Original Article

Supervised Moderate Intensity Exercise Improves Distance Walked at Hospital Discharge Following Coronary Artery Bypass Graft Surgery—A Randomised Controlled Trial

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Background: **This study aimed to determine whether a structured, inpatient (or Phase 1 cardiac rehabilitation), physiotherapy-supervised walking program, with or without musculoskeletal and respiratory exercises, might improve walking capacity and other parameters for patients undergoing coronary artery bypass graft surgery (CABG).**

Methods: **Ninety-three patients awaiting first-time CABG over a 12-month period were randomised to one of three post-operative physiotherapy regimens: 'standard intervention', consisting of gentle mobilisation; 'walking exercise', consisting of a physiotherapy-supervised, moderate intensity walking program; and 'walking/breathing exercise', consisting of the same moderate intensity walking program, musculoskeletal exercises and respiratory exercises. Primary outcomes; six-minute walking assessment (6MWA) distance, vital capacity and health-related quality of life, were measured pre-operatively, at discharge from hospital and at four weeks following discharge.**

Results: **Walking and walking/breathing exercise groups had significantly higher 6MWA distance (444 ± 84 m, 431 ± 98 m, respectively) than the standard intervention group (377 ± 90 m) at discharge from hospital. There was no significant difference between intervention groups for 6MWA distance at four-week follow-up. There was no significant difference between intervention groups in terms of vital capacity and health-related quality of life.**

Conclusions: **A physiotherapy-supervised, moderate intensity walking program in the inpatient phase following CABG improves walking capacity at discharge from hospital. The performance of respiratory and musculoskeletal exercises confers no additional benefit to the measured outcomes.**

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Keywords. Physiotherapy; Coronary artery bypass surgery; Exercise; Quality of life; Cardiac rehabilitation

Introduction

Traditionally, physiotherapists have employed a variety of respiratory interventions after coronary artery bypass graft surgery (CABG) to reduce the incidence of post-operative pulmonary complications (PPC).[1] A recent systematic review provided evidence that such interventions were ineffective at preventing PPC in this population, although it was acknowledged that the component studies were often of low quality, and that further research was indicated.[2] Furthermore, the incidence of PPC following cardiac surgery is both small and decreasing,[3] a trend which has been attributed in part to current management protocols emphasising early post-operative mobility. Accordingly, physiotherapy during inpatient or Phase 1 cardiac rehabilitation (CR) may be more usefully directed at restoring pre-operative physical functional capacity, through prescription of walking exercise and/or thoracic mobility exercises. Even if such approaches have no impact on PPC rates, early restoration of functional outcomes, e.g. walking ability, may shorten the duration of hospital admission and allow for earlier progression to outpatient CR and return to work.

We searched Medline, CINAHL and PEDro using the search terms 'cardiac surgery', 'coronary artery bypass graft', 'CABG', 'physiotherapy', 'physical therapy', 'exer-

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cise' and 'breathing exercise'. We found no studies of the effect of Phase 1 mobilisation per se on walking ability, respiratory capacity, subjective health or length of hospital stay following CABG. We also failed to find any studies investigating effects of post-CABG upper limb/thoracic mobility exercises or carry-over effects of breathing exercises on walking ability or subjective health. Consequently, we formulated the following research questions:

1. Does a Phase 1, moderate intensity walking exercise program, performed under direct physiotherapy supervision, improve sub-maximal exercise capacity, vital capacity, health-related quality of life or length of hospital stay?
2. Does the addition of specific respiratory and musculoskeletal exercises to such a walking program provide further benefit in respect of these outcomes, compared to the walking program alone?

Methods

Patients

A prospective study was performed within the Critical Care Unit and Cardiovascular Ward of Westmead Private Hospital, Sydney, having been approved by the Sydney West Area Health Service Human Research Ethics Committee. Patients awaiting first-time CABG at Westmead Private Hospital between June 2004 and May 2005 were invited to participate in the study, and enrolled after giving written informed consent. Ninety-three patients were enrolled, one of whom did not proceed for operation, yielding a sample size of 92. Three additional patients meeting study criteria declined to participate. Exclusion criteria were planned concomitant surgery, musculoskeletal or neurological impairment precluding performance of a walking assessment, inability to complete questionnaires, and a clinical status which required emergency CABG.

Randomisation

Patients were randomised to three treatment groups (see below) following assessment of study eligibility but prior to initial physiotherapy assessment. Randomisation was performed by means of cards within sequentially numbered, sealed opaque envelopes, group allocation within these being performed randomly (through shuffling of cards) by a research assistant whose contribution to the study went no further. Randomisation was stratified by gender and by history of myocardial infarction in the four weeks prior to surgery. Thirty-two patients were allocated to receive 'standard intervention', 31 to 'walking exercise' and 30 to 'walking/breathing exercise'.

Preliminary sample size calculations suggested that recruitment of 63 patients in each of the three study groups would provide sufficient statistical power to detect a clinically important difference in discharge six-minute walk assessment (6MWA) distance at a significance level of 0.05 (84 patients at 0.017, allowing for multiple comparisons). Data collection was ceased at exactly one year due to a slower than anticipated recruitment rate and a (first and final) interim analysis at this time showing significant differences in 6MWA distance between groups at discharge.

Intervention Groups

Physiotherapy interventions received by the three study groups are documented in Table 1. All physiotherapy interventions were undertaken by one of seven members of Westmead Private Hospital's physiotherapy service, specifically trained in the education and treatment methods used in the study.

Supplemental oxygen was used for all supervised/assisted walks if resting oxygen saturations were <92%. If patients were in fast atrial fibrillation (defined as >120 beats min^{-1} at rest) without haemodynamic compromise, walks were undertaken as prescribed but at a 'comfortable' pace rather than at a 'moderate' or 'somewhat strong' level of perceived exertion. Patients were counselled neither for nor against walking outside of physiotherapy sessions.

The additional respiratory and musculoskeletal exercises undertaken by the walking/breathing exercise group consisted of the following:

(i) Use of an incentive spirometer (Smiths Medical Coach 2, Keene, USA). Patients performed 20 supervised breaths with this device (5 sets of 4 repetitions) within each physiotherapy session. Patients were additionally encouraged to perform 5 sets of 4 repetitions each waking hour.
(ii) Combined lateral basal expansion (deep breathing) exercises (as per Brasher et al., 1993)[3] and upper limb/thoracic spine range of motion exercises (10 repetitions per physiotherapy session of each of shoulder flexion, shoulder/thoracic spine protraction and shoulder/thoracic spine retraction movements).

In all treatment sessions, for all intervention groups, a respiratory assessment was undertaken by the physiotherapist. Following cessation of active physiotherapy treatment in the standard intervention group, daily respiratory assessment continued until hospital discharge.

All physiotherapy-supervised respiratory and musculoskeletal exercises were performed in closed cubicles or individual patient rooms to mitigate against patients comparing post-operative physiotherapy protocols. Nurses and doctors were asked to avoid discussing issues of walking, exercise or physiotherapy with patients, and to refer any questions regarding the study or physiotherapy treatments to the researchers.

At discharge, all patients were referred to an outpatient cardiac rehabilitation program, to be commenced after four-week follow-up with their surgeon and follow-up outcome assessment.

Table 1. *Physiotherapy for Standard Intervention, Walking Exercise and Walking/Breathing Exercise Intervention Groups*

	Standard Intervention[3]	Walking Exercise	Walking/Breathing Exercise
Pre-operative	Education regarding effects of surgery on lung function, body positioning to improve post-operative lung ventilation, huffing/coughing with wound support to facilitate secretion removal.	As per standard intervention plus education regarding the use of a modified RPE scale[5] in relation to a twice daily, progressive, physiotherapy-supervised post-operative walking program.	As per walking exercise, plus education regarding additional breathing exercises (see text for detail).
Post-operative day 1	Patient assisted to sit out of bed.	As per standard intervention, plus walking on spot for 3 repetitions of 1 min.	As per walking exercise, plus additional breathing exercises a.m. and p.m.
Post-operative day 2	Patient assisted to walk/supervised in walking a minimum of 10 m a.m. and p.m.[a]	Patient assisted to walk/supervised in walking 3 circuits of critical care unit (100 m total) a.m., 5 min p.m. (at RPE 3–4/10).	As per walking exercise, plus additional breathing exercises a.m. and p.m.
Post-operative day 3	Patient assisted to walk/supervised in walking a minimum of 30 m a.m. and p.m.[a]	Patient assisted to walk/supervised in walking a minimum of 5 min a.m. and p.m. (at RPE 3–4/10).	As per walking exercise plus additional breathing exercises a.m. and p.m.
Post-operative day 4 onwards	As per day 3 plus ascent and descent of stairs when deemed clinically appropriate. Active physiotherapy treatment ceased when this achieved without assistance.	Walking time progressively increased by 2.5 min as patient able, to maximum of 10 min. Twice daily walking program supervised until discharge from hospital. Ascent and descent of stairs when deemed clinically appropriate.	As per walking exercise plus additional breathing exercises a.m. and p.m.
Discharge onwards	Education regarding progression of activity for the initial 4-week period following discharge from hospital.[22]	Education regarding appropriate progression of twice daily moderate intensity walking program for initial 4-week period following discharge from hospital.	As per walking exercise plus education regarding continued performance of additional exercises.

RPE: Rating of perceived exertion.
[a] Patients could walk further as desired, but were not supervised in this unless physical assistance was required.

Outcomes

There were three primary outcome measures for the study: six-minute walk assessment (6MWA) distance, vital capacity (VC) and health-related quality of life (as measured by the SF-36 Version 2.0 questionnaire, SF-36v2).[4]

Pre-operative testing was performed on the day prior to surgery. Repeat tests were performed on the day of hospital discharge, determined by the operating surgeon (surgeons were blinded to group allocation), and at approximately four weeks after the day of discharge from hospital, to coincide with a routine follow-up appointment with the surgeon. All assessments (pre-operative, discharge and follow-up) were performed in a standardised order; 6MWA, VC, SF-36v2, by one of three physiotherapists trained in assessment procedures. Due to physiotherapy staffing levels and the unpredictable timing of discharge assessment, assessing physiotherapists were not necessarily blinded to group allocation. To limit for potential bias, strict assessment performance criteria (see below) were documented and followed. No feedback regarding 6MWA or VC performance was provided prior to questionnaire administration.

Secondary outcomes were post-operative length of hospital stay, rates of indicators which might contribute to a definition of PPC (see below), and atrial fibrillation during hospitalisation.

Six-Minute Walk Assessment (6MWA)

Patients were instructed to walk laps of an enclosed, air-conditioned 43.5 m corridor for a period of six minutes, covering as much distance as possible whilst exerting themselves at a perceived intensity of exertion of 'moderate' to 'somewhat strong' (i.e. a rating of 3–4 on a modified Borg scale).[5] Patients were allowed to rest if required, and the assessment was ceased if there was angina pain or undue shortness of breath which would normally limit activity and/or necessitate the use of coronary vasodilator therapy. Patients were advised of elapsed time at each minute of the assessment. No other feedback or encouragement was given. Pre-assessment and post-assessment blood pressure, heart rate and oxygen saturation were measured using an electronic sphygmomanometer and saturation probe (Marquette Dash 3000 Patient Monitor, Milwaukee, USA). Peak heart rate for the assessment was measured using a Polar heart rate monitor (Model S120,

Kempele, Finland). Distance covered was measured to the nearest 0.5 m.

Pre-operatively, subjects did not perform a 6MWA if they presented with acute myocardial infarction (AMI) within the four weeks prior to surgery, current resting angina, intravenous medications which could not be ceased (e.g. heparin) or if the surgeon specifically requested non-performance due to concerns of incipient AMI.

Vital Capacity (VC)

VC was measured using a Vitalograph spirometer (20–600, Buckingham, England), testing conforming to American Thoracic Society guidelines.[6] VC was tested four times, over approximately four minutes, and the highest volume was recorded to the nearest 0.05 L (BTPS). Specifically, VC was tested as a 'non-forced' manoeuvre.

The SF-36 Version 2.0 (SF-36v2)[4]

Health-related quality of life was measured using the SF-36v2, a generic, self-reported quality of life survey, which has previously been used and validated in post-cardiac surgery populations.[7–9] The SF-36v2 yields an eight-scale profile of scores (physical function, role-physical, bodily pain, general health, vitality, social function, role-emotional and mental health): scores for each of these subscales can be between 0 (reflecting the highest level of disease burden, or 'worst' health) and 100 (reflecting the lowest level of disease burden, or 'best' health). Normalised physical and mental component summary (PCS, MCS) measures were calculated from subscale scores, for comparison against the general population (considered to have a mean of 50 and standard deviation of 10).

Post-Operative Pulmonary Complication (PPC) Indicators

Incidences of the following potential, contributory indicators of PPC were evaluated retrospectively: post-surgical chest radiograph pathology (specifically atelectasis, lung contusion, lung collapse and/or consolidation) as noted by the reporting radiologist; elevated white blood cell count ($>11.0 \times 10^9\ L^{-1}$) on post-operative days one, two and four; the presence of tympanic temperature $\geq 38\ ^\circ C$ post-operatively; the prescription of respiratory antibiotics; and the isolation of respiratory pathogens on sputum microscopy and culture (if this had been clinically indicated). These indicators were derived from those used previously in an investigation of physiotherapy after cardiac surgery.[3] Clinical practice within our hospital generally aims for maintenance of $SpO_2 > 92\%$ in the post-operative period. We also investigated the incidence of requirement of an $FiO_2 > 50\%$ for >24 h post-operatively to achieve this, as well as the prescription of non-invasive ventilation (NIV) following extubation.

Statistical Methods

The statistical software packages S-PLUS Version 6.2 and SPSS for Windows Version 12 were used to analyse the data. Two-tailed tests with a 5% significance level were used throughout.

Linear mixed effects models were fitted to each primary outcome measure using S-PLUS. In these models, patient identifier was considered as a random effect and time and intervention group as fixed effects. For those outcome measures where the p-value for interaction between time and intervention group approached significance, the effect of intervention group was analysed separately at discharge and at follow-up using general linear models in SPSS. Paired t-tests were used to analyse the effect of time for combined group data.

Kruskal–Wallis non-parametric analysis of variance was used to test for homogeneity of demographic and peri-operative variables, and hospital length of stay. Pearson Chi-Square and Fisher's Exact Test (where expected counts were small) were used to compare rates of PPC indicators and atrial fibrillation.

Results

A flow-chart indicating progression of patients through the study period is shown in Fig. 1.

One patient recruited to the study (standard intervention) was subsequently cleared of significant coronary artery disease and did not proceed for pre-operative assessment or operation. One patient (standard intervention) died on the third post-operative day following an asystolic arrest. Three patients from the standard intervention group and one from the walking exercise group required additional post-operative physiotherapy treatment, including incentive spirometry and chest wall percussion. Results of these patients were analysed on an intention-to-treat basis. Three patients did not present for follow-up testing, one for no specified reason (standard intervention) and two of whom (one walking exercise, one walking/breathing exercise) remained re-hospitalised at the appointed review date.

Baseline demographic and clinical characteristics and selected peri-operative variables for patients/groups are shown in Table 2. There were no significant differences between intervention groups for demographic and peri-operative variables.

6MWA data are presented in Fig. 2. Twenty-five patients did not complete a pre-operative 6MWA for the following reasons: recent AMI ($n = 14$, 4 standard intervention, 5 walking exercise, 5 walking/breathing exercise); chest pain at rest prior to or during 6MWA ($n = 9$, 2 standard intervention, 2 walking exercise, 5 walking/breathing exercise); 100% left main coronary artery disease, surgeon's request ($n = 2$, 1 standard intervention, 1 walking/breathing exercise). The 6MWA distance at discharge and follow-up for these patients was similar to those within their intervention groups who did complete a pre-operative 6MWA.

There was no significant difference between 6MWA distance for intervention groups pre-operatively ($p = 0.31$) or at follow-up ($p = 0.24$). There was, however, a statistically significant difference at discharge from hospital ($p = 0.012$). Pairwise comparisons indicated that the 6MWA distance for the standard intervention group (377 ± 90 m) was significantly lower than that for both

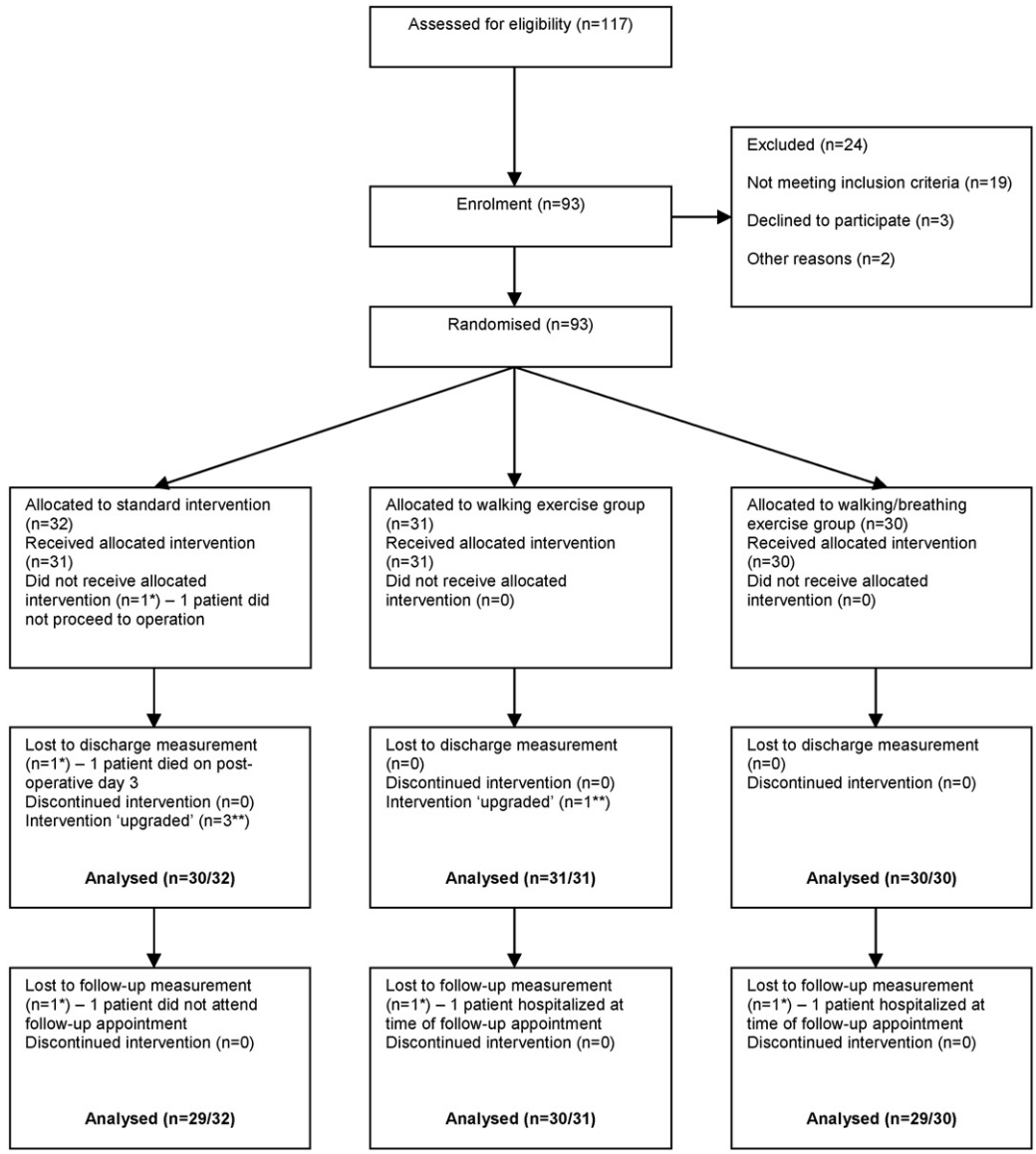

Figure 1. *Flowchart of patients through the study period. (*) Excluded from subsequent analyses. (**) Analysed on 'intention-to-treat' basis.*

the walking exercise group (444 ± 84 m, $p = 0.005$ (0.015 Bonferroni corrected), effect size = 67 m, 95% CI 21–113 m) and the walking/breathing group (431 ± 98 m, $p = 0.022$ (0.065 Bonferroni corrected), effect size = 55 m, 95% CI 8–101 m). There was no significant difference in 6MWA distance between walking exercise and walking/breathing exercise groups ($p = 0.595$ (1.0 Bonferroni corrected), effect size = 12 m, 95% CI −44 to 69 m).

VC and SF-36v2 sub-scale scores are reported in Tables 3, 4a and 4b. There was no significant interaction between the effects of time and intervention group for any of these outcome measures. Significant changes over time for combined group data, however, were noted for VC and all SF-36v2 sub-scales and summary scales.

There was no significant difference between intervention groups for hospital length of stay (standard care: median 7 days, interquartile range (IQR) 6–7 days; walking exercise: median 6 days, IQR 6–8 days; walking/breathing exercise: median 6.5 days, IQR 6–7 days; $p = 0.945$).

Post-Operative Pulmonary Complications Indicators/Atrial Fibrillation

Rates of contributory indicators for PPC, and post-operative atrial fibrillation (AF), are shown in Table 5. There were no significant differences between intervention groups for any PPC indicator or AF rates.

All patients for whom post-operative chest radiograph reports were available (87/91) demonstrated some degree of atelectasis or lung contusion in the period prior to discharge as reported by the consulting radiologist. No attempt was made to objectively grade the degree of lung pathology.

Table 2. *Demographic and Peri-Operative Data (Mean ± S.D.)*

	Standard Intervention ($n = 31$[a])	Walking Exercise ($n = 31$)	Walking/Breathing Exercise ($n = 30$)	All Patients ($n = 92$)
Age (years)	63.6 ± 8.5	63.2 ± 10.8	61.8 ± 7.2	62.9 ± 8.9
BMI (kg m^{-2})	29.5 ± 4.5	28.2 ± 4.4	28.3 ± 3.6	28.7 ± 4.2
Male/female	26/5	27/4	27/3	80/12
NYHA I	8	10	6	24
NYHA II	8	12	13	33
NYHA III	5	4	5	14
NYHA IV	10	5	6	21
OPCAB	1	2	1	4
Number of distal anastamoses	3.4 ± 1.1	3.6 ± 1.4	3.6 ± 1.2	3.5 ± 1.2
Operation duration (min)	182 ± 49	165 ± 46	170 ± 34	172 ± 43
Cardiopulmonary bypass time (min)[b]	69 ± 24	64 ± 15	67 ± 13	67 ± 18
Aortic cross-clamp time (min)[b]	44 ± 13	42 ± 13	43 ± 9	43 ± 12
Post-operative ventilation time (h)	10.0 ± 4.4	10.4 ± 3.3	10.7 ± 4.2	10.4 ± 4.0

BMI: Body mass index; NYHA: New York Heart Association (Class); OPCAB: off-pump coronary artery bypass.
[a] Patient not proceeding for operation not included.
[b] OPCAB patients not included.

Adverse Events Prior to Discharge

One patient in the standard intervention group died on the third post-operative day subsequent to asystolic arrest. One patient in the walking/breathing exercise group required intra-operative insertion of an intra-aortic balloon pump for poor left ventricular function. Two patients (one standard intervention, one walking/breathing exercise group) required sternal re-opening on post-operative day 0 for haemostasis. Four patients, two in each of walking exercise and walking/breathing exercise groups required insertion of intercostal catheter(s) for management of pneumothorax and/or pleural effusion.

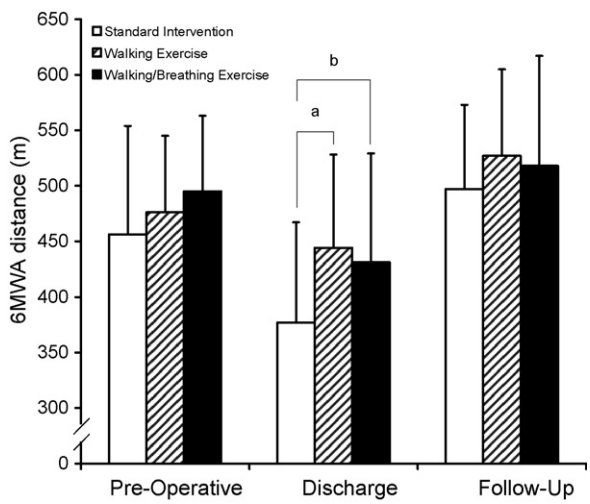

Figure 2. *Results of 6MWA pre-operatively, at discharge and at follow-up. Data are mean ± S.D. a: p = 0.005 (0.015 Bonferroni corrected), b: p = 0.022 (0.065 Bonferroni corrected).*

Adverse Events Following Discharge

Ten patients re-presented to hospital following discharge, two of whom remained in hospital at the planned time of follow-up (for investigation and management of transient ischaemic attack (walking exercise) and pericardial effusion (walking/breathing exercise)). Of the other eight, two were from the standard intervention group, one with pulmonary emboli and one with a bleeding duodenal ulcer. Four were from the walking exercise group, one each presenting with chest pain/malaise, radial artery graft site infection, gouty arthritis and atrial fibrillation. Two patients were from the walking/breathing exercise group, one with collapse/fall of unknown aetiology and one with gastrointestinal bleeding.

Discussion

The principal finding of the present study is that, in a population of patients undergoing first-time, non-emergency CABG, a moderate intensity, Phase 1 walking exercise program performed under direct physiotherapy supervision

Table 3. *Results of VC Pre-Operatively, at Discharge and at Follow-Up*

VC (L BTPS)	Pre-Operatively	Discharge	Follow-Up
Standard intervention	3.6 ± 1.0 ($n = 31$)	2.3 ± 0.7 ($n = 30$)	3.1 ± 0.8 ($n = 29$)
Walking exercise	3.7 ± 0.7 ($n = 31$)	2.4 ± 0.6 ($n = 31$)	3.2 ± 0.7 ($n = 30$)
Walking/breathing exercise	3.8 ± 0.8 ($n = 30$)	2.3 ± 0.6 ($n = 30$)	3.2 ± 0.9 ($n = 29$)
All patients	3.7 ± 0.8 ($n = 92$)	2.3 ± 0.6 ($n = 91$)[a]	3.2 ± 0.8 ($n = 88$)[a,b]

As there were no between-group differences, significant differences in means are reported only for 'all patients'.
[a] $p < 0.05$ vs. pre-operative.
[b] $p < 0.05$ vs. discharge.

Table 4a. *Results of SF-36v2 Questionnaire Physical Indices Pre-Operatively, at Discharge and at Follow-Up*

	Pre-Operatively	Discharge	Follow-Up
Physical function			
Standard intervention	57 ± 24 (n = 31)	45 ± 22 (n = 30)	66 ± 16 (n = 29)
Walking exercise	66 ± 25 (n = 31)	55 ± 24 (n = 31)	71 ± 18 (n = 30)
Walking/breathing exercise	62 ± 26 (n = 29*)	54 ± 22 (n = 29*)	72 ± 20 (n = 28*)
All patients	62 ± 25 (n = 91*)	52 ± 23 (n = 90*)[a]	70 ± 18 (n = 87*)[a,b]
Role-physical			
Standard intervention	53 ± 26 (n = 31)	36 ± 26 (n = 30)	43 ± 25 (n = 29)
Walking exercise	57 ± 26 (n = 31)	47 ± 28 (n = 31)	48 ± 25 (n = 30)
Walking/breathing exercise	62 ± 25 (n = 29*)	47 ± 24 (n = 29*)	40 ± 22 (n = 28*)
All patients	57 ± 26 (n = 91*)	43 ± 26 (n = 90*)[a]	44 ± 24 (n = 87*)[a]
Bodily pain			
Standard intervention	59 ± 23 (n = 31)	51 ± 28 (n = 30)	61 ± 22 (n = 29)
Walking exercise	68 ± 27 (n = 31)	55 ± 29 (n = 31)	63 ± 21 (n = 30)
Walking/breathing exercise	70 ± 25 (n = 29*)	53 ± 22 (n = 29*)	66 ± 22 (n = 28*)
All patients	66 ± 25 (n = 91*)	53 ± 26 (n = 90*)[a]	63 ± 22 (n = 87*)[b]
General health			
Standard intervention	58 ± 21 (n = 31)	66 ± 17 (n = 30)	75 ± 17 (n = 29)
Walking exercise	65 ± 19 (n = 31)	65 ± 19 (n = 31)	78 ± 18 (n = 30)
Walking/breathing exercise	63 ± 19 (n = 29*)	63 ± 20 (n = 29*)	75 ± 17 (n = 28*)
All patients	62 ± 19 (n = 91*)	65 ± 19 (n = 90*)	76 ± 17 (n = 87*)[a,b]
Physical component summary			
Standard intervention	41 ± 10 (n = 31)	37 ± 7 (n = 30)	41 ± 7 (n = 29)
Walking exercise	44 ± 9 (n = 31)	40 ± 9 (n = 31)	44 ± 7 (n = 30)
Walking/breathing exercise	44 ± 10 (n = 29*)	40 ± 8 (n = 29*)	42 ± 6 (n = 28*)
All patients	43 ± 10 (n = 91*)	38 ± 8 (n = 90*)[a]	43 ± 7 (n = 87*)[b]

* One patient unable to comprehend sufficiently the SF-36v2 questionnaire. As there were no between-group differences, significant differences in means are reported only for 'all patients'.
[a] $p < 0.05$ vs. pre-operative.
[b] $p < 0.05$ vs. discharge.

Table 4b. *Results of SF-36v2 Questionnaire Mental Indices Pre-Operatively, at Discharge and at Follow-Up*

	Pre-Operatively	Discharge	Follow-Up
Vitality			
Standard intervention	48 ± 21 (n = 31)	45 ± 23 (n = 30)	58 ± 16 (n = 29)
Walking exercise	54 ± 23 (n = 31)	49 ± 22 (n = 31)	60 ± 20 (n = 30)
Walking/breathing exercise	53 ± 25 (n = 29*)	44 ± 19 (n = 29*)	62 ± 20 (n = 28*)
All patients	52 ± 23 (n = 91*)	46 ± 22 (n = 90*)[a]	60 ± 19 (n = 87*)[a,b]
Social function			
Standard intervention	70 ± 24 (n = 31)	56 ± 27 (n = 30)	66 ± 27 (n = 29)
Walking exercise	73 ± 26 (n = 31)	60 ± 33 (n = 31)	71 ± 28 (n = 30)
Walking/breathing exercise	73 ± 25 (n = 29*)	57 ± 27 (n = 29*)	71 ± 27 (n = 28*)
All patients	72 ± 25 (n = 91*)	58 ± 29 (n = 90*)[a]	69 ± 27 (n = 87*)[b]
Role-emotional			
Standard intervention	68 ± 23 (n = 31)	59 ± 32 (n = 30)	75 ± 26 (n = 29)
Walking exercise	72 ± 30 (n = 31)	69 ± 30 (n = 31)	70 ± 26 (n = 30)
Walking/breathing exercise	78 ± 26 (n = 29*)	66 ± 28 (n = 29*)	73 ± 30 (n = 28*)
All patients	73 ± 27 (n = 91*)	64 ± 30 (n = 90*)[a]	73 ± 27 (n = 87*)
Mental health			
Standard intervention	67 ± 23 (n = 31)	68 ± 21 (n = 30)	79 ± 16 (n = 29)
Walking exercise	68 ± 22 (n = 31)	66 ± 23 (n = 31)	77 ± 18 (n = 30)
Walking/breathing exercise	69 ± 19 (n = 29*)	65 ± 19 (n = 29*)	81 ± 19 (n = 28*)
All patients	68 ± 21 (n = 91*)	66 ± 21 (n = 90*)	79 ± 17 (n = 87*)[a,b]
Mental component summary			
Standard intervention	45 ± 12 (n = 31)	44 ± 13 (n = 30)	50 ± 11 (n = 29)
Walking exercise	46 ± 12 (n = 31)	45 ± 13 (n = 31)	49 ± 10 (n = 30)
Walking/breathing exercise	48 ± 11 (n = 29*)	43 ± 12 (n = 29*)	51 ± 11 (n = 28*)
All patients	46 ± 12 (n = 91*)	44 ± 12 (n = 90*)	50 ± 11 (n = 87*)[a,b]

* One patient unable to comprehend sufficiently the SF-36v2 questionnaire. As there were no between-group differences, significant differences in means are reported only for 'all patients'.
[a] $p < 0.05$ vs. pre-operative.
[b] $p < 0.05$ vs. discharge.

Table 5. *Rates of Indicators of Post-Operative Pulmonary Complication and Atrial Fibrillation*

	Standard Intervention ($n = 30$)	Walking Exercise ($n = 31$)	Walking/Breathing Exercise ($n = 30$)
Elevated WBCC pre-operatively	3 (10%)	4 (13%)	3 (10%)
Elevated WBCC post-operative day 0	17 (57%)	18 (58%)	15 (50%)
Elevated WBCC at any time post-operatively prior to discharge	22 (73%)	21 (68%)	21 (70%)
Tympanic temperature $\geq$38 °C on $\geq$2 consecutive post-operative days	6 (20%)	6 (19%)	5 (17%)
Tympanic temperature $\geq$38 °C at any time post-operatively prior to discharge	16 (53%)	18 (58%)	15 (50%)
Prescription of respiratory antibiotics	1 (3%)	0 (0%)	0 (0%)
Isolation of respiratory pathogens on sputum microscopy and culture	1 (3%)	0 (0%)	0 (0%)
Requirement of $FiO_2 > 50\%$ for > 24 h post-operatively	1 (3%)	0 (0%)	0 (0%)
Requirement of non-invasive ventilation following extubation	1 (3%)	3 (10%)	3 (10%)
Post-operative atrial fibrillation	8 (27%)	9 (29%)	5 (17%)

WBCC: White blood cell count. *Note*: Deceased patient not included.

significantly improved sub-maximal exercise capacity at discharge from hospital (as measured by the 6MWA). In the absence of continuing exercise supervision, however, this benefit was not sustained at four-week follow-up. Further, performance of such a walking program conferred no measurable benefit to patients in terms of perceived, health-related quality of life, or respiratory function.

The clinical importance of this early 'walking fitness' lies in the potential for earlier improvements in functional activity, and expedited referral to exercise-based outpatient (Phase 2) cardiac rehabilitation (CR) programs. While the benefits of these programs are well demonstrated,[10] studies have noted low uptake and/or completion rates.[7,11] Earlier admission to Phase 2 CR following hospital discharge might improve uptake rates, and allow for program completion before other factors, such as return to work, intervene. Regardless of improved walking capacity, we suggest that familiarity with a prescribed walking exercise program may smooth the transition to Phase 2 CR. Also, the early promotion of walking exercise, notwithstanding Phase 2 CR, might also serve to emphasise the importance of exercise in secondary prevention of cardiac issues. The 6MWA scores at hospital discharge for both walking exercise and walking/breathing exercise groups (444 m and 431 m, respectively) are similar to scores reported in CAD populations already attending Phase 2 CR (462 m),[12] (481 m men, 440 m women).[13] They are considerably higher than those previously reported at hospital discharge following CABG (generously estimated at 252 m by extrapolating from a 2-minute walk test),[14] and at referral/admission to cardiac rehabilitation after CABG (258 m, 296 m).[15,16]

From a safety perspective, performance of a moderate intensity walking exercise program acutely after CABG did not increase the risk of developing post-operative atrial fibrillation. The rate of atrial fibrillation in this study (overall 24%, walking and walking/exercise interventions 23%) is less than that reported in a large study population of patients undergoing isolated CABG (31.9%),[17] and no patient in the study developed atrial fibrillation for the first-time post-operatively during a physiotherapy-supervised walking session.

It is interesting that the benefit in walking distance achieved at discharge in the two groups receiving a walking intervention, compared to the standard intervention group, was not sustained at four-week follow-up. This suggests either that: (i) regardless of early walking exercise intervention, patients will tend towards the same 'healthy' or 'normal' level of exercise capacity following successful CABG; or (ii) the effect of early walking exercise intervention requires reinforcement, e.g. early referral to Phase 2 CR.

Does the improvement in sub-maximal exercise capacity at hospital discharge justify the intervention (in relation to time and cost)? Time spent administering exercise interventions was not measured in the current study. Prima facie, though, a twice-daily 10-minute supervised walking program would involve 20 minute of physiotherapy time per patient day. If, however, several patients could be supervised in exercise simultaneously (as in outpatient cardiac rehabilitation programs), the time cost of intervention could be substantially reduced. Potentially, in facilities offering both cardiac surgery and outpatient cardiac rehabilitation programs (and given appropriate monitoring systems), inpatients could perform components of exercise and education alongside outpatients, this also facilitating the transition from inpatient to Phase 2 CR.

A second key finding of this study is that the combination of specific respiratory exercises and musculoskeletal exercises, in addition to a walking exercise program, provided no additional benefit to patients in terms of sub-maximal exercise capacity, health-related quality of life, or respiratory function. The lack of benefit of specific respiratory exercises on post-cardiac surgery variables such as atelectasis, pneumonia, oxygenation and pulmonary function has been well described (for review, see Pasquina et al.).[2] Our results concur, in that we found no difference between PPC marker rates, length of stay

or pulmonary function between walking exercise and walking/breathing exercise groups. The 38% reduction in VC seen at discharge in the present study mirrors that previously reported in CABG/cardiac surgery (results ranging from 28 to 48% reduction, measured at days 3–8 post-operatively)[3,18–20]; its reversal would appear to be a function of post-operative time. The percentage of patients presenting with pyrexia (54%) and leucocytosis (70%) in this study also agrees with findings that these are predictable sequelae of CABG.[21]

Health-Related Quality of Life

It is notable that we found no differences in any aspect of self-rated health across intervention groups at either discharge or follow-up. We hypothesised that better walking capacity for the walking and walking/breathing groups might be reflected in an improved response to physical function indices, but this was not apparent. As such, the results of the SF-36v2 questionnaire are discussed for 'all patients'.

All sub-scales and physical and mental component summary (PCS, MCS) measures of the SF-36v2 questionnaire demonstrated significant changes over the period of review. A higher level of disease burden was noted for all sub-scales, excepting those of 'general health' and 'mental health', and the MCS (which is heavily weighted to the 'mental health' subscale) at discharge compared with pre-operatively. This pattern is similar to that reported previously in cardiac surgery[7] (although absolute scores in our study are higher, possibly reflecting a population with fewer co-morbidities). The six affected sub-scales are measured by questions which specifically ask respondents to consider their limitations to perform physical activity or regular activities and/or socialise, necessarily limited during their inpatient hospital stay. Interestingly, those questions which address general health and mental health are not linked to particular physical or social activities.

All sub-scales, and both PCS and MCS measures, showed significant improvement at follow-up compared with discharge status, with the exception of 'role-physical' and 'role-emotional' subscales, constructs which ask respondents to gauge the effects of physical health and emotional problems on ability to work and perform daily activities over a four-week period. Patients are specifically instructed to limit the performance of normal activities, such as working or driving, in this early post-operative period. Use of the 'acute' version of the SF-36v2, which employs a one-week (rather than four-week) period of recall, might have improved the likelihood of seeing an improvement of these constructs at follow-up.

An increase in subjective health from pre-operative status to follow-up was seen in all constructs except 'role-physical' (remained significantly decreased) and 'role-emotional', 'bodily pain', and 'social functioning' (no significant difference). Despite the obvious trauma of surgery, respondents already indicated significant improvements in physical functioning, general health, vitality and mental health at five to six weeks post-operatively, demonstrating that, notwithstanding a survival benefit of the surgery, CABG tends to improve subjective health at an early post-operative stage, even prior to outpatient cardiac rehabilitation.

Limitations

The primary limitation to the study was the inability to blind outcome assessors to group allocation. We believe that this will have impacted minimally on the results of the study due to the stringent assessment procedures used, which allowed for no assessor subjectivity or encouragement.

Conclusions

A physiotherapy-supervised, structured walking program in the inpatient setting following first-time, elective CABG significantly improves sub-maximal exercise capacity at discharge from hospital. Additional respiratory and musculoskeletal exercises confer no further benefits to patients in terms of sub-maximal exercise capacity, vital capacity or health-related quality of life. Further investigation is required to determine the optimal level or dosage of walking exercise following CABG.

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