Original Article

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Outcomes of a Multi-Modal Hospital-Associated Home-Based Cancer Prehabilitation Program

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Objective To assess the impact of a "one-stop", multi-modal, hospital-associated-home-based prehabilitation model, helmed by a small core team, on newly diagnosed gastrointestinal and urological cancer patients planned for surgery.

Methods This is a retrospective study in a tertiary public hospital, involving all newly diagnosed gastrointestinal and urological cancer patients planned for surgery. The primary outcome measure was the 6-minute walk test (6MWT). Other outcomes included physical, psychological and quality-of-life measures, and patient satisfaction surveys, taken at baseline, pre-operatively (post-prehabilitation), and at 3 months post-operatively.

Results When comparing the baseline to pre-operatively (post-prehabilitation), there was a statistically significant improvement in the 6MWT (21.52 m, p<0.001), 30-Second Sit to Stand test (STS) (1.08 repetitions, p<0.001), Timed Up and Go test (TUG) (0.83 seconds, p=0.014) and Hospital Anxiety and Depression Scale (HADS) (total score 1.77, p<0.001). These were sustained (6MWT: 0.22, p=0.964; STS: 0.08 repetitions, p=0.863; TUG: 0.04 seconds, p=0.939) or further improved (HADS total score 2.06, p=0.003) at 3 months post-operatively. There was also a statistically significant improvement in the EuroQol-5 dimension health score (health-related quality-of-life measure) from baseline to 3 months post-operatively (7.04 points, p=0.001), with more than 90% overall patient satisfaction reported.

Conclusion Prehabilitation applied via our model resulted in significant improvements in functional capacity, psychological and quality-of-life outcomes, sustained at 3 months post-operatively, and is a feasible and effective approach that is well-received by our patients.

Keywords Cancer, Prehabilitation, Delivery of healthcare, Integrated

INTRODUCTION

Cancer prehabilitation has been defined by Silver and Baima [1] as "a process on the cancer continuum of care that occurs between the time of cancer diagnosis and the beginning of acute treatment", and includes both physical and psychological assessments culminating in targeted interventions with objective outcome measures to dem-

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onstrate its impact. The evidence base for the benefits conferred by cancer prehabilitation is increasing and encompasses multiple primary tumours [2-5]. This includes patients with colorectal, prostate, hepato-pancreato-biliary (HPB), lung, and breast cancer who are going for surgery [5-9], as well as those with lung, hematologic, and other cancer types undergoing adjuvant therapy [10-13]. However, the optimal model of cancer prehabilitation remains debatable, particularly given the multitude of barriers to exercise, which is a key component of prehabilitation [14]. It has been suggested that a home-based model may be preferable due to convenience, particularly if coordinated and supported by qualified exercise professionals at a cancer center [15,16]. This model of care had been termed "hospital-associated, home-based" [16], and the key advantages are initial advocacy, better confidence, convenience to patients, and a lower requirement for infrastructure and personnel that lowers costs and improves sustainability. Patients are safeguarded by the feedback loop made available through guidance and monitoring by hospital-based exercise professionals, either through telephone support or physical follow-up.

Even within this model of care, most prehabilitation programs utilize large multidisciplinary teams and may typically require multiple visits by participants. In our context, this created potentially significant logistic and cost issues, particularly for newly diagnosed cancer patients who were seen in an outpatient setting, often resulting in non-attendance.

We had earlier published a framework for cancer prehabilitation [17], which had been set up within our hospital as a hospital-associated, home-based program. The uniqueness of our framework lies in its small core team (comprising only of a prehab coordinator and a physiatrist) to screen, assess, and intervene in most patients, with only limited referrals to other disciplines (eg., physiotherapist, dietician, medical social worker) for a minority of patients. This significantly reduced the overall number of patient visits while ensuring seamless integrated and holistic care.

Using this model of care [17], a study was conducted in patients enrolled into our Prehabilitation Program, with the aim of demonstrating its impact in improving functional capacity as the primary outcome measure, in addition to other physical, psychological and health-related quality-of-life outcome measures, as well as patient satisfaction with the program.

MATERIALS AND METHODS

Entry into the Prehabilitation Program

This is a retrospective study investigating the effects of our Prehabilitation Program, approved by Singhealth Centralised Institutional Review Board (CIRB Ref: 2022/2234). The referral criterion for our Prehabilitation Program was any patient with newly diagnosed colorectal, HPB, upper gastrointestinal (GI) tract (esophagus, gastric) or urological (prostate, bladder, kidneys) cancer planned for surgery at our hospital. They were referred by their primary surgical team (at the point of their cancer diagnosis) to the prehabilitation coordinator. In this study, patients from January 2020 to February 2022 were recruited.

Once referred, the prehabilitation coordinator would screen them for frailty using Fried's physical frailty phenotype, which involves assessment of 5 measures: a) grip strength using hand-grip dynamometer, b) gait speed, c) reduced physical activity for the past 4 weeks, d) exhaustion for the past week, and e) unintentional weight loss. Patients would be considered frail if they met the score criteria for at least 2 items, pre-frail if they met 1 criterion, and non-frail if they met none.

"Frail" and "pre-frail" patients were prioritized for entry into the Prehabilitation Program. In this study, non-frail patients were also allowed to participate in the same program if they were keen.

Patients would then undergo a series of baseline outcome measures by the prehabilitation coordinator including: i) functional measures: the 6-minute walk test (6MWT), 30-Second Sit to Stand test (STS), and Timed Up and Go test (TUG); ii) psychological measure: the Hospital Anxiety and Depression Scale (HADS); and iii) health-related quality-of-life measure: EuroQol-5 dimension (EQ-5D). Demographics including age, sex, race, smoking, and alcohol consumption history were also obtained.

A full summary of the outcome measures and their individual collection time points is given in Table 1.

The physiatrist would then see the patient on the same day, to perform assessments and interventions targeted at the 4 major prehabilitation domains of medical optimization, physical activity with individualized exercise prescription, nutrition, and mental health.

Table 1. Outcome measures and their collection time points

Outcome measure	Collection time points
Functional (physical)	Baseline
6-minute walk test (primary)	Pre-op (post-prehab)
30-Second Sit to Stand test	3-month follow-up
Timed Up and Go test	
Psychological	Baseline
Hospital Anxiety and Depression Scale score	Pre-op (post-prehab)
	3-month follow-up
Quality of life (health-related)	Baseline
EuroQol-5 dimension	3-month follow-up
Others	
Acute post-op hospital length-of-stay	During admission for surgery
Post-op major complications rates (30 day)	During admission for surgery up to 30 days post-op
Readmission rates (30 day & 3 mo)	Up to 3 months post-op
Mortality (30 day & 3 mo)	Up to 3 months post-op
Patient satisfaction survey to Prehab Program (see Appendix 3)	Pre-op (post-prehab) 3-month follow-up

Op, operative; prehab, prehabilitation.

Medical optimization

This included the optimization of chronic diseases such as hypertension and diabetes mellitus, treatment of existing anemia, smoking cessation, and alcohol reduction/abstinence as needed.

Physical activity: exercise prescription and measurement of compliance

At the initial physiatrist consult, all patients would have an evaluation of their premorbid exercise patterns and preferences, individual functional capabilities including a focused examination of their neurological and musculoskeletal systems, as well as the previously-mentioned baseline functional tests. They would be screened for safety to participate in an exercise program based on guidelines by the American College of Sports Medicine, which includes a brief evaluation of their current medical conditions and existing symptoms [18]. Based on the above parameters, an individualized home exercise prescription would be given, with a focus on strengthening and aerobic exercises. The strengthening exercises would typically include 3–5 sets of 10–20 repetitions, 3–7 days/week, of composite exercises primarily targeting the major lower limb proximal muscle groups (such as the hip and knee extensors and flexors, and hip abductors) with incorporation of the key upper limb proximal muscle groups (such as the shoulder abductors, elbow flexors, and extensors) as appropriate. Resistance level would be selected based on individual fitness and preferences. The physiatrist would first demonstrate the entire set of exercises, with the patient performing a return demonstration in order to ensure correct technique and posture, after which exercise sheets would be given to facilitate retention. In this same setting, the caregiver or family member would be requested to be present to learn the exercises as well, in order to provide further reinforcement and supervision at home. The aerobic exercises typically included brisk walking, jogging, stairclimbing, and the use of simple exercise equipment where available (such as stationary cycling and cross-trainers) depending on individual capabilities, preferences, and access to equipment. The initial intensity would typically be moderate, as self-measured by the "Talk" test as per guidelines from the American College of Sports Medicine [19], with an initial duration of at least 10–30 minutes per day for 3–7 days per week, progressing eventually to reach at least 150 minutes weekly of moderate intensity exercise. For unfit and sedentary individuals, the initial intensity would be low and the duration titrated according to individual capabilities. For patients who were fit and already actively exercising, considerations would be made to incorporate components of high-intensity interval training

into their regime.

The compliance of the patients to the home exercise programs was tracked via phone calls made by the coordinator on a 1–2 weekly basis based on the written exercise sheet templates, as well as during the pre-operative visit, where patients would again be asked to demonstrate the exercises taught.

Nutrition

Besides general screening on the adequacy of current dietary intake and general healthy balanced diet targets, focused advice would be given to adopt a high-protein diet (1.2–2.0 g/kg/day, unless contraindicated) to promote post-operative anabolism, and for arginine-based immunonutrition for patients undergoing abdominal surgery to reduce post-operative complications [20].

Mental health

Patients would be screened for features of anxiety and depression, and taught anxiety and stress relief techniques, including diaphragmatic breathing and progressive muscle relaxation where appropriate.

There were pre-defined criteria to trigger referrals to the physiotherapist, dietitian and medical social worker, summarized in the prehabilitation protocol (Appendix 1). The decision for such referrals would be made by the physiatrist after discussion with the patient.

Pre-operative visit

Patients were scheduled to visit the prehabilitation coordinator 1–3 days before their surgery to repeat their functional and psychological measures (Table 1), and to demonstrate the exercises taught for documentation of compliance.

Peri-operative workflow

Patients were reviewed post-operatively (Appendix 2) as inpatients by the Prehabilitation Core Team to assess their functional needs, as well as for the reinforcement of subsequent home exercises post-discharge. Post-operative rehabilitation was typically sited in an outpatient or home setting, unless there were significant medical or caregiving issues requiring further prolongation of their hospitalization.

Patients would be scheduled for an outpatient visit 3 months post-operatively, to explore transition to a long-term, sustainable, community-or-home-based exercise program. The functional, psychological, and quality-of-life outcome measures would be repeated in this setting. Data on post-operative length of stay, major complication rates (defined as surgical-related complications including anastomotic leaks, wound dehiscence, bleeding, and intra-abdominal abscesses), unplanned readmission rates, and mortality would be tracked at the time of discharge, and at the 30-day and 3-month post-operative time points.

Outcome measures

The primary outcome measure was the 6MWT distance (validated measure of functional capacity). Secondary outcome measures included: i) other physical outcome measures: STS and TUG; ii) psychological outcome measure: HADS; iii) health-related quality-of-life outcome measure: EQ-5D; and iv) patient satisfaction survey scores.

Statistical analysis

The patient characteristics were summarized using descriptive statistics. Percentages were used to illustrate the categorical variables, and the continuous variables were expressed as either mean±standard deviation or median with interquartile range. Paired sample t-test or non-parametric Wilcoxon signed-rank test was used to determine whether the participants' outcome measures changed significantly from baseline to the pre-operative period. Multivariable linear regressions were performed to identify the independent predictors of changes in outcome measures. When comparing data across any two time points, only patients with completed data at both time points would be analyzed. Missing data was thus excluded from analysis. All analyses were conducted with Stata version 14 (StataCorp LLC, College Station, TX, USA). A p-value of <0.05 indicated statistical significance.

RESULTS

From January 2020 to February 2022, a total of 211 patients were referred to our program, of which 182 were enrolled (86.3% enrolment rate). Of the 29 patients who declined, 6 felt that they were already doing sufficient exercises and eating well at home, and the remaining 23 did not specify a reason.

Of those enrolled, 120 (65.9%) had colorectal cancers, 45 (24.7%) had HPB cancers, 13 (7.1%) had urological cancers and 4 (2.2%) had upper GI cancers. The reason for this distribution was primarily because our Prehabilitation Program started with colorectal cancer patients, before expanding to include HPB and urological groups in mid-late 2020, and finally upper GI malignancies in late 2021. Table 2 contains a summary of the baseline characteristics and demographics.

Demographics

The mean age of our participants was 70.43±10.64, with 50.5% frail, 26.4% pre-frail, and 23.1% non-frail. 59.3% were males. 78.6%, 13.7%, and 4.9% were of Chinese, Malay, and Indian ethnicity respectively, with the remaining 2.8% coming from other races. 80.8% were non-smokers, 8.2% were current smokers, and 11.0% were ex-smokers. 95.0% did not report any current significant alcohol intake.

Duration of prehabilitation

The duration of prehabilitation was defined as the duration from initial consult with the physiatrist to the date of surgery. We did not advocate delaying surgery just for prehabilitation, but rather worked with whatever time was available, to optimize patients prior to surgery. The mean duration of prehabilitation was 19.29±14.87 days.

Compliance

Compliance was measured at two settings: first during the initial phone call 3–7 days after the initial physiatrist consult (with exercise prescription) where the patient's reported compliance to the minimum sets of exercises prescribed was documented ("full compliance" was defined as the patient reporting having done at least the minimum number of sets prescribed), and secondly during the pre-operative follow-up when the patient was asked to physically demonstrate the taught exercises.

The 65.6% (61/93) of patients reported compliance to the minimal sets of prescribed exercises during the phone call, while 65.9% (81/123) of patients were able to demonstrate all the exercises correctly during the pre-operative follow-up.

Table 2. Baseline characteristics of participants

Baseline characteristic	Value
Total screened	211 (100)
Total enrolled	182 (86.3)
Cancer types	
Colorectal	120 (65.9)
Hepato-pancreato-biliary	45 (24.7)
Urological	13 (7.1)
Upper gastrointestinal	4 (2.2)
Age (yr)	70.43±10.64
Sex, male	108 (59.3)
Race	
Chinese	143 (78.6)
Malay	25 (13.7)
Indian	9 (4.9)
Others	5 (2.8)
Frailty score	
Frail	92 (50.5)
Pre-frail	48 (26.4)
Non-frail	42 (23.1)
Smoking	
Non-smokers	147 (80.8)
Current smokers	15 (8.2)
Ex-smokers	20 (11.0)
Alcohol	
Current significant intake	9 (4.9)
Duration of prehabilitation (day)	19.29±14.87
Compliance	
Reported doing at least the minimum sets prescribed	61 (65.6)[a]
Able to demonstrate all exercises correctly during pre-operative follow-up	81 (65.9)[b]
Source of referrals	
Inpatient	57 (31.3)
Outpatient	125 (68.7)

Values are presented as number (%) or mean±standard deviation.
[a]The total number of participants is 93.
[b]The total number of participants is 123.

Source of referrals and utilization of additional services outside of Prehabilitation Core Team

The 68.7% of the referrals were from outpatient sources, while the rest were referred while inpatient. Of the outpatient referrals, the referral rates to additional services

outside of the Prehabilitation Core Team was 1.4% for physiotherapists, 2.1% for medical social workers, and 1.4% for dieticians.

Outcome measures

Primary outcome measure: 6-minute walk test distance

The mean 6MWT distance at baseline was 303.94 m (95% confidence interval [CI], 285.66–322.22) and that at the pre-operative (post-prehabilitation [prehab]) visit was 325.46 m (95% CI, 305.14–345.77), indicating an improvement of 21.52 m (p<0.001; Table 3).

Other physical outcome measures

For the STS, the mean number of repetitions at baseline was 10.99 (95% CI, 10.23–11.76) and that at the pre-operative (post-prehab) visit was 12.07 (95% CI, 11.25–12.90), indicating an improvement of 1.08 repetitions (p<0.001; Table 3).

For the TUG, the mean time taken at baseline was 12.07 seconds (95% CI, 10.87–13.27) and that at the pre-operative (post-prehab) visit was 11.24 seconds (95% CI, 10.18–12.29) indicating an improvement of 0.83 seconds, (p=0.014; Table 3).

Psychological outcome measures

The mean "depression score" of the HADS at baseline was 2.93 (95% CI, 2.41–3.46) and that at the pre-operative (post-prehab) visit was 1.94 (95% CI, 1.46–2.43), indicating an improvement of 0.99 points (34% improvement, p<0.001; Table 3).

The mean "anxiety score" of the HADS at baseline was 3.24 (95% CI, 2.63–3.86) and that at the pre-operative (post-prehab) visit was 2.53 (95% CI, 1.93–3.12), indicating an improvement of 0.71 points (22% improvement, p=0.027; Table 3).

The mean total score of the HADS at baseline was 6.17 (95% CI, 5.17–7.16) and that at the pre-operative (post-prehab) visit was 4.40 (95% CI, 3.42–5.37), indicating an improvement of 1.77 points (29% improvement, p<0.001; Table 3).

Health-related quality-of-life outcome measures

The health score within the EQ-5D questionnaire was reported, which asked participants to rate on a visual analogue scale of 0 to 100 points how good or bad they felt their health was, on the day of answering the questionnaire.

The mean score at baseline was 69.32 (95% CI, 65.96–

Table 3. Comparison between baseline and post-prehabilitation outcome measures

Outcome measure	Baseline	Pre-operative	Improvement	p-value[a)]
Functional (physical)				
6-minute walk test (m)	303.94 (285.66–322.22)	325.46 (305.14–345.77)	21.52	<0.001
	308 (234, 365)	326 (251, 402)		
30-Second Sit to Stand test (reps)	10.99 (10.23–11.76)	12.07 (11.25–12.90)	1.08	<0.001
	10 (9, 13)	11 (9, 14)		
Timed Up and Go test (s)	12.07 (10.87–13.27)	11.24 (10.18–12.29)	0.83	0.014
	10.9 (8.4, 14.8)	9.5 (8.0, 12.4)		
Psychological (score)				
HADS depression	2.93 (2.41–3.46)	1.94 (1.46–2.43)	0.99 points (34%)	<0.001
HADS anxiety	3.24 (2.63–3.86)	2.53 (1.93–3.12)	0.71 points (22%)	0.027
HADS total	6.17 (5.17–7.16)	4.40 (3.42–5.37)	1.77 points (29%)	<0.001
Health-related quality-of-life				
EuroQol-5 dimension health score	69.32 (65.96–72.68)	76.36 (72.42–80.29)[b)]	7.04 points	0.001

Values are presented as mean (95% confidence interval) or median (interquartile range).
Missing data were excluded from analysis. When comparing data across any two time points, only patients with completed data at both time points would be analyzed.
HADS, Hospital Anxiety and Depression Scale.
[a)]p-value was obtained using Wilcoxon signed-rank test.
[b)]This data is the 3-month post-operative time point.

72.68) and that at the 3-month post-operative time point was 76.36 (95% CI, 72.42–80.29), indicating an improvement of 7.04 points (p=0.001; Table 3).

Sustainability of initial gains

When comparing the primary and functional outcome measures between the pre-operative (post-prehab) visit and the 3-month post-operative time point, the 6MWT distance had fallen by 0.22 m (p=0.964), STS improved by 0.08 repetitions (p=0.863), TUG increased by 0.04 seconds (p=0.939). These changes were all not statistically-significant, suggesting sustainability of the patients' initial gains. Refer to Table 4 for more details.

When comparing the psychological outcome measures between pre-operative and 3-month post-operative, there was a further improvement in the anxiety score (mean [95% CI] at pre-operative was 2.82 [1.99–3.65] vs. post-operative of 1.46 [0.83–2.09], improvement of 1.36 points, p=0.001) and depression score (mean [95% CI] at pre-operative was 2.31 [1.61–3.01] vs. post-operative of 1.79 [1.22–2.36], improvement of 0.52 points, p=0.117), the former being statistically significant. Refer to Table 4 for more details.

Patient satisfaction survey

The patient satisfaction survey (Appendix 3) comprised 7 questions scored with a Likert scale, and was administered to all patients during the pre-operative (Fig. 1) and 3-month post-operative follow-up visits (Fig. 2).

Most patients felt that the program had provided relevant knowledge for beneficial lifestyle changes and increased their physical activity levels and awareness of nutrition. They expressed satisfaction with their encounters with the prehabilitation coordinator and physiatrist, and were willing to recommend such a program to other suitable patients. More than 90% expressed overall satisfaction ("agree" or "strongly agree" for Questions 4 and 5), and close to 90% acknowledged that they had benefitted from the program ("agree" or "strongly agree" for Question 6). Between the two surveys, more favorable responses were obtained at the pre-operative time point, which was the focus of our Prehabilitation Program.

Associations of key variables with changes in outcome measures

Table 5 shows the associations between key variables and the changes in outcome measures, based on multivariate regression models.

A better performance in the TUG done at baseline was associated with better improvement in the same test, when repeated pre-operatively (β=-0.37, p<0.001). This association was not found in the 6MWT and STS.

A lower HADS (total, anxiety, and depression) score at baseline was associated with better improvement in the same score when repeated pre-operatively (β=-0.58, -0.68 and -0.75 respectively, with p<0.001).

An older age and a higher frailty score were both independently associated with an increase in the post-operative length of stay (β=0.01, p=0.009 and β=0.14, p=0.003 respectively).

Table 4. Comparison between pre-operative and 3-month post-operative outcome measures

Outcome measure	Pre-operative	Post-operative	Difference	p-value[a)]
Functional (physical)				
6-minute walk test (m)	305.94 (280.14–331.74)	306.16 (280.39–331.92)	0.22	0.964
30-Second Sit to Stand test (reps)	11.35 (10.29–12.42)	11.43 (10.34–12.51)	0.08	0.863
Timed Up and Go test (s)	12.24 (10.77–13.72)	12.28 (10.96–13.59)	0.04	0.939
Psychological (score)				
HADS depression	2.31 (1.61–3.01)	1.79 (1.22–2.36)	0.52 points (23%)	0.117
HADS anxiety	2.82 (1.99–3.65)	1.46 (0.83–2.09)	1.36 points (48%)	0.001
HADS total	4.40 (3.42–5.38)	2.34 (1.18–3.49)	2.06 points (47%)	0.003

Values are presented as mean (95% confidence interval).
Missing data were excluded from analysis. When comparing data across any two time points, only patients with completed data at both time points would be analyzed.
HADS, Hospital Anxiety and Depression Scale.
[a)]p-value was obtained using Wilcoxon signed-rank test.

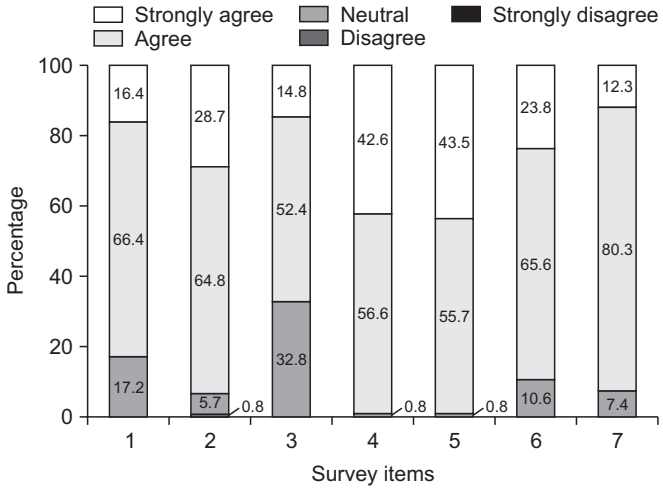

Fig. 1. Results of patient satisfaction survey (pre-operative). Survey items: (1) This program has given me relevant knowledge for lifestyle changes that will benefit my health. (2) This program had caused me to increase my physical activity level. (3) This program had caused me to be more conscious of my nutrition. (4) Overall, I am satisfied with the interaction I had with the prehabilitaion doctor. (5) Overall, I am satisfied with the interaction I had with the prehabilitaion coordinator. (6) Overall, I have benefitted from this program. (7) I will recommend this program to other patients if they are suitable.

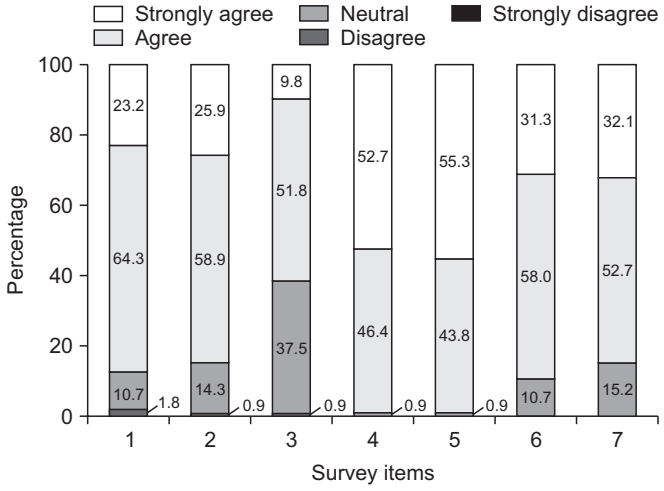

Fig. 2. Results of patient satisfaction survey (post-operative). Survey items: (1) This program has given me relevant knowledge for lifestyle changes that will benefit my health. (2) This program had caused me to increase my physical activity level. (3) This program had caused me to be more conscious of my nutrition. (4) Overall, I am satisfied with the interaction I had with the prehabilitaion doctor. (5) Overall, I am satisfied with the interaction I had with the prehabilitaion coordinator. (6) Overall, I have benefitted from this program. (7) I will recommend this program to other patients if they are suitable.

The associations relating to the different cancer subgroups should be interpreted with caution, due to the relatively larger numbers of patients with colorectal cancer recruited from the outset, in comparison to other groups.

DISCUSSION

One of the earliest prehabilitation programs in Singapore was set up by Khoo Teck Puat Hospital in 2007 for frail elderly patients undergoing colorectal surgery, and involved a transdisciplinary, trans-institutional approach, to achieve significantly enhanced functional recovery and shorter hospital lengths of stay for participants [21]. While highly encouraging, such programs have yet to gain widespread adoption among patients with other types of cancers in Singapore [22].

One of the unique features of our Prehabilitation Program was the very small core team comprising only of physiatrists and prehabilitation coordinators, to screen, assess, and intervene in the majority of our prehabilitation patients, while only referring a minority of patients to additional services. This contrasts most prehabilitation programs where large, multidisciplinary teams are typically involved. The main advantage of our approach would thus be a "one-stop service" with a reduced number of visits, resulting in greater convenience and time savings for patients and staff.

For such an approach to work, our small core team needed to possess a wide spectrum of skillsets as both the assessment and interventions spanned multiple domains. The involvement of specific physiatrists within our program, all of whom were also certified in internal medicine and exercise prescription (Exercise Is Medicine Singapore, Changi Sports Medicine Centre) is thus critical, due to their ability to perform medical optimization, provide medical clearance for exercises with specific precautions where relevant, and personalize exercises based on existing impairments or medical co-morbidities. In addition, the physiatrists were further cross-trained by dieticians and psychologists to bolster their ability to assess and intervene in the nutrition and mental health domains.

This "one-stop service" was particularly important in saving time and additional visits for patients who were

Table 5. Multivariate regression model (adjusted for race)

Multivariate regression model (final model)	Δ 6MWT (m) (baseline vs. pre-op) (n=106)		Δ STS (reps) (baseline vs. pre-op) (n=95)		Δ TUG (s) (baseline vs. pre-op) (n=99)		Δ HADS scores (baseline vs. pre-op) (n=121)		Δ HADS depression scores (baseline vs. pre-op) (n=121)		Δ HADS anxiety scores (baseline vs. pre-op) (n=121)		Δ EQ-5D health score (baseline vs. 3 mo) (n=81)		Post-op length-of-stay (log transformed) (n=172)	
	β	p-value	β	p-value	β	p-value	β	p-value	β	p-value	β	p-value	β	p-value	β	p-value
Prehab duration	-0.07	0.822	-0.01	0.484	0.03	0.243	-0.03	0.350	-0.02	0.198	-0.01	0.659	-0.28	0.021	-0.01	0.365
Inpt vs. outpt (ref: inpt)	-9.25	0.446	1.22	0.080	-0.29	0.742	0.89	0.412	0.99	0.017	0.72	0.163	3.03	0.434	-0.16	0.220
Frality score	3.69	0.473	0.22	0.405	0.52	0.116	0.31	0.486	0.05	0.785	-0.27	0.176	-1.39	0.207	0.14	0.003
Cancer types (ref: colorectal)																
Hepato-biliary	-5.45	0.612	0.31	0.631	-0.01	0.988	-0.66	0.541	0.28	0.530	-0.49	0.373	4.88	0.207	0.27	0.040
Urology	10.72	0.585	-0.09	0.938	-1.06	0.433	4.63	0.037	1.29	0.127	1.09	0.320	-16.13	0.046	-0.45	0.073
Upper GI	-18.62	0.705	-	-	4.82	0.197	8.23	0.097	1.42	0.239	0.09	0.950	-7.16	0.632	1.04	0.013
Sex (ref: female)																
Male	4.87	0.617	0.47	0.408	0.45	0.500	0.51	0.584	0.19	0.597	0.51	0.265	14.06	<0.001	0.12	0.290
Age	-0.68	0.196	-0.01	0.747	0.01	0.670	-0.04	0.430	-0.01	0.693	-0.01	0.980	0.48	0.015	0.01	0.009
Baseline	-0.04	0.538	-0.14	0.071	-0.37	<0.001	-0.58	<0.001	-0.75	<0.001	-0.68	<0.001	-0.67	<0.001	-	-

6MWT, 6-minute walk test; op, operative; STS, 30-Second Sit to Stand test; TUG, Timed Up and Go test; HADS, Hospital Anxiety and Depression Scale; EQ-5D, EuroQol-5 dimension; prehab, prehabilitation; inpt, inpatient; outpt, outpatient; ref, reference; GI, gastrointestinal.

newly diagnosed in the outpatient setting, as evidenced by the extremely low referral rate to services beyond the Prehabilitation Core Team.

Our results demonstrated a statistically and clinically significant improvement in functional capacity (as measured by the 6MWT, one of the most common outcome measures used in many prehabilitation trials), that was sustained up to 3 months after surgery. Other physical measures (such as the STS and TUG) were also similarly improved. There was also a statistically-significant improvement in the psychological outcome measures (both anxiety and depression scales of the HADS) and the EQ-5D. Overall, there was high patient acceptability, given the highly favorable patient satisfaction responses garnered.

These results were consistent with multiple recent systematic reviews and meta-analyses demonstrating the benefits of cancer prehabilitation on functional outcome measures and psychological well-being [2-5].

The relatively lower level of compliance (~65%) of our patients to the prescribed exercises was likely because the exercise program was home-based. In a recently published feasibility study for prehabilitation in high-risk patients scheduled for major abdominal cancer surgery, Waterland et al. [23] quoted "while >60% of participants preferred home-based prehabilitation, adherence was low", with only 28%–35% self-reported compliance to >70% of their exercise prescription.

In our Program, measures were taken to improve compliance, which included the involvement and co-engagement of caregivers in the initial exercise prescription, the follow-up phone calls and pre-operative visits with the prehabilitation coordinator, and a smartphone app to facilitate retention of the prescribed exercises and to allow the patient to set customizable reminders. We note that despite this lower level of compliance, most patients still demonstrated significant improvements as alluded above.

A higher frailty score and and older age were two significant and independent factors affecting post-operative length of stay. This was consistent with other studies [24], highlighting the potential utility of targeting the elderly and frail for greater potential cost-effectiveness, hence the importance of screening for frailty and subsequent prioritization of resources in prehabilitation.

There was a lack of a control group for this study, and the improvements demonstrated were thus mainly from a "pre-post" longitudinal perspective. Future randomized controlled studies would be needed to validate the positive impact of our Prehabilitation Program.

Our current cohort comprised mostly colorectal cancer patients with relatively small representation by other subgroups (HPB, urological, upper GI) due to their later inclusion, and more data would be required to determine the generalizability of the benefits to these subgroups, as well as the impact on their post-operative length-of-stay.

In contrast to many prehabilitation programs which only involve pre-frail or frail patients, we took in non-frail patients as well, which may potentially limit the overall demonstrable improvements due to the influence of a ceiling effect in the latter group.

Prehabilitation applied via our "one-stop", hospital-associated, home-based model of care resulted in significantly improved functional capacity, psychological welfare, and quality of life that were at least sustained for up to 3 months after surgery. The program was well-received by our patients, making it a feasible and likely effective approach in the Singaporean context. Future randomized controlled studies would serve to validate the positive impact of our Prehabilitation Program.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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AUTHOR CONTRIBUTION

Conceptualization: Kwok KM, Tay SS. Methodology: Kwok KM, Tay SS. Formal analysis: Kwok KM. Project administration: Kwok KM, Tay SS. Visualization: Kwok KM, Tay SS. Writing – original draft: Kwok KM. Writing – review and editing: Kwok KM, Tay SS. Approval of final manuscript: all authors.

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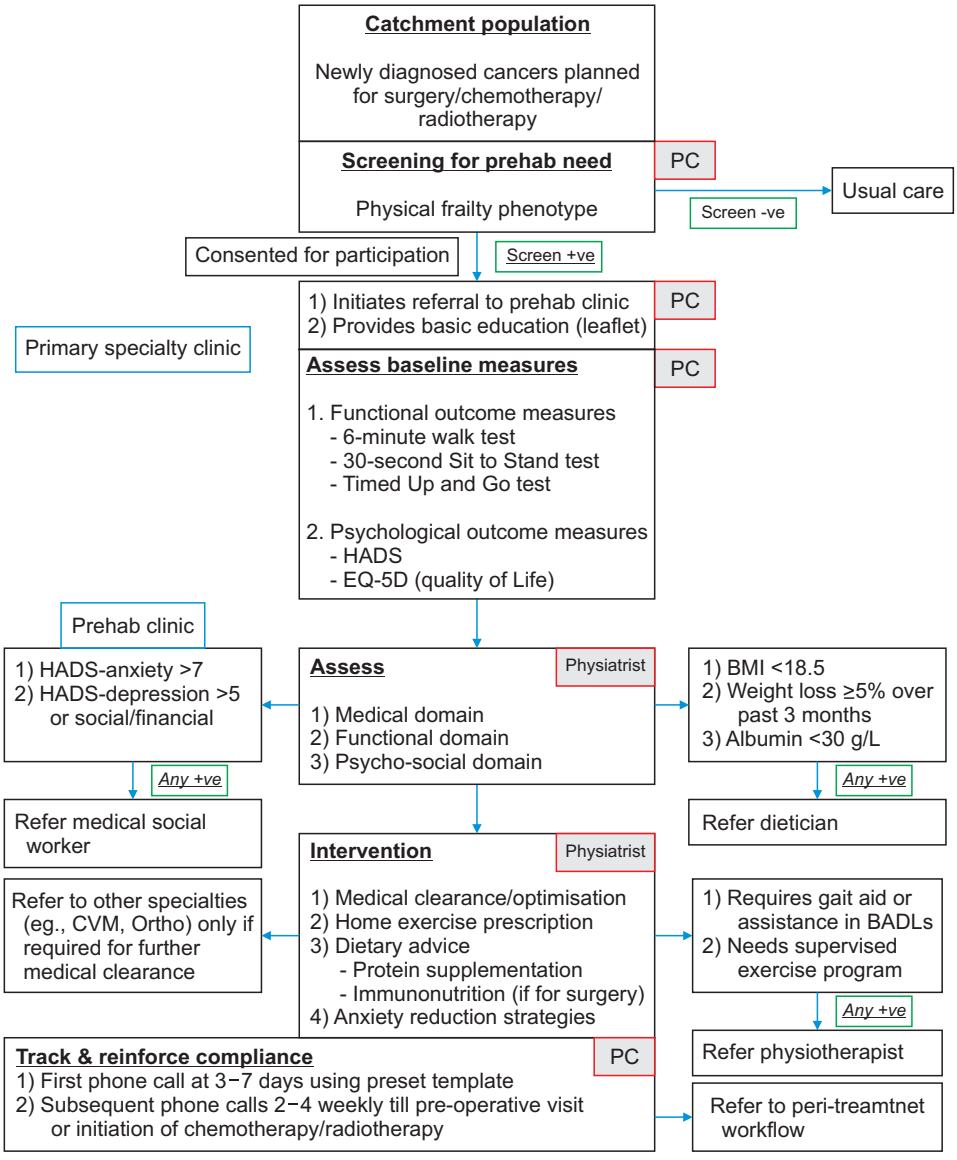
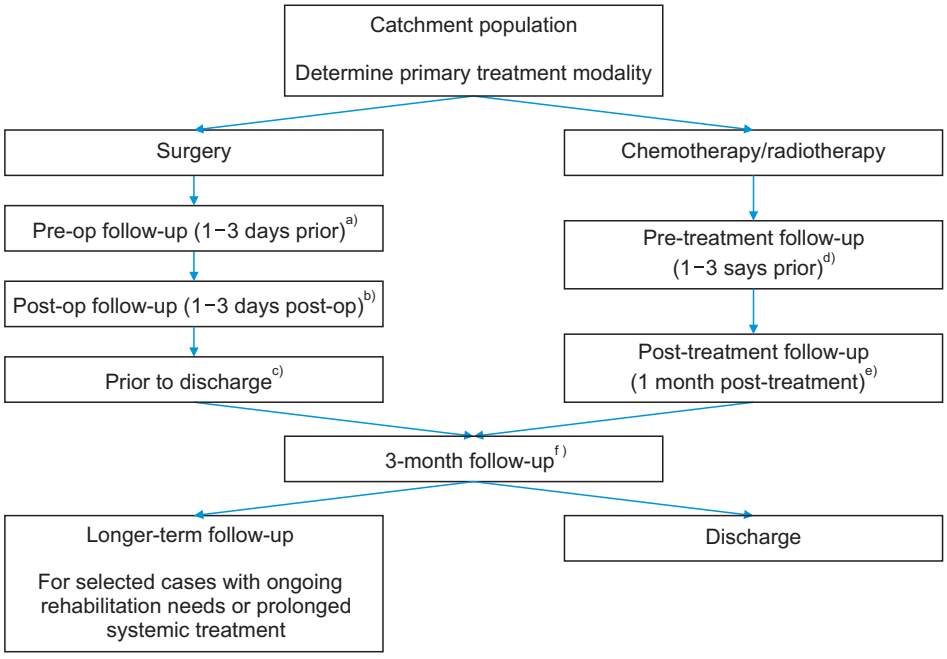
Appendix 1. Prehabilitation protocol. Prehab, prehabilitation; PC, done by prehab coordinator; HADS, Hospital Anxiety and Depression Scale; EQ-5D, EuroQol-5 dimension; Physiatrist, done by physiatrist; CVM, cardiology; Ortho, orthopaedics surgery; BMI, body mass index; BADLs, Basic Activities of Daily Living.



Appendix 2. Peri-treatment workflow. Op, operative; PC, prehabilitation coordinator; HADS, Hospital Anxiety and Depression Scale; Prehab, prehabilitation; EQ-5D, EuroQol-5 dimension.



a) Pre-op follow-up

1) PC repeats the following outcome measures
   a. 6-minute walk test
   b. 30-Second Sit to Stand test
   c. Timed Up and Go test
   d. HADS
2) PC does patient satisfaction survey (to Prehab Program)
3) PC assesses and documents compliance (gets patient to demonstrate exercises taught)

b) Post-op follow-up

1) PC maintains tracking list and flags case to physiatrist
2) Physiatrist reviews and advises on:
   a. Siting for further rehabilitation (inpatient rehabilitation vs. outpatient vs. home)
   b. Medical optimization
   c. Reinforcement/adjustment of exercise prescription
3) PC coordinates
   a. Referral/communication to inpatient dietician
   b. Referral/communication to inpatient physiotherapist
   c. Referral to inpatient Rehab Team (only if required)

c) Prior to discharge

1) PC coordinates
   a. Appointments with Prehab Clinic (physiatrist/PC) in 3 months
   b. Outpatient referral to physiotherapist/occupational therapist (only if required, after discussion with physiatrist)
2) PC documents the following secondary outcome measures
   a. Acute hospital length-of-stay
   b. Post-op major complications

[d]**Pre-treament follow-up**
1) PC repeats the following outcome measures
   a. 6-minute walk test
   b. 30-Second Sit to Stand test
   c. Timed Up and Go test
   d. HADS
2) PC does patient satisfaction survey (to Prehab Program)
3) PC assesses and documents compliance (gets patient to demonstrate exercises taught)
4) PC arranges follow-up with physiatrist 1 month after treatment initiation

[e]**Post-treatment follow-up**
1) Physiatrist reviews and advises on:
   a. Need for outpatient physiotherapy/occupational therapy referral (eg., in cases of functional decline)
   b. Medical optimization
   c. Nutritional assessment & need for outpatient dietician referral
   d. Mental health assessment & need for further referral to medical social worker
   e. Reinforcement/adjustment of exercise prescription

[f]**3-month follow-up**
1) PC repeats the following outcome measures
   a. 6-minute walk test
   b. 30-Second Sit to Stand test
   c. Timed Up and Go test
   d. HADS
   e. EQ-5D
2) PC does patient satisfaction survey (to post-op Rehab Program)
3) PC documents the following secondary outcome measure
   a. 3-month readmission rates
4) Physiatrist reviews and advises on:
   a. Transition to community exercise programs and facilities
   b. Further follow-ups

Appendix 3. Patient satisfaction survey

PREHABILITATION PROGRAM PATIENT SURVEY

Thank you for participating in the Prehabilitation Program. Our aims are to improve your post-operative functional recovery through a series of assessment and interventions targeting your physical activities, nutrition and mental health (where appropriate). We would like to know how you feel about this program.

For each item identified below, please circle the number
that best fits your impression of the Prehabilitation Program

1 – Strongly disagree; 2 – Disagree; 3 – Neutral; 4 – Agree; 5 – Strongly agree

Survey item	Scale				
1. This Program has given me **relevant knowledge** for **lifestyle changes** that will benefit my health.	1	2	3	4	5
2. This Program had caused me to **increase** my **physical activity** level.	1	2	3	4	5
3. This Program had caused me to be **more conscious** of my **nutrition**.	1	2	3	4	5
4. Overall, I am satisfied with the interaction I had with the **Prehabilitation Doctor**.	1	2	3	4	5
5. Overall, I am satisfied with the interaction I had with the **Health & Wellness Professional**.	1	2	3	4	5
6. Overall, I have **benefitted** from this Program.	1	2	3	4	5
7. I will **recommend** this Program to other patients if they are suitable.	1	2	3	4	5
ANY OTHER COMMENTS					