Abstract

Growing attention has been placed on cancer prehabilitation in the recent years as the number of publications increase. The real-world application of prehabilitation remains heterogeneous and its implementation has been challenging during the COVID-19 pandemic. However, the pandemic has also provided impetus for change-leveraging technology and digitalization. This paper will discuss the pre-existing models of care, adaptations that had taken place in the pandemic, the model of care in the author’s institution, and the future direction of cancer prehabilitation.

© 2022 The Authors. Published by Elsevier Inc. on behalf of American Congress of Rehabilitation Medicine. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

KEYWORDS
Cancer prehab; COVID-19; Prehabilitation; Rehabilitation; Technology

Cancer prehabilitation has been defined as a process on the cancer continuum of care that occurs between the time of cancer diagnosis and the beginning of acute treatment. The potential benefits of cancer prehabilitation have been supported by international reviews and meta-analyses (table 1). The benefits have been reported in gynecological, urologic, colorectal, and hepatobiliary and upper gastrointestinal cancers. The benefits differed between the different cancer diagnostic groups and included physical and psychological parameters, length of stay, postoperative complications, and quality of life.

More studies are needed on head and neck cancers. Multimodal models of care include exercise, nutritional intervention and psychological support in general. Other domains such as respiratory muscle training and breathing exercises may be applied prior to cardiothoracic surgery, whereas pelvic floor exercises and sexual well-being may be incorporated into the prostate cancer prehabilitation program. In breast cancer patients, locoregional exercise pertinent to specific treatment-related impairments has been implemented. It appears that high-intensity interval training (HIIT) may significantly improve peak O2 consumption, is safe, and produces positive outcomes on health-related events.

Because of the heterogeneity of cancer related impairments, randomized controlled studies are usually performed in single cancer diagnostic groups (table 2). The real-world application of prehabilitation in program implementation remains heterogeneous and not straightforward. While cancer prehabilitation is gaining attention with the increasing literature, the COVID-19 pandemic has the potential to affect its implementation.

Disclosures: none.

Cite this article as: Arch Rehabil Res Clin Transl. 2022;4:100236

https://doi.org/10.1016/j.arrct.2022.100236

2590-1095 © 2022 The Authors. Published by Elsevier Inc. on behalf of American Congress of Rehabilitation Medicine. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).
| No. | Diagnostic Group | Author | Title | Journal |
|-----|------------------|--------|-------|---------|
| 1.  | Gynecological    | S. Schneider | Prehabilitation Programs and ERAS protocols in gynecologic oncology: a comprehensive review | Arch Gynecol Obstet 2020;301:315-26 |
| 2.  | Various cancers  | Stefano Palma | High-intensity interval training in the prehabilitation of cancer patients- a systematic review and meta-analysis | Supportive Care Cancer 2021;29:1781-94 |
| 3.  | Head and neck cancer | Irene Loewen | Prehabilitation in head and neck cancer patients: a literature review | J Otolaryngol Head Neck Surg 2021;30:2 |
| 4.  | Various cancer exercise | Christina M. Michael | Prehabilitation exercise therapy for cancer: a systematic review and meta-analysis | Cancer Medicine 2021;10:4195-205 |
| 5.  | Colorectal, hepatobiliary, Upper GI | Lambert JE | The impact of prehabilitation on patient outcomes in hepatobiliary, colorectal, and upper gastrointestinal cancer surgery; a PRISMA-accordant meta-analysis | Ann Surg 2021;274:70-7 |
| 6.  | Various cancers  | Ioanna Tsimopoulou | Psychological prehabilitation before cancer surgery: a systematic review | Ann Surg Oncol 2015;22:4117-23 |
| 7.  | NSCLC            | Elisabeth J. Driessen | Effects of prehabilitation and rehabilitation including a home-based component on physical fitness, adherence, treatment tolerance, and recovery in patients with non-small cell lung cancer: a systematic review | Crit Rev Oncol Hematol 2017;114:63-76 |
| 8.  | Urologic cancers | Logan G. Briggs | Prehabilitation exercise before urological cancer surgery: a systematic and interdisciplinary review | Eur Urol 2022;81:157-67 |
| 9.  | Lung cancer      | Vanessa Ferreira | Effects of preoperative nutrition and multimodal prehabilitation on functional capacity and postoperative complications in surgical lung cancer patients: a systematic review | Support Care Cancer 2021;29:5597-610 |
| 10. | Colorectal cancer | Charlotte J. Molenaar | Prehabilitation vs no prehabilitation to improve functional capacity, reduce postoperative complications and improve quality of life in colorectal cancer surgery | Cochrane Database Syst Rev 2022;19:5 (5): CD013259 |
| 11. | Breast           | Ajax Yang | The effect of preoperative exercise on upper extremity recovery following breast cancer surgery: a systematic review | Int J Rehabil Res 2018;41:189-96. |

**Table 1** Systematic reviews and meta-analysis of cancer prehabilitation

- **Prehab:** 3 RCTs, 1 pilot, 1 study protocol. Study protocols are heterogeneous but showed improvement in physical and psychological parameters.
- **ERAS:** 12 observational studies, 1 RCT. Shorter LOS, improvement in complications.
- **Systematic review and meta-analysis:** Comparative studies on HITT in cancer prehab. 8 studies. 896 patients. Heterogeneous. Sig improvement in peak O2 consumption (V\text{O}_2 peak). Feasible and safe, low risk of adverse events, positive outcomes on health related events in prehab settings.
- **29 original research 2006-2020:** On dysphagia Range from stretching to ROM, trismus, swallowing specific exercises Variability in prehab timing, exercise type, dose, duration, outcomes, makes selection of optimal program difficult.
- **21 studies, 1564 patients enrolled:** Meta-analysis of 5 studies showed statistically significant improvement in the 6MWT in the prehab group. Prehab was found to be safe, acceptable, and feasible.
- **15 studies: RCT 9, uncontrolled 6** Prehab reduced LOS. No significant difference in functional capacity (6MWT), reduction in post-op complications, mortality rates. Prehab recommended to accelerate recovery from cancer surgery.
- **7 studies, 3 RCT, 6 uncontrolled:** Breast, colorectal, prostate cancer. No change in LOS, complications, mortality. Positively affected immunologic function. Affected PROM for example, QOL.
- **9 rehab and 1 prehab showed sig or clinically relevant improved physical fitness:** 3 home-based, 8 combined training. Adherence varied strongly. Studies on home based rehab or prehab not adequately powered.
- **12 studies, 7 demonstrated therapeutic validity:** All demonstrated sig improvement in cardiorespiratory fitness. 4 had sig improvement in QOL. None demonstrated reduction in postsurgical complications, mortality, LOS, readmission rates.
- **5 studies: 1 nutrition and 4 multimodal** Multimodal: improvements in functional walking capacity and pulmonary function during pre-operative period. No effects on postoperative outcomes. Lower rates of postoperative complications unique to nutrition-only study.
- **3 RCTs, 250 participants with non-metastatic colorectal cancer,** improved functional capacity, may result in fewer complications, fewer ED visits, possibly higher readmission rates.
- **6 studies. Implementing exercise program and optimizing preoperative fitness,** especially shoulder ROM, before breast cancer surgery in conjunction with individualized rehabilitation program may benefit postmastectomy ipsilateral upper extremity recovery.
| No. | Author | Title | Diagnostic Gp | Remarks |
|-----|--------|-------|---------------|---------|
| 1   | Akiyama 22 (2021) Japan | Efficacy of enhanced prehabilitation for patients with esophageal cancer undergoing esophagectomy | Esophageal cancer | Inpatient setting: 7 days pre-operative. Preoperative 6MWD (enhanced prehab [EP] vs control group, \(492.9 \pm 79.7 \text{ vs } 418.9 \pm 71.8 \text{ m, } P < .001\)) and postoperative (EP vs control group, \(431.5 \pm 80 \text{ vs } 378 \pm 68.7 \text{ m, } P < .001\)). Respiratory complications rate lower in EP (4.3%) than control group (36%) \((P = .007)\). Incidence of atelectasis lower in EP (0%) than control group (24%) \((P = .012)\). |
| 2   | Minnella 23 (2021) Canada | Prehabilitation in thoracic cancer surgery: from research to standard of care | Thoracic cancer | Centre-based, involving multiple health care providers, including anesthesiologists, kinesiologists, dieticians, nurse. 45 high-risk patients received 1-month personalized prehabilitation program: 16 in trimodal program (exercise, nutrition, psychological), 22 received a program with both nutrition and exercise. After prehab, 6-minute walking distance improved by 29.9 m (standard deviation 47.3 m) \((n = 35; P = .001)\) and oxygen uptake at anaerobic threshold improved by 1.6 (1.7) ml/kg/min \((n = 13; P = .004)\). Length of hospital stay was 2 (interquartile range 1-4) days in prehabilitated patients vs 3 (two-7) days in the usual care group \((P = .101)\). |
| 3   | van Rooijen 17 (2019) International | Multimodal prehabilitation in colorectal cancer patients to improve functional capacity and reduce postoperative complications: the first international randomized controlled trial for multimodal prehabilitation. | Colorectal | Multicenter RCT. Supervised in-hospital training, 3x/week x 4 weeks. Intervention group receives 4 weeks of prehabilitation, control group, which will receive no prehabilitation. Both groups receive perioperative care in accordance with the enhanced recovery after surgery (ERAS) guidelines. Primary outcomes are functional capacity (6MWT) and postoperative status determined with the Comprehensive Complication Index (CCI). Secondary outcomes include HRQoL, length of hospital stay (LOS), and a cost-effectiveness analysis. |
| 4   | Sheill 24 (2020) Ireland | Preoperative exercise to improve fitness in patients undergoing complex surgery for cancer of the lung or oesophagus (PREHITT): protocol for a randomized controlled trial | Lung or esophagus cancer | Protocol. 2 weeks HITT program. 78 participants. Medical clearance from primary physician. Performed on an electromagnetically braked cycle ergometer in St James Hospital, under direct supervision. |
| 5   | Chabot 25 (2021) Canada | Functional capacity of prediabetic patients; effect of multimodal prehabilitation in patients undergoing colorectal cancer resection | Colorectal cancer | RCT, data pooled from 2 published RCTs. 4 weeks supervised prehab clinic, multimodal prehab. Protective effect against loss of functional capacity after surgery was stronger in pre-diabetic patients. |
| No. | Author          | Title                                                                 | Diagnostic Gp | Remarks                                                                                                                                                                                                 |
|-----|-----------------|----------------------------------------------------------------------|---------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 6   | Wu              | The feasibility of prehabilitation as part of the breast cancer       | Breast        | Multi-modal, face to face advisory interventions on nutrition, smoking cessation, and psychosocial support. On-site supervised exercise 24 patients were able to partake and return questionnaires. 25 (93%) prehabilitation patients recorded high satisfaction with the program. Significant reduction in anxiety among prehabilitation patients. No significant improvements in the other PROs. No changes to hospital length of stay, readmissions, and complications. |
|     |                 | treatment pathway                                                    |               |                                                                                                                                                                                                         |
|     |                 |                                                                      |               |                                                                                                                                                                                                         |
| 7   | Berkel          | Effects of Community-based Exercise prehabilitation for patients      | Colorectal    | Single blind randomized clinical study. 3 week (3 sessions per week) personalized, supervised exercise program in community physical therapy practices Postoperative complication rates were lower in the prehab group |
|     | (2022) Netherlands | scheduled for colorectal surgery with high risk for postoperative    | Surgery       |                                                                                                                                                                                                         |
|     |                 | complications: results of a randomized controlled trial              |               |                                                                                                                                                                                                         |
| 8   | Moore           | Implementing a system-wide cancer prehabilitation programme: the     | Various cancers | Centre-based, anesthesiologist led, multi-disciplinary. “Surgery School” for education and then community-based exercise gyms 3 × /week. (prehab 3-6 weeks, rehab 12 weeks) Phone calls Classes went online during pandemic as centers were closed Implementation of the Prehab4Cancer pathway |
|     | (2021) UK       | journey of Greater Manchester’s “prehab4cancer”                     |               |                                                                                                                                                                                                         |
| 9   | Janssen         | Effect of a multimodal prehabilitation program on postoperative      | Esophageal    | Multimodal home-based                                                                                                               |
|     | (2022)          | recovery and morbidity in patients undergoing a totally minimally    |               | Prehab (n=52) vs control group (n=43): median time to functional recovery 6 vs 7 days (P=.074), LOHS 7 vs 8 days (P=.039), hospital readmission rate 9.6 vs 14.3% (P=.484), 17% reduction in 30-day overall postoperative complication rate in prehab group (P=.106). Reduction of 14% in CPC rate was observed (P=.190). Despite no difference in severity (Clavien-Dindo) of complications (P=.311), ICU readmission rate was lower in prehab group (3.8 vs 16.3%, P=.039). |
|     | (2022)          | invasive esophagectomy                                              |               |                                                                                                                                                                                                         |
|     | (2022)          |                                                                      |               |                                                                                                                                                                                                         |
| 10  | Liu             | Two-week multimodal prehabilitation program improves perioperative   | Lung          | Multimodal home-based                                                                                                               |
|     | (2020)          | functional capability in patients undergoing thoracoscopic lobectomy |               | Median duration of prehabilitation was 15 days. Average 6MWD was 60.9 m higher perioperatively in prehabilitation vs control group (95% CI, 32.4-89.5; P<.001). No differences in lung function, disability and psychological assessment, LOS, short-term recovery quality, postoperative complications, and mortality, except for forced vital capacity (FVC; 0.35 L higher in the prehabilitation group, 95% CI, 0.05-0.66; P=.021). |
|     | China           | for lung cancer: a randomized controlled trial                      |               |                                                                                                                                                                                                         |
| No. | Author | Title | Diagnostic Gp | Remarks |
|-----|--------|-------|---------------|---------|
| 11  | Minnella (2018) | Effect of exercise and nutrition prehabilitation on functional capacity in esophageal cancer surgery: a randomized controlled trial | Upper GI | Individualized, home-based (EMM) prescribed. Multimodal |
|     |        |       |               |         |
|     |        |       |               | 68 randomized, 51 included in primary analysis. Prehabilitation vs control group had improved functional capacity both before (mean [SD] 6MWD change, 36.9 [51.4] vs -22.8 [52.5] m; *P* < .001) and after surgery (mean [SD] 6MWD change, 15.4 [65.6] vs -81.8 [87.0] m; *P* < .001). |
| 12  | Ngo-Huang (2019) | Home-based exercise prehabilitation during preoperative treatment for pancreatic cancer is associated with improvement in physical function and quality of life. | Pancreatic cancer | Home-based program with moderate-intensity aerobic exercise, strengthening. Improved physical function and QOL |
|     |        |       |               | 50 participants enrolled. 6MWT, 5 × STS, and GS significantly improved from baseline to restaging follow-up (*P* = .001, *P* = .049, and *P* = .009, respectively). Increases in self-reported aerobic exercise, weekly MVPA, and LPA were associated with improvement in 6MWT (*β* = .19, *P* = .048; *β* = .18, *P* = .03; and *β* = .08, *P* = .03, respectively) and self-reported physical functioning (*β* = .02, *P* = .03; *β* = .03, *P* = .005; and *β* = .01, *P* = .02, respectively). Increased weekly LPA was associated with increased HRQOL (*β* = .03, *P* = .02). Increased SA was associated with decreased HRQOL (*β* = .02, *P* = .01) |
| 13  | Halliday (2021) | Adherence to pre-operative exercise and the response to prehabilitation in oesophageal cancer patients | Esophageal cancer | Personalized home-based pre-operative exercise program |
|     |        |       |               | 67 patients. Jan 2016-Dec 2018. Greater exercise volume is associated with lower risk of post-op pneumonia. Patients with high baseline fitness require less supervision to reach goals and completed more physical activity |
| 14  | Ferreira (2020) | Multimodal prehabilitation for lung cancer surgery: a randomized controlled trial | Lung cancer | Involves multiple health care workers, for example, kinesiologist, dietician, psychology-trained personnel. Home-based, unsupervised exercise program |
|     |        |       |               | Multimodal prehab × 4 weeks prior to surgery is as effective in recovering functional capacity as multimodal rehabilitation |
| 15  | Wu (2021) | The feasibility and effects of a telehealth-delivered home-based prehabilitation program for cancer patients during the pandemic | Various cancers, surgical and non-surgical | Telehealth delivered prehab, includes personalized training exercises, dietary advice, medical optimization, psychological support |
|     |        |       |               | 182 referred. 76% enrolled. Significant improvement in perceived health, fatigue |
|     |        |       |               | Established during pandemic |
| 16  | Piraux (2020) | Feasibility and preliminary effectiveness of a tele-prehabilitation program in esophageal cancer patients | Esophagogastric cancer patients | Tele-prehabilitation program, including aerobic, resistance, inspiratory muscle training, 2-4 weeks. Main outcomes were recruitment, retention, attendance rate, satisfaction, and adverse events. Secondary outcomes: functional |

(continued)
During the COVID-19 outbreak, new guidelines providing alternative treatment options for cancer have been established\(^\text{38,39}\); however, there are no guidelines for cancer prehabilitation during the COVID-19 pandemic, as it is a relatively new field. This paper aims to discuss the possible direction of prehabilitation in this pandemic and beyond.

Review of the existing prehabilitation models

Prior to the discussion of how the pandemic had affected the practice of cancer prehabilitation, a review of existing models of care was necessary. (Table 2) The review found many to be multimodal\(^\text{15,23,25,26,29–31}\), requiring multiple healthcare providers and that exercise training required supervision on site.\(^\text{17,20,23,25,26,24,28,40}\). Some home-based programs\(^\text{29–31}\) are multimodal in nature, whereas others mainly involve exercise programs\(^\text{32,33}\). A study by Ngo-Huang involved patients with resectable pancreatic adenocarcinoma receiving preoperative chemotherapy and/or chemoradiation in a home-based exercise program, participating in 60 min of moderate-intensity aerobic exercises daily and strengthening exercises weekly. The patients showed meaningful improvements in physical function, and physical activity was associated with improved physical function and health related quality of life\(^\text{32}\). A review article on home-based prehabilitation suggested that it is a feasible alternative to hospital-based care\(^\text{41}\). Rarely would cancer prehabilitation be conducted in an inpatient setting\(^\text{22}\).

In a study on a technology-supported multimodal prehabilitation program in moderate-to-high risk patients undergoing lung cancer resection, inputs from various healthcare professionals such as the dietician and psychologist were needed along with a supervised exercise program. Exercise trackers were utilized to monitor patient participation, and progress was assessed by a trained physiotherapist\(^\text{36}\).

Infrequently, alternative models have been reported, of which one was a tele-rehabilitation program for esophageal gastric cancer patients, which was found to be feasible with excellent recruitment and retention rates, no adverse events, and significant improvements in fatigue, quality of life, and physical and emotional well-being\(^\text{35}\). A community-based exercise prehabilitation program for colorectal surgery patients found that postoperative complication rates were lower in the prehabilitation group. This was a supervised program in community physical therapy practices\(^\text{27}\).

Adaptations during COVID-19 pandemic

Adaptations During COVID-19 Pandemic

During the COVID-19 pandemic, adaptations had to be implemented for various prehabilitation studies\(^\text{42}\) and programs\(^\text{43}\). Interactions between participants and staff were conducted through telephone or web conferencing instead of in-person visits\(^\text{42,43}\). Exercise equipment, manuals, and protein supplementation were mailed to the patients, and exercises were conducted at home instead of being facility-based\(^\text{42}\). Study outcome measures that required in-person assessment were omitted\(^\text{42}\).

With the capacity of hospitals affected by the need to care for COVID-19 patients, a shift of prehabilitation to the
community may be required. In Europe, the effects of home-based prehabilitation for patients undergoing colorectal cancer surgery during the COVID-19 pandemic showed that it was effective, resulting in a shorter hospital length of stay, postoperative complications and attenuated lean mass loss in the early postoperative period\textsuperscript{44}. Currently, the European project PAPRIKA leverages digital support\textsuperscript{45,46} to implement prehabilitation programs. The program averages 4 weeks and involves endurance training, increasing physical activity, nutritional and psychological support. Digital support includes an adaptive case management platform for professionals, integrated with the electronic health record (EHR), and a self-management app for patients, integrated with the regional health folder. Digital innovations are also being developed which allow community-based prehabilitation as well\textsuperscript{47}. These innovations support multi-modal prehabilitation granting prehabilitation professionals’ access to patients for communication and providing feedback while monitoring the task status of the patient.

Many UK prehabilitation programs were modified into online classes during the pandemic\textsuperscript{48-50}. A UK telehealth-delivered home-based prehabilitation program that was adapted from a face-to-face program was reported to be feasible and effective in improving patient reported outcomes\textsuperscript{51}. The main outcomes of recruitment and retention rates were reported to be 76\% and 75\% respectively. Secondary outcomes were changes in patient-reported outcome measures upon completion of pre-hab and included the EQ-5D-3L and Functional Assessment of Chronic Ill-ness Therapy (FACIT)-Fatigue Scale. Statistically significant improvements were observed in self-rated health and fatigue. In the USA, a structured multimodal virtual prehabilitation program was organized for neoadjuvant surgical oncology patients during the pandemic with goals of promoting optimal outcomes and preparing the patient for surgery\textsuperscript{52}. As many centers adapt, Verduzco-Guiterrez et al described how a virtual prehabilitation visit could be conducted with adaptations to the physical examination and could serve as guidance to other physicians\textsuperscript{53}.

The approach at Changi General Hospital, Singapore

A cancer prehabilitation program for colorectal patients was started in our acute general hospital in January 2020 and has since expanded into a cancer prehabilitation framework for various surgical patients as well as patients on neoadjuvant and adjuvant chemotherapy and radiotherapy\textsuperscript{54}. As the wait time for surgery averaged 19 days at our hospital, a service was planned to optimally utilize this window period. A systematic review and meta-analysis of the effects and duration of exercise-based prehabilitation found that the duration of prehabilitation varies between 2 and 14 weeks. There were significant improvements in functional capacity although prehabilitation lasting more than 3 weeks tended to lower overall complications (not statistically significant)\textsuperscript{55}. There were studies that found delays of up to 56-62 days in colorectal surgery did not lead to poorer overall or cancer-free survival in patients with primary colorectal cancer who underwent curative surgical treatment\textsuperscript{56,57}. Another study cited improved disease-free survival in stage 3 colorectal patients after prehabilitation\textsuperscript{58}, making the case of delaying surgery for prehabilitation. However, the decision was made in conjunction with the hospital medical board not to delay surgery for prehabilitation to avoid a backlog of cases. The average duration of prehabilitation was 19.3 days in our program.

This was designed as a one-stop service, where patients are referred to the prehabilitation coordinator from surgical clinics once they are planned or listed for surgery. The coordinator screens patients for frailty using Fried’s physical frailty phenotype and administers baseline measurements. Frail and pre-frail patients were prioritized for participation in the program. Patients were assessed by a physiatrist on the same day in four domains: medical optimization, exercise prescription, nutritional advice, and mental wellness. A physiatrist typically spends an hour for each patient. The prescribed interventions can be started immediately without waiting for appointments with other professionals. It is a hospital-associated, home-based program. The prehabilitation coordinator made phone calls to monitor the patient’s progress and compliance. Patients had access to the coordinator if they required clarifications regarding the exercise prescriptions or the program, and were referred to physiotherapists, dieticians, or psychiatrists if there were specific indications\textsuperscript{59}. Four patients were referred to the physiotherapist. These patients had preexisting mobility issues. Two of them were prescribed seated exercises while awaiting a therapy appointment. Five patients were referred to the dietician, five to the social worker, four were referred by surgeons and two to the psychologist, of which one had preexisting appointments.

The prescribed exercises consisted of aerobic and strengthening exercises. Aerobic exercises are typically of moderate intensity and are self-measured by the “Talk” test (as per guidelines from the American College of Sports Medicine) for a minimum of 30 min on 5 days per week. This typically includes walking, jogging, cycling, or the use of exercise equipment depending on individual capabilities, preferences, and access to equipment. For already active individuals, high-intensity interval training was incorporated. For unfit and sedentary individuals, the initial intensity is low, and the duration is titrated according to individual capabilities. Strengthening exercises typically include 3-5 sets of 10-20 repetitions, 3-7 days a week of composite exercises, primarily targeting the major lower limb proximal muscle groups and upper limb proximal muscle groups. This approach remained feasible when Singapore faced a lockdown from 7 April to 1 June 2020 during which outpatient therapy services were disrupted, as only essential medical services were permitted. Outpatient therapy services were considered non-essential and were reinstated only partially by the end of 2020 because of social distancing measures. While cancer surgery was considered essential, hospital visits were limited, and many patients avoided leaving their homes. The cancer prehabilitation service was not disrupted, mainly because it was a hospital-associated home-based program. The outcome measures included the following: (1) Functional Outcome Measures, namely 6-minute-walk-test (6MWT), 30 seconds sit-to-stand test (30CST), timed up and go test; (2) Psychological Outcome Measures, namely Hospital Anxiety and Depression Scale; and (3) Health-related Quality of Life Outcome Measures.

The outcomes of 188 pre-surgical cancer prehabilitation patients were analyzed in 4 groups: colorectal,
hepatobiliary, upper gastrointestinal, and urological cancers. There were statistically significant improvements in the 6MWT, 30CST, timed Up and Go test and Hospital Anxiety and Depression Scale at the pre-operative assessment compared to baseline and the European Quality of Life 5 Dimensions scores at 3 months assessment (Table 3).

In the period of March to September 2021, we had the opportunity to develop a digital platform to support prehabilitation. This was a cancer prehabilitation exercise diary on

| Table 3 | Comparison between baseline and post-prehab outcome measures |
|---------|-------------------------------------------------------------|
|          | Baseline. | Pre-Op | Improvement | P Value |
| 6 Minutes Walk Test (meters) |          |                    |                     |        |
| - Mean (95% CI) | 303.94 (285.66, 322.22) | 325.46 (305.14, 345.77) | 21.52 | <0.001 |
| - Median (IQR) | 308 (234, 365) | 326 (251, 402) |                     |        |
| 30-Seconds Sit-to-Stand Test (reps) |          |                    |                     |        |
| - Mean (95% CI) | 10.99 (10.23, 11.76) | 12.07 (11.25, 12.90) | 1.08 | <0.001 |
| - Median (IQR) | 10 (9, 13) | 11 (9,14) |                     |        |
| Timed Up and Go test (s) |          |                    |                     |        |
| - Mean (95% CI) | 12.07 (10.87, 13.27) | 11.24 (10.18, 12.29) | 0.83 | 0.014 |
| - Median (IQR) | 10.9 (8.35, 14.8) | 9.5 (8, 12.4) |                     |        |
| Psychological Outcome Measures |          |                    |                     |        |
| HADS Depression Score | Baseline | Pre-Op | Improvement | P Value |
| Mean (95% CI) | 2.93 (2.41, 3.46) | 1.94 (1.46, 2.43) | 0.99 (34%) | <0.001 |
| HADS anxiety score | Baseline | Pre-Op | Improvement | P value |
| Mean (95% CI) | 3.24 (2.63, 3.86) | 2.53 (1.93, 3.12) | 0.71 (22%) | 0.027 |
| HADS total score | Baseline | Pre-Op | Improvement | P value |
| Mean (95% CI) | 6.17 (5.17, 7.16) | 4.40 (3.42, 5.37) | 1.77 (29%) | <0.001 |
| Quality of Life (Health-Related) Outcome Measures |          |                    |                     |        |
| European Quality of Life 5 Dimensions | Baseline | 3-Month Post-Op | Improvement | P value |
| Mean (95% CI) | 69.32 (65.96, 72.68) | 76.36 (72.42, 80.29)* | + 7.04 | 0.001 |

NOTE: P value was obtained using Wilcoxon Signed Rank test.
Abbreviations: CI, confidence interval; HADS, hospital anxiety and depression scale; IQR, inter-quartile range; Post-op, post operation; Pre-op, preoperation.
* taken at 3 months post-op

Fig 1 Health Buddy phone application: (a) overview of functions, (b) exercise diary interface, and (c) YouTube videos (available in English and Mandarin).
Feasibility of the program during the pandemic

As of mid-January 2022, 219 patients were screened, and 188 patients were enrolled in our prehabilitation program. The recruitment rate was 86% (defined by the number enrolled vs total referred) and the retention rate was 73% (referred to as the percentage that completed the program up to the time of the surgery). The compliance or adherence rate was 65.9% (81/123). This was measured by the completion of the minimum number of prescribed exercise sets and the ability to demonstrate all exercises correctly during follow-up. This suggests that the program was feasible. At the end of the 3-month period, patients were reviewed for suitability for transition to community exercise programs using government-funded facilities and programs. 20% of the patients were undergoing active cancer treatment or had new impairments and were not suitable for transition. 10% of the patients had pre-existing exercise programs and declined to be referred to community programs. The remaining patients were given a choice between community group programs and facilities vs continuing home exercise programs. 10% of all patients were referred to community exercise programs. Most preferred home exercises because of the pandemic.

Discussion

In addition to potential cost savings in pre-surgical prehabilitation,68-70 benefits include a reduction in cancer recurrence with regular exercise and lifestyle changes.69 The Clinical Oncology Society of Australia recommends that exercise become a standard of care in oncology across all disease states, incorporated into cancer care from the time of diagnosis.61 Prehabilitation programs that are practical, lower cost, and empower the patient to take charge of their own health62 would possibly be more sustainable. Home-based programs reduce the infrastructure costs of building exercise centers and site rental fees. Barriers that were removed included cost, time spent traveling, access to an exercise facility, and geographic isolation. The drawbacks include a lack of supervision, which could result in exercises being performed incorrectly or not at all. A comprehensive assessment was performed at the initial visit to our center, especially regarding medical clearance for exercise. In our culture, patients may be more willing to exercise when encouraged by a physician. In the future, a clinical pathway could be instituted for screening and referral of patients.63

In a study that implemented telehealth prehabilitation education sessions for patients prior to surgery, most (77%) responded that they preferred an online education session as opposed to attending a hospital-based one.37 Online classes make the program available to people who stay in rural areas and are more convenient for some. Smartphone ownership has increased over the years.64 Furthermore, with the pandemic, digital literacy has increased, with programs to help the elderly acquire digital literacy65 to reduce inequity in access.66

The pandemic has caused disruptions but has also facilitated changes in how prehabilitation is practiced with digitalization and technological adaptations. According to a narrative review, surgical patients faced the threats of extended wait times for surgery, reduced access to supportive services, and an elevated risk of poor outcomes,67 and accessible strategies were needed to reduce this effect. As COVID-19 moves toward endemicity, some changes may remain. The advantages of home-based or community programs with technological enablers include better access to care, lower costs, and greater scalability. The processes and integration would continue to evolve to improve for the reduction in physical contact and clinical assessments. Other areas that would continue to improve include user-friendly technological enablers that would remain personalized to various degrees.

Challenges in cancer prehabilitation include the heterogeneity of exercise protocols, program duration, multimodal components used, and varying outcome measures applied. The implementation for different cancer diagnostic groups which have varying treatment protocols, prognosis, and complications of disease or treatment can also be overwhelming. In the mitigation of this, one should lower barriers to start a cancer prehabilitation program, start with 1 diagnostic group at a time and expand to other diagnostic groups after sufficient study of the patient population, workflow, and discussion with relevant stakeholders.52 Outcome measures should be captured, and workflow and protocols adapted to refine the program as the program matures. Despite these challenges, cancer prehabilitation will continue to gain traction in terms of publication and implementation. The application is not straightforward as it is a relatively new field and will vary in different cultures and funding models. Publications describing different models of care in the various programs globally should be encouraged so that cancer prehabilitation would be made available in many more parts of the world.

Conclusions

Cancer prehabilitation has gained increasing attention in the recent years and the number of published studies on prehabilitation has been rising. The COVID-19 pandemic poses a challenge to the implementation of cancer prehabilitation programs; however, it has also facilitated changes, especially in the areas of digitalization and the leverage of technology. As the world moves toward endemicity, one can look forward to some of these advances, gaining acceptance with potential scaling to the masses.
Corresponding author
San San Tay, MBBS, MRCP (UK), MMED (Int Med), FAMS, Department of Rehabilitation Medicine, Changi General Hospital, 2 Simei Street 3, Singapore 529889. E-mail address: tay.san@nationalhealth.com.sg.

ACKNOWLEDGMENTS
The author thanks Dr Kah Meng Kwok, Dr Yiding Li, Dr Mark Tan, Dr Insali Soe, APN Lina Jia, Christopher De Conceicao, Mon Hnin Tun, Singhealth Corporate Communications, Changi General Hospital Corporate Communications and surgical colleagues for the collaboration.

References
1. Silver JK, Baima J. Cancer prehabilitation: an opportunity to decrease treatment-related morbidity, increase cancer treatment options, and improve physical and psychological health outcomes. Am J Phys Med Rehabil 2013;92:715-27.
2. Treanor C, Kyaw T, Donnelly M. An international review and meta-analysis of prehabilitation compared to usual care for cancer patients. J Cancer Surviv 2018;12:64-73.
3. Lambert JE, Hayes LD, Keegan TJ, Subar DA, Gaffney CJ. The impact of prehabilitation on patient outcomes in hepatobiliary, colorectal, and upper gastrointestinal cancer surgery: a PRISMA-accordant meta-analysis. Ann Surg 2021;274:70-7.
4. Schneider S, Armbrust R, Spies C, du Bois A, Sehouli J. Prehabilitation programs and ERAS protocols in gynecological oncology: a comprehensive review. Arch Gynecol Obstet 2020;301:315-26.
5. Briggs LG, Reitblat C, Bain PA, et al. Prehabilitation exercise before urogynecologic cancer surgery: a systematic and interdisciplinary review. Eur Urol 2022;81:157-67.
6. Ferreira V, Lawson C, Ekmekjian T, et al. Effects of preoperative nutrition and multimodal prehabilitation on functional capacity and postoperative complications in surgical lung cancer patients: a systematic review. Support Care Cancer 2021;29:597-610.
7. Molenaar CJ, van Rooijen SJ, Fokkenrood HJ, et al. Prehabilitation versus no prehabilitation to improve functional capacity, reduce postoperative complications and improve quality of life in colorectal cancer surgery. Cochrane Database Syst Rev 2022;5:CD013259.
8. Yang A, Sokolof J, Glatui A. The effect of preoperative exercise on upper extremity recovery following breast cancer surgery: a systematic review. Int J Rehabil Res 2018;41:189-96.
9. Driessen EJ, Peeters ME, Bongers BC, et al. Effects of prehabilitation and rehabilitation including a home-based component on physical fitness, adherence, treatment tolerance, and recovery in patients with non-small cell lung cancer: a systematic review. Crit Rev Oncol Hematol 2017;114:63-76.
10. Michael CM, Lehrer EJ, Schmitz KH, Zaorsky NG. Prehabilitation exercise therapy for cancer: a systematic review and meta-analysis. Cancer Med 2021;10:4195-205.
11. Tsimopoulou I, Pasquall S, Howard R, et al. Psychological prehabilitation before cancer surgery: a systematic review. Ann Surg Oncol 2015;22:4177-23.
12. Loewen I, Jeffery CC, Rieger J, Constantinescu G. Prehabilitation in head and neck cancer patients: a literature review. J Otolaryngol Head Neck Surg 2021;50:2.
13. Goldsmith I, Chesterfield-Thomas G, Toghill H. Pre-treatment optimization with pulmonary rehabilitation in lung cancer: making the inoperable patients operable. ECLinicalMedicine 2020;31:100663.
14. Paterson C, Roberts C, Toohey K, McKie A. Prostate cancer prehabilitation and the importance of multimodal interventions for person-centered care and recovery. Semin Oncol Nurs 2020;36:151048.
15. Santa Mina D, Brahmbhatt P, Lopez C, et al. The case for prehabilitation prior to breast cancer treatment. PM R 2017;9:5305-16.
16. Palma S, Hasenoehr L, Jordakieva G, Ramazanova D, Crevenna R. High-intensity interval training in the prehabilitation of cancer patients—a systematic review and meta-analysis. Support Care Cancer 2021;29:1781-94.
17. van Rooijen S, Carlil F, Dalton S, et al. Multimodal prehabilitation in colorectal cancer patients to improve functional capacity and reduce postoperative complications: the first international randomized controlled trial for multimodal prehabilitation. BMC Cancer 2019;19:98.
18. Ferreira V, Minnella EM, Awasthi R, et al. Multimodal prehabilitation for lung cancer surgery: a randomized controlled trial. Ann Thorac Surg 2021;112:1600-8.
19. Santa Mina D, Milton WJ, Matthew AG, et al. Prehabilitation for radical prostatectomy: a multicenter randomized controlled trial. Surg Oncol 2018;27:289-98.
20. Mikami Y, Kouda K, Kawasaki S, et al. Preoperative in-hospital rehabilitation improves physical function in patients with pancreatic cancer scheduled for surgery. Tohoku J Exp Med 2020;251:279-85.
21. Giles C, Cummins S. Prehabilitation before cancer treatment. BMJ 2019;366:l5120.
22. Akiyama Y, Sasaki A, Fujii Y, et al. Efficacy of enhanced prehabilitation for patients with esophageal cancer undergoing esophagectomy. Esophagus 2021;18:56-64.
23. Minnella EM, Baldini G, Quang AT, et al. Prehabilitation in thoracic cancer surgery: from research to standard of care. J Cardiotorac Vasc Anesth 2021;35:3255-64.
24. Shell G, Guinan E, O’Neill L, et al. Preoperative exercise to improve fitness in patients undergoing complex surgery for cancer of the lung or oesophagus (PRE-HIIT): protocol for a randomized controlled trial. BMC Cancer 2020;20:321.
25. Chabot K, Gillis C, Minnella EM, et al. Functional capacity of pre-diabetic patients: effect of multimodal prehabilitation in patients undergoing colorectal cancer resection. Acta Oncol 2021;60:1025-31.
26. Wu F, Laza-Cagigas R, Pagarkar A, et al. The feasibility of prehabilitation as part of the breast cancer treatment pathway. PM R 2021;13:1237-46.
27. Berkel AEM, Bongers BC, Kotte H, et al. Effects of community-based exercise prehabilitation for patients scheduled for colorectal surgery with high risk for postoperative complications: results of a randomized clinical trial. Ann Surg 2022;275:e299 306.
28. Moore J, Merchant Z, Rowlinson K, et al. Implementing a system-wide cancer prehabilitation programme: the journey of Greater Manchester’s ‘Prehab-cancer’. Eur J Surg Oncol 2021;47(3 Pt A):524-32.
29. Janssen THJB, Fransen LFC, Heesakkers FFBM, et al. Effect of a multimodal prehabilitation program on postoperative recovery and morbidity in patients undergoing a totally minimally invasive esophagogastrectomy. Dis Esophagus 2022;35: doab082.
30. Liu Z, Qiu T, Pei L, et al. Two-week multimodal prehabilitation program improves perioperative functional capability in patients undergoing thoracoscopic lobectomy for lung cancer: a randomized controlled trial. Analges Analg 2020;131:840-9.
31. Minnella EM, Awasthi R, Loiselie SE, et al. Effect of exercise and nutrition prehabilitation on functional capacity in esophagogastrectomy surgery: a randomized clinical trial. JAMA Surg 2018;153:1081-9.
32. Ngo-Huang A, Parker NH, Bruera E, et al. Home-based exercise prehabilitation during preoperative treatment for pancreatic cancer is associated with improvement in physical function and quality of life. Integr Cancer Ther 2019;18:1534735419894061.
33. Halliday LJ, Doganay E, Wynter-Blyth V, Osborn H, Buckley J, Moorthy K. Adherence to pre-operative exercise and the response to prehabilitation in oesophageal cancer patients. J Gastrointest Surg 2021:25:890–9.

34. Wu F, Rotimi O, Laza-Cagigas R, Rampal T. The feasibility and effects of a telehealth-delivered home-based prehabilitation program for cancer patients during the pandemic. Curr Oncol 2021;28:2248–59.

35. Piraux E, Caty G, Reychler G, Forget P, Deswysen Y. Cost-effectiveness of a technology-supported multimodal prehabilitation program in moderate-to-high risk patients undergoing lung cancer resection: randomized controlled trial protocol. BMC Health Serv Res 2020;20:207.

36. Barberan-Garcia A, Navarro-Ripoll R, Sánchez-Lorente D, et al. Prehab models and COVID-19 adaptations 11

37. Waterland JL, Chahal R, Ismail H, et al. Implementing a telehealth prehabilitation education session for patients preparing for major cancer surgery. BMC Health Serv Res 2021;21:443.

38. Guckenberger M, Belka C, Bezjak A, et al. Practice recommendations for lung cancer radiotherapy during the COVID-19 pandemic: an ESTRO-ASTRO consensus statement. Int J Radiat Oncol Biol Phys 2020;107:63–40.

39. Coles CE, Aristei C, Bliss J, et al. International guidelines on radiation therapy for breast cancer during the COVID-19 pandemic. Clin Oncol (R Coll Radiol) 2020;32:279–81.

40. Awasthi R, Minnella EM, Ferreira V, Ramanakumar AV, Scheede-Bergdahl C, Carl F. Supervised exercise training with multimodal pre-habilitation leads to earlier functional recovery following colorectal cancer resection. Acta Anaesthesiol Scand 2019;63:461–7.

41. van Gestel T, Groen LCB, Puijk JR, et al. Fit4Surgery for cancer patients during covid-19 lockdown—a systematic review and meta-analysis. Eur J Surg Oncol 2022. S0748-7983(22)00085-3.

42. Santa Mina D, Sellers D, Au D, et al. A pragmatic non-randomized trial of prehabilitation prior to cancer surgery: study protocol and COVID-19-related adaptations. Front Oncol 2021;11:62907.

43. Gonella F, Massucco P, Perotti S, et al. Telemedicine prehabilitation as a result of COVID-19: disruptive technological solutions. Br J Surg 2021;108:e215–6.

44. López-Rodríguez-Arias F, Sánchez-Guillén L, Aranaz-Ostáriz V, et al. Effect of home-based prehabilitation in an enhanced recovery after surgery program for patients undergoing colorectal cancer surgery during the COVID-19 pandemic. Support Care Cancer 2021;29:7785–91.

45. European Institute of Innovation and Technology. Patient Empowerment for Major Surgery Preparation at Home. 2022. Available at: https://etihealth.eu/product-service/paprika/. Accessed August 9, 2022.

46. ClinicalTrials.gov. PAPRIKA—Patients Empowerment for Major Surgery Preparation @Home (PAPRIKA). 2022. Available at: https://www.clinicaltrials.gov/ct2/show/NCT04295668. Accessed April 25, 2022.

47. Barberan-Garcia A, Cano I, Bongers BC, et al. Digital support to multimodal community-based prehabilitation: looking for optimization of health value generation. Front Oncol 2021;11:662013.

48. Active Against Cancer. Who we are. 2022. Available at: http://activeagainstcancer.org. Accessed January 17, 2022.

49. Macmillan Cancer Support. SafeFit. 2021. Available at: https://www.macmillan.org.uk/cancer-information-and-support/get-help/physical-help/safefit. Accessed January 21, 2022.

50. Sell NM, Silver JK, Rando S, Draviam AC, Mina DS, Qadan M. Prehabilitation telemedicine in neoadjuvant surgical oncology patients during the novel COVID-19 coronavirus pandemic. Ann Surg 2020;272:e81–3.

51. Verduzco-Gutierrez M, Bean AC, Tenforde AS, Tapia RN, Silver JK. How to conduct an outpatient telemedicine rehabilitation or prehabilitation visit. PM R 2020;12:714–20.

52. Tay SS, Kwok KM. Setting up a cancer prehabilitation framework in Singapore. J Cancer Rehabil 2021;4:1–6.

53. Falz R, Bischoff C, Thieme R, et al. Effects and duration of exercise-based prehabilitation in surgical therapy of colon and rectal cancer: a systematic review and meta-analysis. J Cancer Res Clin Oncol 2022;148:2187–213.

54. Strous MTA, Janssen-Heijnen MLG, Vogelaar FJ. Impact of therapeutic delay in colorectal cancer on overall survival and cancer recurrence—is there a safe timeframe for prehabilitation? Eur J Surg Oncol 2019;45:2295–301.

55. Hangaard Hansen C, Gögenur M, Twilling Madsen M, Gögenur I. The effect of time from diagnosis to surgery on oncological outcomes in patients undergoing surgery for colon cancer: a systematic review. Eur J Surg Oncol 2018;44:1479–85.

56. Trépanier M, Minnella EM, Paradis T, et al. Improved disease-free survival after prehabilitation for colorectal cancer surgery. Ann Surg 2019;270:493–501.

57. SingHealth Group. Health Buddy App. 2021. Available at: https://www.singhealth.com.sg/patient-care/patient-visitor-info/health-buddy-app. Accessed April 25, 2022.

58. Silver JK. Cancer prehabilitation and its role in improving health outcomes and reducing health care costs. Semin Oncol Nurs 2015;31:13–30.

59. Dholakia J, Cohn DE, Straughn JM, Dilley SE. Prehabilitation for medically frail patients undergoing surgery for epithelial ovarian cancer: a cost-effectiveness analysis. J Gynecol Oncol 2021;32:e92.

60. Cormie P, Zopf EM, Zhang X, Schmitz KH. The impact of exercise on cancer mortality, recurrence, and treatment-related adverse effects. Epidemiol Rev 2017;39:71–92.

61. Cormie P, Atkinson M, Bucci L, et al. Clinical Oncology Society of Australia position statement on exercise in cancer care. Med J Aust 2018;209:184–7.

62. Jain R, Gibson L, Coburn N. Prehabilitation for surgical oncology patients: empowering patient volition. Support Care Cancer 2018;26:3665–7.

63. Stout NL, Brown JC, Schwartz AL, et al. Exercise oncology clinical pathway: screening and referral for personalized interventions. Cancer 2020;126:2750–8.

64. Pew Research Center. Mobile fact sheet. 2021. Available at: https://www.pewresearch.org/internet/fact-sheet/mobile. Accessed January 17, 2022.

65. UN Development Program. Digital Literacy opens up a new world during Covid-19. 2021. Available at: https://www.un.org/desa/digitallife/digital-literacy-opens-up-a-new-world-during-covid-19. Accessed January 17, 2022.

66. Infocom Media Development Authority. Digital For Life. 2021. Available at: https://www.imda.gov.sg/digitalforlife. Accessed January 15, 2022.

67. Silver JK, Santa Mina D, Bates A, et al. Physical and psychological health behavior changes during the COVID-19 pandemic that may inform surgical prehabilitation: a narrative review. Curr Anesthesiol Rep 2022;12:109–24.