of the entire cohort was 77.0 years (IQR=69.8-83.0), 127 patients (63.5%) were male, and the median BMI was 21.7 kg/m<sup>2</sup> (IQR=19.4-24.0). Colorectal cancer accounted for 166 patients (83.0%) and gastric cancer for 34 patients (17.0%). Minimally invasive surgery was performed in 181 patients (90.5%).

Compared with patients without possible sarcopenia, those with possible sarcopenia were older (median, 81.5 vs. 75.0 years;  $p<0.001$ ), had a lower BMI (20.0 vs. 22.1 kg/m<sup>2</sup>;  $p<0.001$ ), and had a lower preoperative SPPB scores (11.0 vs. 12.0 points;  $p<0.001$ ). Postoperative day 1 serum albumin (2.9 vs. 3.1 g/dl;  $p=0.001$ ) and hemoglobin (10.1

vs. 11.0 g/dl;  $p=0.001$ ) levels were also lower in the possible sarcopenia group. The proportion of patients with ECOG PS  $\geq 2$  was higher in the possible sarcopenia group (11.1% vs. 2.1%;  $p=0.018$ ). Despite receiving longer daily rehabilitation sessions (26.3 vs. 22.5 min;  $p=0.003$ ), the possible sarcopenia group had a higher rate of functional decline at discharge (35.2% vs. 12.3%;  $p<0.001$ ). There was no significant difference in the incidence of postoperative complications between the two groups ( $p=0.170$ ).

Table II shows the incidences and severities of postoperative complications. In the group without possible sarcopenia, five patients had more than one postoperative complication each.

Table III shows the results of the modified Poisson regression for the entire cohort. Across all models, possible sarcopenia was significantly associated with functional decline at discharge: crude model (RR=2.85, 95%CI=1.59-5.15;  $p<0.001$ ), Model 1 (RR=2.43, 95%CI=1.30-4.57;

Table I. Patient characteristics.

| Variables                                     | Overall<br>(n=200)         | Possible sarcopenia<br>(n=54) | Without possible sarcopenia<br>(n=146) | p-Value |
|---|----------------------------|-------------------------------|--|---------|
| Age, years                                    | 77.0 (69.8-83.0)           | 81.5 (76.3-85.0)              | 75.0 (68.3-81.0)                       | <0.001  |
| Male  | 127 (63.5)                 | 30 (55.6)                     | 97 (66.4)                              | 0.210   |
| BMI, kg/m <sup>2</sup>                        | 21.7 (19.4-24.0)           | 20.0 (18.4-21.8)              | 22.1 (20.5-24.5)                       | <0.001  |
| CCI   | 1 (0-2)                    | 1 (0-3)                       | 1 (0-2)                                | 0.015   |
| Colorectal                                    | 166 (83.0)                 | 46 (85.2)                     | 120 (82.2)                             | 0.773   |
| pStage ≥III                                   | 78 (39.0)                  | 26 (48.1)                     | 52 (35.6)                              | 0.147   |
| Preoperative treatment                        |                            |                               |  | 0.766   |
| No treatment                                  | 182 (91.0)                 | 48 (88.9)                     | 134 (91.8)                             |         |
| Chemotherapy                                  | 11 (5.5)                   | 4 (7.4)                       | 7 (4.8)                                |         |
| Endoscopic                                    | 7 (3.5)                    | 2 (3.7)                       | 5 (3.4)                                |         |
| Intraoperative factors                        |                            |                               |  |         |
| Open  | 19 (9.5)                   | 8 (14.8)                      | 11 (7.5)                               | 0.198   |
| Duration of surgery, minutes                  | 236.0 (193.5-306.0)        | 245.0 (206.8-306.8)           | 232.5 (189.3-304.3)                    | 0.234   |
| Blood loss, ml                                | 20.0 (0-80.0)              | 45.0 (0.0-118.8)              | 20.0 (0.0-75.0)                        | 0.066   |
| Positive surgical margins                     | 3 (1.5)                    | 3 (5.6)                       | 0 (0.0)                                | 0.027   |
| PCEA  | 180 (90.0)                 | 47 (87.0)                     | 133 (91.1)                             | 0.559   |
| Postoperative laboratory data                 |                            |                               |  |         |
| Alb, g/dl                                     | 3.0 (2.8-3.3)              | 2.9 (2.6-3.1)                 | 3.1 (2.8-3.3)                          | 0.001   |
| CRP, mg/dl                                    | 5.5 (3.7-7.4)              | 5.4 (3.7-7.1)                 | 5.5 (3.7-7.6)                          | 0.838   |
| WBC, ×10 <sup>3</sup> /μl                     | 8,250.0 (7,207.0-10,787.5) | 8,215.0 (7,337.5-10,257.5)    | 8,315.0 (7,192.5-10,840.0)             | 0.736   |
| Hb, g/dl                                      | 10.8 (9.9-11.9)            | 10.1 (9.2-11.2)               | 11.0 (10.1-12.0)                       | 0.001   |
| Perioperative factors                         |                            |                               |  |         |
| Postoperative ICU admission                   | 3 (1.5)                    | 1 (1.9)                       | 2 (1.4)                                | 1.000   |
| Initial oral intake, days                     | 2.0 (2.0-2.0)              | 2.0 (2.0-2.0)                 | 2.0 (2.0-2.0)                          | 0.974   |
| Postoperative day of first gait exercise, day | 1.0 (1.0-1.0)              | 1.0 (1.0-1.0)                 | 1.0 (1.0-1.0)                          | 0.007   |
| Postoperative complications                   |                            |                               |  | 0.170   |
| No complications                              | 165 (82.5)                 | 49 (90.7)                     | 116 (79.5)                             |         |
| CD Grade II                                   | 26 (13.0)                  | 4 (7.4)                       | 22 (15.1)                              |         |
| Severe Complication CD Grade ≥III             | 9 (4.5)                    | 1 (1.9)                       | 8 (5.5)                                |         |
| Preoperative functional status                |                            |                               |  |         |
| ECOG PS ≥2                                    | 9 (4.5)                    | 6 (11.1)                      | 3 (2.1)                                | 0.018   |
| Pre-operative SPPB sum score, points          | 12.0 (11.0-12.0)           | 11.0 (9.0-12.0)               | 12.0 (11.3-12.0)                       | <0.001  |
| Discharge SPPB sum score, points              | 12.0 (11.0-12.0)           | 11.0 (9.0-12.0)               | 12.0 (12.0-12.0)                       | <0.001  |
| Preoperative handgrip strength, kg            | 28.8 (21.2-35.4)           | 17.7 (15.5-25.1)              | 32.6 (24.8-38.9)                       | <0.001  |
| Calf circumference, cm                        | 33.5 (31.5-36.0)           | 31.3 (29.0-33.6)              | 34.5 (32.1-36.9)                       | <0.001  |
| Rehabilitation intervention factors           |                            |                               |  |         |
| Daily rehabilitation duration, min            | 22.6 (20.0-27.5)           | 26.3 (21.6-29.9)              | 22.5 (20.0-25.7)                       | 0.003   |
| Weekly rehabilitation frequency               | 5.3 (4.7-5.6)              | 5.3 (4.7-5.8)                 | 5.1 (4.6-5.4)                          | 0.140   |
| PLOS, day                                     | 11.0 (8.0-14.0)            | 12.0 (9.0-14.0)               | 10.0 (8.0-13.0)                        | 0.287   |
| Functional decline at discharge               | 37 (18.5)                  | 19 (35.2)                     | 18 (12.3)                              | <0.001  |

Continuous variables were reported median (interquartile range), and categorical variables were reported number (%). Alb: Albumin; BMI: body mass index; CCI: Charlson Comorbidity Index; CD: Clavien-Dindo classification; CRP: C-reactive protein; Hb: hemoglobin; ICU: intensive care unit; PLOS: postoperative length of stay; ECOG PS: Eastern Cooperative Oncology Group Performance Status; SPPB: Short Physical Performance Battery; WBC: white blood cell.

$p=0.006$ ), Model 2 (RR=2.15, 95%CI=1.09-4.25;  $p=0.027$ ), and Model 3 (RR=2.44, 95%CI=1.23-4.87;  $p=0.011$ ).

Table IV shows the sensitivity analysis using the modified Poisson regression for patients aged ≥65 years. As in the main analysis, possible sarcopenia was

significantly associated with functional decline at discharge across all models: crude model (RR=3.05, 95%CI=1.68-5.61;  $p<0.001$ ), Model 1 (RR=2.67, 95%CI=1.40-5.15;  $p=0.003$ ), Model 2 (RR=2.64, 95%CI=1.29-5.51;  $p=0.009$ ), and Model 3 (RR=2.96, 95%CI=1.42-6.33;  $p=0.005$ ).

Table II. *Postoperative complication incidence and severity.*

|                            | Possible sarcopenia with complications (n=5) | Without possible sarcopenia with complications (n=30) |
|----------------------------|--|---|
| Grade II                   |  |   |
| Abdominal abscess          |  | 4   |
| Anastomotic leakage        | 1  | 3   |
| Ascites                    |  | 1   |
| Bowel obstruction          |  | 1   |
| Chylous ascites            |  | 1   |
| Delayed gastric emptying   |  | 1   |
| Ileus                      |  | 6   |
| Intra-abdominal hemorrhage |  | 1   |
| Pancreatic fistula         |  | 1   |
| Postoperative bleeding     | 1  |   |
| Pneumonia                  | 1  | 1   |
| Residual urine             |  | 1   |
| Surgical-site infection    |  | 3   |
| Urinary retention          | 1  | 1   |
| Grade IIIa                 |  |   |
| Abdominal abscess          |  | 1   |
| Anastomotic leakage        |  | 4   |
| Anastomotic stricture      |  | 1   |
| Ileus                      |  | 1   |
| Pancreatic fistula         |  | 1   |
| Urinary retention          | 1  |   |
| Grade IIIb                 |  |   |
| Anastomotic leakage        |  | 1   |
| Grade IVa                  |  |   |
| Respiratory failure        |  | 1   |

## Discussion

In this study, preoperative possible sarcopenia as defined by the AWGS 2025 criteria was associated with functional decline at discharge in patients undergoing surgery for colorectal or gastric cancer. This association remained after adjusting for demographic and clinical variables, and similar results were observed in patients aged  $\geq 65$  years. These findings suggest that low preoperative muscle strength may be associated with poorer short-term recovery of physical function after gastrointestinal cancer surgery.

A key strength of this study is that possible sarcopenia, as assessed using the AWGS2025 criteria, can be readily implemented in clinical practice as a simple screening tool for risk stratification of potential declines in physical function

at discharge. In addition, the use of modified Poisson regression, which directly estimates relative risks without the overestimation inherent in odds ratios when the outcome is common, enables straightforward interpretation. Furthermore, this study used an analytical model that included not only confounding factors but also the postoperative course, demonstrating that possible sarcopenia is associated with decreased physical function at discharge, independent of the occurrence of postoperative complications.

Notably, this association persisted after adjusting for the preoperative SPPB scores. These findings suggest that possible sarcopenia is not merely a proxy for poor baseline lower extremity function. In other words, even when two patients have comparable preoperative SPPB scores, the patient with low handgrip strength appears more susceptible to the effects of surgical stress and the period of reduced activity that follows and may therefore be slower to recover physical function at discharge.

Handgrip strength, used in the assessment of possible sarcopenia, is regarded as a marker of overall muscle strength, muscle mass, nutritional status, and physical reserve, and has been described as a “sixth vital sign” (24-28). Previous studies have shown that low handgrip strength is associated with postoperative complications and short-term mortality after gastrointestinal cancer surgery (11, 12, 29). However, these studies primarily examined the relationship between handgrip strength and complications or mortality and did not assess postoperative changes in physical function. Our results add to this literature by demonstrating an association between low preoperative handgrip strength, defined as possible sarcopenia according to the AWGS 2025 criteria, and functional decline at discharge as measured using the SPPB.

In particular, in our cohort, postoperative complications were not more frequent in the possible sarcopenia group. This suggests that the functional decline associated with possible sarcopenia may not be mediated by the occurrence of postoperative complications. Even in the exploratory model with additional adjustments for postoperative complications and length of hospital stay, this association

Table III. *The association between possible sarcopenia and functional decline at discharge.*

| Variables           | Crude model <sup>a</sup> | <i>p</i> -Value | Adjusted model 1 <sup>b</sup> | <i>p</i> -Value | Adjusted model 2 <sup>c</sup> | <i>p</i> -Value | Adjusted model 3 <sup>d</sup> | <i>p</i> -Value |
|---------------------|--------------------------|-----------------|-------------------------------|-----------------|-------------------------------|-----------------|-------------------------------|-----------------|
|                     | RR (95%CI)               |                 | RR (95%CI)                    |                 | RR (95%CI)                    |                 | RR (95%CI)                    |                 |
| Possible sarcopenia | 2.85 (1.59-5.15)         | <0.001*         | 2.43 (1.30-4.57)              | 0.006*          | 2.15 (1.09-4.25)              | 0.027*          | 2.44 (1.23-4.87)              | 0.011*          |

The results of modified Poisson regression analysis are shown for the risk factor of functional decline at discharge. \*Statistically significant difference ( $p < 0.05$ ). <sup>a</sup>Crude model univariate analysis. <sup>b</sup>Adjusted model 1 adjusted for age and sex. <sup>c</sup>Adjusted model 2 adjusted for age, sex, BMI, CCI, cancer location, surgical method, and preoperative SPPB scores. <sup>d</sup>Adjusted model 3 adjusted for age, sex, BMI, CCI, cancer location, surgical method, preoperative SPPB scores, CD, and postoperative length of stay. BMI: Body mass index; CCI: Charlson Comorbidity Index; CD: Clavien-Dindo classification; CI: confidence interval; RR: relative risk; SPPB: Short Physical Performance Battery.

Table IV. *Sensitivity analysis of association between possible sarcopenia and functional decline in patients aged  $\geq 65$  years at discharge.*

| Variables           | Crude model <sup>a</sup> | <i>p</i> -Value | Adjusted model 1 <sup>b</sup> | <i>p</i> -Value | Adjusted model 2 <sup>c</sup> | <i>p</i> -Value | Adjusted model 3 <sup>d</sup> | <i>p</i> -Value |
|---------------------|--------------------------|-----------------|-------------------------------|-----------------|-------------------------------|-----------------|-------------------------------|-----------------|
|                     | RR (95%CI)               |                 | RR (95%CI)                    |                 | RR (95%CI)                    |                 | RR (95%CI)                    |                 |
| Possible sarcopenia | 3.05 (1.68-5.61)         | <0.001*         | 2.67 (1.40-5.15)              | 0.003*          | 2.64 (1.29-5.51)              | 0.009*          | 2.96 (1.42-6.33)              | 0.005*          |

The results of modified Poisson regression analysis are shown for the risk factor of functional decline at discharge. \*Statistically significant difference ( $p < 0.05$ ). <sup>a</sup>Crude model univariate analysis. <sup>b</sup>Adjusted model 1 adjusted for age and sex. <sup>c</sup>Adjusted model 2 adjusted for age, sex, BMI, CCI, cancer location, surgical method, and preoperative SPPB scores. <sup>d</sup>Adjusted model 3 adjusted for age, sex, BMI, CCI, cancer location, surgical method, preoperative SPPB scores, CD, and postoperative length of stay. BMI: Body mass index; CCI: Charlson Comorbidity Index; CD: Clavien-Dindo classification; CI: confidence interval; RR: relative risk; SPPB: Short Physical Performance Battery.

remained significant. These findings indicate that possible sarcopenia, as reflected by low preoperative handgrip strength, may represent reduced physiological reserve, making these patients more vulnerable to postoperative disuse-related muscle wasting and, consequently, delayed recovery of physical function (30, 31).

From a clinical perspective, possible sarcopenia can be easily assessed using handgrip strength, which requires minimal equipment and can be quickly performed in routine preoperative settings. Our findings suggest that preoperative screening for possible sarcopenia may be a practical approach for identifying patients at a higher risk of short-term functional decline. Patients with low handgrip strength may benefit from closer postoperative monitoring and consideration of perioperative rehabilitation or prehabilitation (32, 33).

*Study limitations.* First, it is a single-center retrospective observational study, and the number of outcome events was relatively small, resulting in wide confidence intervals

in the multivariable analyses. In addition, we could not adjust for nutritional status or physical activity, both of which have been associated with physical function in previous studies (18). Malnutrition and decreased activity levels are more likely to occur in the possible sarcopenia group. These unmeasured confounders are more likely to be present in the possible sarcopenia group and may have biased the association away from the null, potentially leading to an overestimation of the true effect. Larger multicenter studies are needed to confirm these findings, improve the precision of the estimates, and address unmeasured preoperative confounding factors. Second, 117 patients were excluded, mainly because they had been admitted before the standardized clinical pathway was fully implemented. During that earlier period, rehabilitation was prescribed at the discretion of the attending physician rather than according to a universal protocol. Consequently, many excluded patients may have had better baseline function and may not have been referred for rehabilitation.

The analyzed cohort may therefore represent a population with relatively greater clinical needs, potentially overestimating the prevalence of possible sarcopenia and the incidence of functional decline compared with the broader surgical population. Third, the amount and intensity of physical activity and the specific components of rehabilitation were not measured. In particular, a scoping review by Monticone *et al.* reported that physical activity intensity is often under-recorded in studies of perioperative rehabilitation after gastric cancer surgery (34). Future studies should examine how postoperative physical activity level and intensity relate to recovery using objective measures, such as activity monitors. Fourth, many patients in the without possible sarcopenia group scored the maximum of 12 points on the SPPB. This likely reflects a ceiling effect inherent in the SPPB scoring system. Because of this ceiling effect, there may have been limitations in detecting functional decline. Future studies might consider supplementing the SPPB with measures that use continuous scales, such as the 6-minute walk test or the incremental shuttle walk test, to mitigate the ceiling effect.

Despite these limitations, our study has notable strengths, including the application of the AWGS 2025 criteria, use of the SPPB as a validated and objective outcome measure, and a sequential adjustment strategy that demonstrated the robustness of the association across several models.

## Conclusion

Preoperative possible sarcopenia is associated with functional decline at discharge after colorectal or gastric cancer surgery. Measuring handgrip strength before surgery may help identify patients at risk of poor short-term functional recovery and inform perioperative rehabilitation planning.

## Conflicts of Interest

The Authors declare that they have no conflicts of interest in relation to this study.

## Authors' Contributions

Naohiro Furuya: Conceptualization, Data curation, Formal analysis, Methodology, Visualization, Writing–original draft, Writing – review and editing. Junichi Ando: Data curation, Writing – review and editing. Hinata Murakami: Data curation, Writing–review and editing. Aoi Hashimoto: Data curation, Writing – review and editing. Yuki Takano: Supervision, Writing – review and editing. Daisuke Soma: Supervision, Writing – review and editing.

## Acknowledgements

The Authors would like to thank the patients and staff of the Saitama Sekishinkai Hospital for their cooperation.

## Funding

This research received no external funding.

## Artificial Intelligence (AI) Disclosure

During the preparation of this manuscript, two large language models [Gemini 3.1 and ChatGPT (GPT-5.4)] was used solely for language editing and stylistic improvements in select paragraphs. No sections involving the generation, analysis, or interpretation of research data were produced by generative AI. All scientific content was created and verified by the authors. Furthermore, no figures or visual data were generated or modified using generative AI or machine learning–based image enhancement tools.

## References

- 1 Bray F, Laversanne M, Sung H, Ferlay J, Siegel RL, Soerjomataram I, Jemal A: Global cancer statistics 2022: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. *CA Cancer J Clin* 74(3): 229-263, 2024. DOI: 10.3322/caac.21834
- 2 Korc-Grodzicki B, Downey RJ, Shahrokni A, Kingham TP, Patel SG, Audisio RA: Surgical considerations in older adults with cancer. *J Clin Oncol* 32(24): 2647-2653, 2014. DOI: 10.1200/JCO.2014.55.0962

- 3 Lawrence VA, Hazuda HP, Cornell JE, Pederson T, Bradshaw PT, Mulrow CD, Page CP: Functional independence after major abdominal surgery in the elderly. *J Am Coll Surg* 199(5): 762-772, 2004. DOI: 10.1016/j.jamcollsurg.2004.05.280
- 4 Tahiri M, Sikder T, Maimon G, Teasdale D, Hamadani F, Sourial N, Feldman LS, Guralnick J, Fraser SA, Demyttenaere S, Bergman S: The impact of postoperative complications on the recovery of elderly surgical patients. *Surg Endosc* 30(5): 1762-1770, 2016. DOI: 10.1007/s00464-015-4440-2
- 5 Guralnik JM, Simonsick EM, Ferrucci L, Glynn RJ, Berkman LF, Blazer DG, Scherr PA, Wallace RB: A short physical performance battery assessing lower extremity function: association with self-reported disability and prediction of mortality and nursing home admission. *J Gerontol* 49(2): M85-M94, 1994. DOI: 10.1093/geronj/49.2.m85
- 6 Blackwood J, Rybicki K: Physical function measurement in older long-term cancer survivors. *J Frailty Sarcopenia Falls* 6(3): 139-146, 2021. DOI: 10.22540/JFSF-06-139
- 7 Almugbel FA, Timilshina N, Papadopoulos E, Al-Showbaki L, Alibhai SM: The role of grip strength and short physical performance battery test in predicting chemotherapy-related outcomes in older adults with cancer. *J Geriatr Oncol* 13(3): 318-324, 2022. DOI: 10.1016/j.jgo.2021.12.002
- 8 Thomas EM, Smith J, Curry A, Salsberry M, Ridgeway K, Hunt B, Desanto K, Falvey JR: Association of physical function with hospital readmissions among older adults: A systematic review. *J Hosp Med* 20(3): 277-287, 2025. DOI: 10.1002/jhm.13538
- 9 Nakano J, Fukushima T, Tanaka T, Fu JB, Morishita S: Physical function predicts mortality in patients with cancer: a systematic review and meta-analysis of observational studies. *Support Care Cancer* 29(10): 5623-5634, 2021. DOI: 10.1007/s00520-021-06171-3
- 10 Chen LK, Hsiao FY, Akishita M, Assantachai P, Lee WJ, Lim WS, Muangpaisan W, Kim M, Merchant RA, Peng LN, Tan MP, Won CW, Yamada M, Woo J, Arai H: A focus shift from sarcopenia to muscle health in the Asian Working Group for Sarcopenia 2025 Consensus Update. *Nat Aging* 5(11): 2164-2175, 2025. DOI: 10.1038/s43587-025-01004-y
- 11 Simonsen C, de Heer P, Bjerre ED, Suetta C, Hojman P, Pedersen BK, Svendsen LB, Christensen JF: Sarcopenia and postoperative complication risk in gastrointestinal surgical oncology. *Ann Surg* 268(1): 58-69, 2018. DOI: 10.1097/SLA.0000000000002679
- 12 Wang H, Yang R, Xu J, Fang K, Abdelrahim M, Chang L: Sarcopenia as a predictor of postoperative risk of complications, mortality and length of stay following gastrointestinal oncological surgery. *Ann R Coll Surg Engl* 103(9): 630-637, 2021. DOI: 10.1308/rcsann.2021.0082
- 13 von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP, STROBE Initiative: Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies. *BMJ* 335(7624): 806-808, 2007. DOI: 10.1136/bmj.39335.541782.AD
- 14 Perera S, Mody SH, Woodman RC, Studenski SA: Meaningful change and responsiveness in common physical performance measures in older adults. *J Am Geriatr Soc* 54(5): 743-749, 2006. DOI: 10.1111/j.1532-5415.2006.00701.x
- 15 Charlson ME, Pompei P, Ales KL, MacKenzie CR: A new method of classifying prognostic comorbidity in longitudinal studies: Development and validation. *J Chronic Dis* 40(5): 373-383, 1987. DOI: 10.1016/0021-9681(87)90171-8
- 16 Tominaga T, Nonaka T, Takeshita H, Kunizaki M, Sumida Y, Hidaka S, Sawai T, Nagayasu T: The Charlson Comorbidity Index as an independent prognostic factor in older colorectal cancer patients. *Indian J Surg* 80(1): 54-60, 2018. DOI: 10.1007/s12262-016-1544-4
- 17 Niemeläinen S, Huhtala H, Jämsen E, Kössi J, Andersen J, Ehrlich A, Haukijärvi E, Koikkalainen S, Koskensalo S, Mattila A, Pinta T, Uotila-Nieminen M, Vihervaara H, Hyöty M: One-year functional outcomes of patients aged 80 years or more undergoing colonic cancer surgery: prospective, multicentre observational study. *BJS Open* 6(4): zrac094, 2022. DOI: 10.1093/bjsopen/zrac094
- 18 Yanagisawa T, Tatematsu N, Horiuchi M, Migitaka S, Yasuda S, Itatsu K, Kubota T, Sugiura H: Preoperative physical activity predicts postoperative functional recovery in gastrointestinal cancer patients. *Disabil Rehabil* 44(19): 5557-5562, 2022. DOI: 10.1080/09638288.2021.1939447
- 19 Hara T, Kogure E, Kubo A, Kakuda W: Preoperative improvement in physical function by comprehensive rehabilitation leads to decreased postoperative complications in gastrointestinal cancer patients. *Prog Rehabil Med* 6: 20210001, 2021. DOI: 10.2490/prm.20210001
- 20 Huisman MG, Audisio RA, Ugolini G, Montroni I, Viganò A, Spiliotis J, Stabilini C, de Liguori Carino N, Farinella E, Stanojevic G, Veering BT, Reed MW, Somasundar PS, de Bock GH, van Leeuwen BL: Screening for predictors of adverse outcome in onco-geriatric surgical patients: A multicenter prospective cohort study. *Eur J Surg Oncol* 41(7): 844-851, 2015. DOI: 10.1016/j.ejso.2015.02.018
- 21 Dindo D, Demartines N, Clavien PA: Classification of surgical complications: a new proposal with evaluation in a cohort of 6336 patients and results of a survey. *Ann Surg* 240(2): 205-213, 2004. DOI: 10.1097/01.sla.0000133083.54934.ae
- 22 Zou G: A modified Poisson regression approach to prospective studies with binary data. *Am J Epidemiol* 159(7): 702-706, 2004. DOI: 10.1093/aje/kwh090
- 23 King PM, Blazeby JM, Ewings P, Kennedy RH: Detailed evaluation of functional recovery following laparoscopic or open surgery for colorectal cancer within an enhanced recovery programme. *Int J Colorectal Dis* 23(8): 795-800, 2008. DOI: 10.1007/s00384-008-0478-0
- 24 Kim SH, Kim T, Park JC, Kim YH: Usefulness of hand grip strength to estimate other physical fitness parameters in

- older adults. *Sci Rep* 12(1): 17496, 2022. DOI: 10.1038/s41598-022-22477-6
- 25 Norman K, Stobäus N, Gonzalez MC, Schulzke JD, Pirlich M: Hand grip strength: Outcome predictor and marker of nutritional status. *Clin Nutr* 30(2): 135-142, 2011. DOI: 10.1016/j.clnu.2010.09.010
- 26 Kim J, Kang S, Kim D, Kang H: Associations of physical activity and handgrip strength with health-related quality of life in older Korean cancer survivors. *Cancers (Basel)* 14(24): 6067, 2022. DOI: 10.3390/cancers14246067
- 27 Vaishya R, Misra A, Vaish A, Ursino N, D'Ambrosi R: Hand grip strength as a proposed new vital sign of health: a narrative review of evidences. *J Health Popul Nutr* 43(1): 7, 2024. DOI: 10.1186/s41043-024-00500-y
- 28 Bohannon RW: Grip strength: an indispensable biomarker for older adults. *Clin Interv Aging* 14: 1681-1691, 2019. DOI: 10.2147/CIA.S194543
- 29 Jiang X, Xu X, Ding L, Zhu H, Lu J, Zhao K, Zhu S, Xu Q: Predictive value of preoperative handgrip strength on postoperative outcomes in patients with gastrointestinal tumors: a systematic review and meta-analysis. *Support Care Cancer* 30(8): 6451-6462, 2022. DOI: 10.1007/s00520-022-06983-x
- 30 Zhou J, Liu X, Guo X, Yang X, Ma X, Liu W: Grip strength is an important predictor for nutritional risk and early postoperative ambulation in gastrointestinal tumors undergoing laparoscopic surgery: a prospective multicenter clinical study. *World J Surg Oncol* 21(1): 273, 2023. DOI: 10.1186/s12957-023-03163-x
- 31 Dudas G, Chhetri I, Whyte M, Rayman M, Simmonds R, Catchpole A, Griffiths M, Creagh-Brown B: Patients having major abdominal cancer surgery exhibit significant acute muscle wasting. *J Cachexia Sarcopenia Muscle* 16(3): e13858, 2025. DOI: 10.1002/jcsm.13858
- 32 Soendenbroe C, Boraxbekk CJ, Mackey AL: Enhancing muscle and brain resilience: The role of prehabilitative exercise in mitigating disuse effects. *J Physiol* 603(13): 3711-3724, 2025. DOI: 10.1113/JP284499
- 33 Meneses-Echavez JF, Loaiza-Betancur AF, Díaz-López V, Echavarría-Rodríguez AM, Triana-Reina HR: Prehabilitation programs for individuals with cancer: a systematic review of randomized-controlled trials. *Syst Rev* 12(1): 219, 2023. DOI: 10.1186/s13643-023-02373-4
- 34 Monticone M, Rocca B, Pretta A, Scribante A, Scartozzi M, Dal Farra F: What is the role of physical exercise after surgery for gastric cancer? A scoping review. *ESMO Gastrointest Oncol* 7: 100117, 2025. DOI: 10.1016/j.esmogo.2024.100117