Original Article

Rehabilitation strategies following esophageal cancer (the ReStOre trial): a feasibility study

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SUMMARY. As survival rates in esophageal cancer improve, the role of rehabilitation programs in this group is emerging as an important issue. This study aims to determine the feasibility of a multidisciplinary rehabilitation program to optimize physical function and quality of life in esophageal cancer survivors. This single-arm feasibility study recruited patients who had completed curative treatment for esophageal cancer, including esophagectomy, with node-negative postsurgical pathology. The multidisciplinary program consisted of 12 weeks of supervised and home-based exercise, dietetic counseling, and education sessions. Feasibility outcomes included recruitment rates, adherence, adverse events, and retention. Other outcomes included cardiopulmonary fitness (maximal cardiopulmonary exercise test and the six minute walking test), quality of life (QOL) (European Organisation for Research and Treatment of Cancer (EORTC) questionnaires) and body composition (bioimpedance analysis). Change in outcomes from baseline to postintervention was measured using the paired sample t-tests. Twelve participants (mean (standard deviation) age 61.4 (7.29) years, eight male) consented to participate, representing a recruitment rate of 55%. Mean class attendance was 82(13)% and mean adherence to the home exercise program was 118(76)%. No adverse events occurred. Retention to the program was 100%. VO₂max improved by 3.99(2.7) mL/kg/min ($p < 0.004$). The six minute walking test distance increased by 56.3(35.3) m ($p < 0.003$). Global, functional, and symptom QOL scores improved. Body composition remained stable. This pilot study demonstrated high feasibility and acceptability in this complex cohort. Clinically significant improvements in functional performance and QOL were evident without compromise to body composition. The results of this study will help guide the design of a forthcoming larger randomized controlled trial.

KEY WORDS: diet, esophageal cancer, rehabilitation.

INTRODUCTION

Esophageal cancer is traditionally associated with poor prognosis; however, survival rates are

improving.¹ Globally, 5-year survival for localized tumors has improved to approximately 40%.² Curative treatment for esophageal carcinoma involves surgery (esophagectomy), often combined with a

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Specific Author contributions: Ms Linda O'Neill is a PhD candidate and physiotherapist working predominantly with the esophageal cancer clinical trials program at St James's Hospital. She was involved in the design and implementation of the exercise intervention, acquisition of data, and led the drafting of this manuscript. Dr Emer Guinan is an assistant professor in Interprofessional Learning at Trinity College and a physiotherapist specializing in exercise oncology and works predominantly with the esophageal cancer clinical trials program at St James's Hospital. She was also involved in the design of the intervention, data acquisition, and the drafting of the manuscript through all stages. Dr Suzanne Doyle is an assistant professor at the School of Biomedical Sciences at Dublin Institute of Technology and a research dietitian with a special interest in esophageal cancer. She was responsible for designing and implementing the dietary intervention, data acquisition, and contributed to the manuscript. Dr Jessie Elliott is a surgical research fellow working with the upper gastrointestinal surgery team at St James's Hospital. She assisted with data acquisition and review of the manuscript. Dr Jacintha O'Sullivan is an associate professor in the Department of Surgery at Trinity College Dublin. She contributed to the study design and the manuscript. John Reynolds is the professor of Surgery at St James's Hospital and the national lead for the management of esophageal cancer in Ireland. He contributed to the study design and the manuscript development. Juliette Hussey is a professor in physiotherapy at Trinity College Dublin with a special interest in exercise oncology. She is the principal investigator for the ReStOre (Rehabilitation Strategies Following Esophageal Cancer) trial at St James's Hospital. She led the design of the study and contributed to the manuscript development.

multimodality approach consisting of neoadjuvant chemotherapy or chemoradiotherapy.^{3,4} Treatment is associated with high morbidity and a mortality rate of up to 5%.^{3,5} Esophageal cancer survivors experience long-term complications including fatigue, reflux, dysphagia, pain, and diarrhoea,⁶ which may lead to nutritional and functional compromise resulting in impaired quality of life (QOL).⁶⁻⁸ Limited literature has measured the deficits in physical performance of esophageal cancer survivors; however, subjectively patients report compromised QOL and functional status.^{3,6} The rehabilitative strategies in esophageal cancer (ReStOre trial) will develop a multidisciplinary rehabilitation program to help address the specific issues faced by survivors of esophageal cancer.

It is well acknowledged that there is a need for the development of research into rehabilitation programs in lesser studied cancers, such as esophageal cancer, to help address the multifaceted rehabilitative needs survivors may experience.⁷ To date, rehabilitative research in esophageal cancer has focused on prehabilitation, during neoadjuvant treatment, and also on early postoperative inpatient rehabilitation.⁸⁻¹¹ A randomized trial of a 4-week dietary and walking intervention versus usual medical care was performed to preserve walking ability and prevent nutritional decline in 29 participants undergoing neoadjuvant chemoradiotherapy for esophageal cancer.⁸ In terms of rehabilitation, a pilot study with eight patients who had undergone esophagectomy reported increased walking distance in the six minute walking test (6MWT) from 159.63 to 223.63 m following an in-patient multidisciplinary-led rehabilitation program during the immediate 4 weeks post-surgery.¹¹

This study is the first to investigate the feasibility of a 12-week multidisciplinary-led rehabilitation program consisting of supervised exercise sessions, dietary counseling, and education sessions for survivors of esophageal cancer who are greater than 6 months postcompletion of curative treatment. The primary objective was to examine feasibility as determined by recruitment rate, adherence, acceptability, and adverse events. Secondary objectives were to investigate the impact of the intervention on physical function and QOL.

MATERIALS AND METHODS

Study design

This study was a single-arm feasibility study. Ethical approval was obtained from the St James' Hospital/Tallaght Hospital Joint Research Ethics Committee. Participants provided written informed consent. All study appointments were completed in the Wellcome Trust HRB Clinical Research Facility at St James's Hospital, Dublin.

Study participants

Suitable participants were identified from the Upper Gastrointestinal Cancer Registry of St James's Hospital, Dublin. Twenty-two potential participants were contacted via letter and invited to express an interest in participation. Inclusion criteria included >6 months post successful completion of curative treatment for histologically confirmed esophageal cancer that included esophagectomy with/without neoadjuvant/adjvant chemo/radiotherapy, medical approval to participate, living within one-hour travel radius of the research facility, and willing to attend the scheduled program of appointments. Exclusion criteria included unsuccessful treatment outcome, comorbidities that would preclude safe exercise participation, and evidence of metastatic or recurrent disease.

Measures

Feasibility

Feasibility was determined through analysis of recruitment rates (percentage of eligible study population that consented to participation), program adherence (number of prescribed supervised and unsupervised sessions completed), retention, acceptability of the intervention and assessments, and improvement of outcomes and adverse events.

Secondary outcomes including physical fitness, QOL, and body composition were assessed at two time points: T1 (prerehabilitation) and T2 (postrehabilitation).

Physical fitness

Physical fitness was examined by cardiopulmonary exercise testing (CPET) and the 6MWT. An accelerometer measured physical activity levels.

The CPET was performed on a cycle ergometer. Expired gases were measured via indirect calorimetry using a portable COSMED metabolic cart. An incremental protocol starting at a power of 10 Watts increasing at increments of 10 Watts per minute was implemented. Criteria for test termination included participants reporting feeling unwell or pain unrelated to the test, extreme hypertension (>250 systolic and/or >115 diastolic), abnormal exercise ECG, severe cardiac arrhythmias, or a reduction in pedal frequency below 50 reps per minute. All participants completed the test until a steady state of oxygen consumption was achieved or until symptoms such as leg fatigue prevented continuation.

The 6MWT was completed as per the American Thoracic Society 2002 Guidelines.¹² Participants walked at their fastest pace along a 30-m course with the aim of walking the furthest distance possible in 6 minutes. Standardized instructions and encouragement were provided. The 6MWT has been

(A) Rehabilitation Schedule

	Supervised Exercise	Home Exercise	1:1 Dietetic Counselling	Multidisciplinary Education
Week 1				
Week 2				
Week 3				
Week 4				
Week 5				
Week 6				
Week 7				
Week 8				
Week 9				
Week 10				
Week 11				
Week 12				

(B) Prescribed frequency, intensity and time of exercise programme

	Frequency*		Intensity†	Time
	Supervised Intervention	Home Exercise Programme		
Week 1	2	1	30-45% HRR	20
Week 2	2	1	30-45% HRR	20
Week 3	2	2	35-50% HRR	20
Week 4	2	2	35-50% HRR	25
Week 5	1	2	35-50% HRR	25
Week 6	1	3	40-55% HRR	25
Week 7	1	3	40-55% HRR	30
Week 8	1	4	40-55% HRR	30
Week 9	0	4	45-60% HRR	30
Week 10	1	5	45-60% HRR	35
Week 11	0	5	45-60% HRR	35
Week 12	1	5	45-60% HRR	35

*Indicates frequency of exercise sessions in days per week. †Based on pilot data from our research group it is anticipated that baseline exercise fitness levels will be "very poor" and "poor". Exercise prescription will commence at 30-45% HRR and progress gradually over the course of the intervention to a maximum of 45-60% HRR (moderate intensity activity)

Fig. 1 Rehabilitation schedule and exercise prescription. (A) The prescribed weekly frequency of supervised and home-based exercise sessions, 1:1 dietary counseling, and education sessions. (B) The prescribed weekly progression of the supervised and home-based exercise sessions. HRR, heart rate reserve.

well utilized in both the research and clinical settings.¹³ Its use has also been validated in assessing exercise capacity in cancer and has excellent test–retest reliability.¹⁴

Activity levels were determined through the use of Actigraph GT3X+ (Actigraph, Pensacola, Florida), a triaxial accelerometer. Accelerometers provide accurate, reliable measurements of activity and sedentary behavior.^{15,16} Actigraph data were analyzed using the Actilife 6 software. Participants wore the monitor around their waist secured with an elasticated belt during waking hours for one-week prerehabilitation and one-week postrehabilitation. Monitor wear and nonwear time was logged in an activity diary.

Quality of life

QOL was assessed using the European Organisation for Research and Treatment of Cancer (EORTC) core quality of life questionnaire, the QLQ-C30 (version 3.0), and the esophageal specific subscale, the QLQ-OES18. The QLQ-C30 is a well utilized and validated tool for the assessment of QOL in cancer survivors.^{14,17} It captures QOL measured in separate functional, symptom, and global QOL domains. Scores for each question were calculated and linearly transformed into a 0–100 scale as per the EORTC scoring manual.¹⁸ A high functional score indicated high function, whereas a high symptom score indicated high symptom burden.

Body composition

Weight and height were measured, and body mass index was calculated using a SECA digital medical scale and stadiometer. Bioimpedance analysis was performed using a Seca mBCA machine (Seca, Hamburg). Data results for fat mass, fat mass percentage,

fat-free mass, fat mass index, fat-free mass index, and skeletal muscle mass were recorded.

Intervention

The rehabilitation schedule is illustrated in Figure 1A.

Exercise program

The supervised exercise sessions consisted of a warm-up, a main program of aerobic exercise completed on a treadmill, stationary bike or a cross trainer, followed by a cool down, light resistance work, and stretching exercises. Intensity was prescribed by percentage heart rate reserve (HRR). Subjects commenced exercising at 30–45% HRR. This was based on CPET results of participants, which indicated that participants had mostly either very poor or poor exercise tolerance (Fig. 2). Intensity was monitored during supervised and home sessions using polar heart rate monitors. Home sessions were recorded in an exercise diary. Duration, frequency, and intensity of exercise were increased as the program progressed by the study physiotherapist in line with ACSM guidelines for exercise testing and prescription¹⁹ (Fig. 1B). By the end of the program, participants were prescribed 150 minutes of moderate intensity exercise (60% HRR) per week.

Dietary counseling

Nutritional assessments were carried out in a 1:1 setting by the study dietitian. Dietary intake was assessed using a 24-hour diet recall and semi-structured interview. Gastrointestinal symptoms were assessed using a Gastrointestinal Symptom Rating Score. Participants reported varied dietary issues that included poor appetite, early satiety, weight loss, obesity, dumping syndrome, and malabsorption. Tailored dietary advice

VO₂ max improved from 20.08(5.2) ml/min/kg at T1 to 24.08(4.99) ml/min/kg at T2, which is an increase of 3.99(2.7) ml/min/kg ($p < .004$).

6MWT distance improved from 532.17(78.25)m at T1 to 588.5(73.14) at T2, which is an increase of 56.3(35.33)m ($p < .003$).

Fig. 2 Exercise test results.

Table 1 Demographic characteristics of participants

Characteristic		Mean (standard deviation)/frequency (%)
Sex	Male	8(66.67%)
	Female	4(33.33%)
Age (years)		61.41(7.29)
Height (cm)		171.11(9.37)
Weight (kg)		70.93(19.95)
BMI (kg/m ²)		24.04(8.54)
Time postsurgery at program commencement (months)		22.16(8.54)
Histological type of tumor	Adenocarcinoma	8(66.67%)
	Squamous cell carcinoma	4(33.33%)
	Transhiatal esophagectomy	2(16.67%)
	Two-stage esophagectomy	5(41.67%)
	Three-stage esophagectomy	5(41.67%)
Type of surgery		
Neoadjuvant treatment (yes/no)	Yes	10(88.33%)
	No	2(16.67%)
Adjuvant treatment (yes/no)	Yes	1(8.33%)
	No	11(91.67%)

and education were delivered to the participants by the dietitian with specific dietary goals set at the end of each session. The number of available dietary reviews within the rehabilitation program is illustrated in Figure 1A; however, the dietitian determined the number of sessions received by each participant based on clinical need.

Education intervention

Group education sessions focused on topics that were of specific relevance to esophageal cancer survivors. Education sessions were delivered by a range of members of the multidisciplinary team and representatives of organizations that support people with esophageal cancer, including a representative of the surgical team, cancer nurse specialist, dietitian, physiotherapist, psycho-oncology, a mindfulness practitioner, and representatives from local cancer charities.

Statistical analysis

Statistical analyses were performed using SPSS 22 (SPSS Inc., Chicago, IL, USA). Data were presented as mean (standard deviation). Prior to analysis, variables were tested for normality of distribution using the Shapiro–Wilk test. Normally distributed data were analyzed using a paired t-test. Nonparametric data were analyzed using the Wilcoxon Signed Rank test. A p value of <0.05 was considered as statistically significant.

RESULTS

Demographic characteristics

Descriptive characteristics for the 12 participants are presented in Table 1.

Table 2 Actigraph activity monitor results

	T1 mean (SD)	T2 mean (SD)	Mean difference (SD)	<i>p</i> -value
Total time per activity				
Total sedentary (minutes per week)	3587.00(623.21)	3309.42(582.21)	↓277.58(534.84)	0.100
Total light (minutes per week)	1871.91(542.05)	1690.91(415.88)	↓181.00(339.68)	0.092
Total moderate (minutes per week)	276.50(172.46)	298.92(181.85)	↑22.42(87.84)	0.396
Total vigorous (minutes per week)	16.41(34.11)	17.75(31.79)	↑01.33(14.56)	0.893
Total very vigorous (minutes per week)	00.00(00.00)	01.17(03.73)	↑01.17(03.73)	0.180
Total moderate and vigorous activity (minutes per week)	292.91(192.44)	317.88(187.05)	↑24.92(90.92)	0.363

↑↓ Directions of arrows indicate either increase or decrease in time spent at a particular level of activity. SD, standard deviation.

Table 3 European Organisation for Research and Treatment of Cancer (EORTC), core quality of life questionnaire, the QLQ-C30, and esophageal cancer subscale, the QLQ-OES18 results

	T1 mean(SD)	T2 mean(SD)	Mean difference(SD)	<i>p</i> -value
QLQ-C30				
Global health status/ QOL	70.83(20.26)	81.25(11.85)	↑10.42(10.73) [†]	0.006*
Physical function	81.67(20.52)	87.22(18.74)	↑05.55(10.94)	0.083
Role function	72.22(39.14)	87.50(20.26)	↑15.28(24.06) [†]	0.160
Emotional function	86.80(13.51)	86.10(13.45)	↓00.70(02.41)	0.317
Cognitive function	77.78(21.71)	80.56(18.58)	↑02.78(18.56)	0.588
Social function	79.17(29.41)	87.50(14.43)	↑08.33(20.72)	0.167
Symptom scales				
Fatigue	28.70(21.95)	28.70(26.15)	↔0.00(14.98)	1.000
Nausea/vomiting	04.17(10.36)	05.55(10.86)	↑01.38(04.81)	0.317
Pain	13.89(18.58)	05.55(12.97)	↓08.34(13.30)	0.063
Dyspnea	25.00(28.87)	22.22(29.59)	↓02.78(09.62)	0.317
Insomnia	36.11(41.34)	22.22(25.95)	↓13.89 (33.21) [†]	0.102
Appetite loss	22.22(25.95)	22.22(32.82)	↔0.00(24.62)	1.000
Constipation	16.67(30.15)	11.11(16.41)	↓05.56(19.25)	0.317
Diarrhea	25.00(32.18)	11.11(16.41)	↓13.89(30.01) [†]	0.109
Financial difficulties	25.00(40.51)	11.11(21.71)	↓13.89(33.21) [†]	0.180
QLQ-OES18				
Dysphagia	11.11(14.98)	09.26(13.26)	↓01.85(15.59)	0.854
Eating problems	14.58(10.73)	11.11(08.21)	↓03.47(06.60)	0.084
Reflux	12.50(20.25)	09.72(19.41)	↓02.78(09.62)	0.492
Pain	09.26(09.28)	06.48(10.00)	↓02.78(08.37)	0.257
Trouble swallowing saliva	05.55(12.97)	02.78(09.62)	↓02.77(09.62)	0.317
Choked when swallowing	05.55(12.97)	11.11(16.41)	↑05.56(12.97)	0.157
Dry mouth	16.67(22.47)	08.33(15.07)	↓08.34(15.07)	0.083
Trouble with taste	08.33(15.07)	08.33(15.07)	↔0.00(0.00)	1.000
Trouble with coughing	16.67(17.41)	05.57(12.97)	↓11.10(25.95) [†]	0.157
Trouble talking	02.78(09.62)	02.78(09.62)	↔0.00(0.00)	1.000

↓↑↔ Directions of arrows indicate direction of change in each quality of life scale.

[†]Clinically meaningful improvement. SD, standard deviation.

Feasibility outcomes

Twelve participants out of a potential study population of 22 consented to participate representing a recruitment rate of 55%. The program was well accepted by all participants with 100% completing the program. Adherence to the supervised rehabilitation program was 82(13)%. Adherence to the home exercise program that was assessed using exercise diaries was 118(76)%. No adverse events were recorded during the intervention or assessments.

Physical performance

At T1 participant's average, VO₂max was 20.08(5.2) mL/min/kg. Postintervention this increased by an

average of 3.99(2.7) mL/min/kg ($p < .004$) to 24.08(4.99) mL/min/kg at T2 (Fig. 2). Distance walked in the 6MWT also improved from 532.17(78.25) m at T1 to 588.5(73.14) m (mean increase 56.3(35.33) m) at T2 ($p < .003$) (Fig. 2). No significant changes were observed in activity levels as measured by the Actigraph accelerometers (Table 2).

Quality of life

QOL scores from the QLQ-C30 and QLQ-OES18 subscales are detailed in Table 3. The clinically significant difference for the EORTC is defined as an increase of 10% or more in a function scale or a reduction of 10% in a symptom scale.²⁰ Global QOL showed a statistically and clinically meaningful

Table 4 Anthropometric data

	T1 mean (SD)	T2 mean (SD)	Mean difference (SD)	<i>p</i> -value
Weight (kg)	70.93(19.95)	70.29(19.47)	0.65(1.52)	0.169
Height (cm)	171.11(9.36)	171.18(9.26)	0.07(0.35)	0.523
BMI (kg/m ²)	24.04(05.02)	23.79(4.82)	0.25(0.51)	0.121
Bioimpedance analysis (<i>n</i> = 9)				
Fat mass (kg)	19.48(08.40)	19.74(8.04)	0.26(1.42)	0.596
Fat mass percentage (%)	27.11(05.86)	28.22(05.38)	1.11(1.61)	0.073
Fat free mass (kg)	50.67(14.99)	49.94(15.02)	0.73(1.10)	0.139
Fat mass index (kg/m ²)	06.47(02.45)	06.62(02.31)	0.16(0.38)	0.252
Fat-free mass index (kg/m ²)	16.78(03.25)	16.53(03.31)	0.23(0.38)	0.093
Skeletal muscle mass (kg) (<i>n</i> = 8)	25.44(08.72)	24.86(08.97)	0.58(0.86)	0.093

BMI, body mass index; SD standard deviation.

improvement of 10.42(10.73)% ($p < .006$). The role function scale and symptom scales of sleep, diarrhoea, financial issues, and cough all showed clinically significant improvements (Table 3).

Effects on body composition

Bioimpedance analysis was completed on 9 of the 12 participants. Three participants were unable to be assessed secondary to joint replacements and compression socks. Skeletal muscle mass results are reported for eight of these participants. Muscle mass was too low for the bioimpedance analyzer to detect in one participant. No significant changes occurred in any of the body composition variables (Table 4).

DISCUSSION

This study established that a 12-week multidisciplinary rehabilitation program is safe and feasible for survivors of esophageal cancer. Feasibility was demonstrated through recruitment rates, adherence, acceptability, and lack of adverse events. Participants also showed significant improvements in physical performance measures and QOL following the intervention. This suggests the efficacy of this program warrants further investigation and validation, ideally within a randomized control trial (RCT).

The recruitment rate of 55% was obtained through a maildrop to potential participants. There is limited literature regarding the expected rate of recruitment in cancer survivor exercise trials; however, studies suggest <40% is typical.²¹ Good feasibility was also demonstrated by a high adherence rate of 82(13)% to the supervised sessions. A previous review by Kampshoff *et al.* examining exercise adherence in cancer survivors reported that adherence ranged from 62 to 78%,²² therefore emphasizing the particularly high acceptability of the ReStOre intervention. The majority of participants in the review by Kampshoff *et al.*²² were breast or colorectal cancer survivors, who typically experience less treatment-related morbidity, and therefore may present fewer barriers

to exercise compared to the complex needs of the cohort recruited to ReStOre. Participants in this feasibility study reported that work and family commitments and travel to the research center were barriers to attending supervised sessions. Compliance with the home exercise sessions was monitored using exercise diaries. Participants had a mean compliance of 118(76)%. The large standard deviation perhaps highlights the discrepancies in motivation among participants. The results show that several participants greatly exceeded the prescribed amount of home sessions whereas some participants struggled to comply. Participants reported lack of time, lack of motivation, aversion to instruction, other illness, and work and family commitments as reasons that prevented them from achieving the prescribed number of exercise sessions. The ReStOre trial implemented a number of recommended methods to promote habitual exercise in cancer survivors.²³ These included goal setting, self-monitoring (using polar heart rate monitors), and encouraging participants to repeat the same level of exercise achieved in their rehabilitation class in an unsupervised capacity. The large variance in compliance with the unsupervised sessions in this study concurs with the review findings of Bourke *et al.*²⁴ that it is difficult to get sedentary cancer survivors to adhere to the recommended 150 minutes of moderate intensity activity per week. All 12 participants completed the intervention signaling high acceptability. In terms of safety, no adverse events occurred during any assessments or treatment sessions.

Clinically meaningful and statistically significant improvements in aerobic fitness were also demonstrated through increases in both VO₂max and 6MWT distance. The use of CPET to measure cardiopulmonary fitness in patients with esophageal cancer has largely been confined to the preoperative setting.²⁵⁻²⁷ Little is known about the physical fitness of esophageal cancer survivors as previous work has used subjective measures to determine physical function.^{3,6} The results of the T1 assessments demonstrate that survivors of esophageal cancer have very poor or poor levels of aerobic fitness.²⁸ Postintervention participants demonstrated an improvement in VO₂max

of 3.99(2.7) mL/min/kg, which is an improvement of greater than one metabolic equivalent of oxygen (MET) (1 MET = 3.5 mL/min/kg). In a systematic review and metaanalysis of exercise interventions in breast cancer survivors, Mc Neely *et al.*²⁹ pooled data from three studies that assessed change in fitness using CPET and deemed an increase in exercise capacity of 3.39 mL/min/kg to be clinically meaningful. An improvement in 1 MET corresponds with a 12% (men) and a 17% (women) reduction in mortality.^{29,30} Therefore, the improvement in VO₂max achieved by this feasibility study's participants may be considered a meaningful result. Improvement in physical function was also demonstrated by the 6MWT. In patients with cancer, a change of 54 m is deemed a clinically meaningful difference,³¹ and therefore the improvement observed in this study, 56.3(35.3)m, may be considered clinically meaningful for the participants. Large variance was seen in the physical activity scores as measured by the Actigraph activity monitor, and no statistically significant improvements were observed. A small increase of 24.92(90.92) minutes per week in moderate-vigorous physical activity (MVPA) may have contributed to the improvements observed in aerobic fitness. MVPA is an important outcome for cancer survivors as it has been shown to correlate highly with QOL and overall survival in breast and colon cancer survivors.^{15,16}

Several domains of QOL improved following the ReStOre intervention. At baseline, participants had global health scores that were slightly lower than normative values (T1 average = 70, normative data = 81).³² At follow-up, global health scores exceeded the normative data (T2 average = 81). Role function, which, at T1, was below average compared to normative data (T1 = 72, normative data = 85) improved to an average 87.5 at T2 which, although it did not gain statistical significance, is a meaningful clinical change. As survivors of cancer often experience psychosocial issues that may impair their ability to optimally engage in society,³³ it is important to see that participants felt that their role function had improved as a result of the rehabilitation program. None of the symptom scales improved significantly. This may have been due to the small sample size and large variation in the symptoms experienced by participants. The future RCT will aim to detect improvements in symptom scores as previous research has documented the long-term symptom burden survivors of esophageal cancer experience.^{6,17}

Body composition did not change with the intervention. Malnutrition is a serious long-term issue for patients postesophagectomy. Other symptoms such as dysphagia and reflux can also impair patient's ability to ingest adequate amounts of food.^{34,35} Weight loss post-surgery consists of loss of fat mass and depletion of skeletal muscle mass, termed sarcopenia.^{36,37} Postoperative weight loss has been associated with

reduced disease-free survival.³⁴ Therefore, it is an important outcome achieved by this feasibility study that the nutritionally compromised study population, under the guidance of a physiotherapist and dietitian, were able to increase their exercise levels to the internationally recommended amount per week²⁸ without any compromise to body composition. The severity of the loss of skeletal muscle mass that may occur in esophageal cancer survivors was highlighted by the results of one participant whose skeletal muscle mass was too low to detect by bioimpedance analysis. Sarcopenia has been identified as a potential biomarker for poor prognosis in esophageal carcinoma.³⁷ The future RCT will incorporate a resistance training component to attempt to counteract the devastating consequences of sarcopenia.

This feasibility study had several limitations. First, as a pilot study, it had a small sample size and a single arm. The primary aim of this study design was to assess feasibility, and a larger adequately powered RCT will be implemented to examine the efficacy of the intervention. Other lessons learned which will inform the RCT program include the need for a resistance training component to combat the loss of muscle mass described in esophageal cancer survivors and also the need for a wellness measure. Postintervention feedback highlighted that there was a great sense of improved confidence and well-being among participants as a result of participation in the multidisciplinary program. In the forthcoming RCT, an outcome that captures the 'wellness' factor will be included. Finally, the cohort of survivors included in this feasibility study were known to have node negative pathology and lived within a manageable commute of the research center. Accordingly, the generalisability of the results to a wider cohort of cancer survivors is unclear.

In conclusion, a 12-week multidisciplinary rehabilitation program consisting of exercise, dietary counseling, and education was found to be feasible for survivors of esophageal cancer who were greater than one year post-treatment completion. Clinically significant improvements in functional performance and QOL were evident without compromise to body composition. While results of this feasibility study are limited, the efficacy of this program will be further investigated in the forthcoming RCT.

ACKNOWLEDGEMENTS

This project was funded by a Health Research Board (HRB) grant. We would like to acknowledge the assistance and support of the Wellcome Trust/HRB Clinical Research Facility at St. James' Hospital in providing a dedicated environment for the conduct of high-quality clinical research activities. We would also like to thank the Irish Cancer Society, the

Oesophageal Cancer Fund, and the ARC Cancer Support Centre for their contributions to the education sessions.

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