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# A postoperative shoulder exercise program improves function and decreases pain following open thoracotomy: a randomised trial

Julie Reeve<sup>1</sup>, Kathy Stiller<sup>2</sup>, Kristine Nicol<sup>3</sup>, Kathryn M McPherson<sup>1</sup>, Paul Birch<sup>3</sup>, Ian R Gordon<sup>4</sup> and Linda Denehy<sup>4</sup>

<sup>1</sup>AUT University, New Zealand, <sup>2</sup>Royal Adelaide Hospital, Australia, <sup>3</sup>Auckland District Health Board, New Zealand, <sup>4</sup>The University of Melbourne, Australia

**Question:** Does a postoperative physiotherapy exercise program incorporating shoulder exercises improve shoulder function, pain, range of motion, muscle strength, and health-related quality of life in patients undergoing elective pulmonary resection via open thoracotomy? **Design:** Randomised trial with concealed allocation, assessor blinding, and intention-to-treat analysis. **Participants:** 76 patients who underwent pulmonary resection via open thoracotomy. **Intervention:** All participants received standard medical and nursing care involving a clinical pathway. The experimental group also received physiotherapy interventions that included daily supervised, progressive exercises until discharge and a postoperative exercise booklet on discharge. **Outcome measures:** Preoperatively and up to 3 months postoperatively pain was measured with a numerical rating scale, shoulder function with the Shoulder Pain and Disability Index, and quality of life with the Short Form-36. Shoulder range of motion and muscle strength were measured in a subgroup. **Results:** The experimental group had 1.3 units (95% CI 0.3 to 2.2) less shoulder pain (scored /10) and 2.2 units (95% CI 0.2 to 4.3) less total pain (scored /30) at discharge, and 7.6% (95% CI 1.7 to 13.6) better function at 3 months. The Short Form-36 physical component score was 4.8 points (95% CI -0.3 to 10.0) better for the experimental group than the control group at 3 months. Differences between groups in all range of motion and strength measures were small and statistically non-significant. **Conclusion:** A physiotherapist-directed postoperative exercise program resulted in significant benefits in pain and shoulder function over usual care for patients following open thoracotomy. **Trial registration:** ANZCTR N12605000201673. [Reeve J, Stiller K, Nicol K, McPherson KM, Birch P, Gordon IR, Denehy L (2010) A postoperative shoulder exercise program improves function and decreases pain following open thoracotomy: a randomised trial. *Journal of Physiotherapy* 56: 245–252]

**Key words:** Randomised controlled trial, Physical therapy (specialty), Thoracotomy, Postoperative complications, Pain, Postoperative pain, Shoulder, Exercise

## Introduction

Postoperative pulmonary complications are a major cause of morbidity after thoracotomy, resulting in patient discomfort, prolonged length of hospital stay, and increased healthcare costs (Stephan et al 2000, Zehr et al 1998). Thoracotomy can also lead to long-term restriction of shoulder function and range of motion, reduced muscle strength, chronic pain, and reduced health-related quality of life (Gerner 2008, Kutlu et al 2001, Li et al 2003, Schulte et al 2009). In Australia and New Zealand, physiotherapy is routinely provided after thoracotomy with the aim of preventing and treating both pulmonary and musculoskeletal complications (Reeve et al 2007).

Reeve and colleagues (2010) recently reported the primary outcome associated with the current study. A respiratory physiotherapy intervention provided after pulmonary resection via open thoracotomy did not decrease the incidence of postoperative pulmonary complications or length of stay, compared to that achieved by a control group who were managed by medical and nursing staff using a standardised clinical pathway. This clinical pathway included early and frequent position changes in bed, sitting out of bed from the first postoperative day, early ambulation, and frequent pain assessment. The ability of a postoperative physiotherapy shoulder exercise program to prevent or minimise shoulder dysfunction after thoracotomy has

not been investigated. Therefore, the research questions associated with the secondary outcomes of this study were:

1. In patients undergoing elective pulmonary resection via open thoracotomy, does a postoperative physiotherapy exercise program that includes progressive shoulder exercises improve pain, range of motion, muscle strength and shoulder function?
2. Does the program improve health-related quality of life?

## Method

### Design

A randomised trial with intention-to-treat analysis, assessor blinding, and concealed allocation was undertaken as described fully by Reeve and colleagues (2008). Participants were recruited by one of the study investigators (JR, KN, PB) on the day before surgery. On the first postoperative day, eligible patients were allocated to an experimental or control group, based on a computer-generated randomisation table, with each allocation sealed in a consecutively numbered, opaque envelope. Group allocation was revealed by a research assistant. Outcomes were measured up to three months postoperatively. Therapist-rated outcomes were measured by a physiotherapist blinded to group allocation. To aid maintenance of blinding, participants were asked not to discuss any aspect of the trial with assessors. Medical and nursing staff were not informed of group allocation.

## Participants

Patients aged 18 years and above undergoing elective pulmonary resection via an open thoracotomy at Auckland City Hospital were eligible for participation. Exclusion criteria were: unwilling or unable to participate, unable to understand English, tumour invasion into the chest wall or brachial plexus, and receiving physiotherapy for respiratory or shoulder problems within the 2 weeks prior to admission. Additionally, patients were excluded if they developed a postoperative pulmonary complication prior to randomisation on day 1 postoperatively or remained mechanically ventilated for more than 24 hours postoperatively. Any participants who developed neurological or mobility problems postoperatively that required more than two physiotherapy interventions were provided with physiotherapy as deemed appropriate and their data analysed in an intention-to-treat manner.

## Intervention

All participants received usual medical and nursing care while in hospital, which involved a standard clinical pathway. This clinical pathway included early and frequent position changes in bed, sitting out of bed from day 1 postoperatively, early ambulation, and pain assessment, but did not include any shoulder or thoracic cage exercises. As part of the informed consent process, preoperatively all participants received a booklet providing non-specific advice regarding postoperative exercises as shown in Appendix 1 (see eAddenda for Appendix 1).

Experimental group participants received a targeted respiratory physiotherapy intervention (including deep breathing and coughing exercises) and an exercise program. The exercise program was supervised by a physiotherapist, according to a detailed written protocol and the exercise booklet shown in Appendix 2 (see eAddenda for Appendix 2). The program entailed progressive ambulation and progressive shoulder and thoracic cage exercises. These exercises were undertaken, with physiotherapy supervision, twice on the first two postoperative days and then once daily until discharge. The exercises were progressed every day by increasing the number of repetitions and exercise complexity. Experimental group participants were encouraged to practise the exercises outside of physiotherapy intervention times, but this was not supervised or monitored. Toward the end of their hospital stay, experimental group participants were given a discharge exercise booklet, shown in Appendix 3 (see eAddenda for Appendix 3). This booklet provided detailed shoulder and thoracic exercises that incorporated all functional and anatomical shoulder movements and advice regarding progression of ambulation after discharge. The physiotherapist coached each experimental group participant individually regarding post-discharge exercise frequency, duration, and progression. At discharge, an exercise diary was given to experimental group participants with instructions to complete it daily and return it at their final assessment three months postoperatively. In order to maintain concealment of group allocation, the exercise diary was returned to the principal investigator (JR) in a reply-paid envelope. Control group participants received no postoperative physiotherapy intervention.

## Outcome measures

Participant-rated outcomes (pain, shoulder function, and health-related quality of life) were measured on all participants up to three months postoperatively. Following

hospital discharge, the scales and questionnaires with which these were measured were mailed to participants for completion and return in a reply-paid envelope. Therapist-rated outcomes (shoulder range of motion, muscle strength) were assessed in participants who lived within 60 kilometres of the hospital and indicated that they would be able to attend outpatient assessments after hospital discharge. All outcome measures were recorded at baseline, 1, and 3 months postoperatively. Additionally, pain and range of motion were measured at discharge from hospital.

Pain was measured by asking participants to shade areas on a body chart where they had experienced pain or discomfort on the day of assessment and to rate the intensity of their pain in each area using a numerical rating scale (from 0 = no pain to 10 = pain as bad as you can imagine). Three pain regions were identified: incisional (along the incision or within two intercostal spaces above or below), thoracic cage (apart from incisional), and the shoulder joint complex (upper limb proximal to the mid-humerus, including the clavicular and scapular areas and the trapezius muscle). Pain that was superior to the cervical spine, inferior to the umbilicus, or distal to the mid-humerus was excluded from analysis. The pain scores reported were for the shoulder region (out of 10) and for total pain (out of 30, calculated by adding together the pain scores for the three regions).

Active shoulder range of motion was measured with digital inclinometry<sup>a</sup> using a standard protocol. Total shoulder motion allowing movement of all joints in the shoulder complex was measured, not isolated glenohumeral movement. Shoulder flexion, elevation through abduction, and external rotation were measured as these movements elongate the muscles divided during open thoracotomy. For shoulder flexion, the starting position was sitting (standardised chair, hips and knees flexed to approximately 90°, feet on floor, contralateral forearm resting on a fixed table to minimise trunk movement) with the affected arm at the side, elbow extended, shoulder in neutral rotation, and the participant asked to flex the arm while maintaining elbow extension. For shoulder abduction, the starting position was sitting (as for flexion) with the arm at the side, the shoulder in external rotation and the elbow extended. The participant was asked to abduct the arm while maintaining elbow extension. For shoulder external rotation, the starting position was supine with the arms at the side and supported by the bed, the affected elbow flexed to 90°, and the hand in a loose fist. The participant was asked to externally rotate the arm, keeping the elbow on the bed and leading with the dorsum of the hand. Anatomical surface markings were made to guide placement of the inclinometer. After a practice movement, each range of motion was repeated twice and the higher measure recorded.

Shoulder muscle strength was measured using a hand-held dynamometer<sup>b</sup>. Strength measurements were taken for flexion, abduction, extension, and internal rotation as these are some of the actions of the muscles divided during open thoracotomy. All measurements were taken with the participant sitting (as above) with the affected arm one gripped fist's width (at the lower end of the humerus) from the side of the body, the elbow flexed to 90° and the forearm in neutral rotation. Anatomical surface markings were again used to guide dynamometer placement. Resistance was applied against the direction of shoulder movement for 3–5 sec using the 'make' rather than 'break' technique (Stratford and Balsor 1994). Standard instructions and verbal

encouragement were given. After one practice contraction, each movement was measured 3 times with 1 min between measurements and the highest value was recorded.

Shoulder function was measured using the Shoulder, Pain and Disability Index (Roach et al 1991), which is a self-rated questionnaire designed to measure shoulder pain and disability. Although this questionnaire has not been used previously in a post-thoracotomy population, its validity, reliability, responsiveness, and ease of completion have been demonstrated in patients with primary shoulder disorders (Bot et al 2004, Paul et al 2004). It has 13 items divided into two subscales (pain and disability). All items were rated on a visual analogue scale anchored with 'No pain' and 'Worst pain imaginable' for pain, and 'No difficulty' and 'So difficult it requires help' for disability. Scores for each subscale range 0–100, with higher scores indicating greater pain or disability. A total score (0–100) was calculated by averaging the two subscale scores. If more than two items of a subscale were not answered, no subscale or total score could be calculated.

Health-related quality of life was self-rated using the Medical Outcomes Study Short Form 36-item version 2 (New Zealand) survey. Data were entered into scoring software<sup>c</sup> with algorithms to generate linear T-score transformations, which were used for summary component scores, as endorsed by the developers of the questionnaire. These transformations place scores on scales with a mean of 50 and a SD of 10.

### Data analysis

The sample size for this study, based on the primary outcome of postoperative pulmonary complications, determined that a total sample size of 168 patients was required. However, recruitment ceased after an *a priori* interim analysis when the sample size equalled 76 (Reeve et al 2010). Using data from patients after open thoracotomy (Li et al 2003), we calculated that 10 participants per group would be required to find a difference in shoulder range of motion of 15°, which was considered the minimum clinically worthwhile difference.

Analyses were conducted on an intention-to-treat basis, using all available data from randomised participants. Between-group differences of changes from baseline were analysed using independent samples *t* tests. Mean difference (95% CI) between groups are presented. Data related to the time to drain removal and length of hospital stay were not normally distributed, so Mann-Whitney *U* tests were used to compare groups.

## Results

### Flow of participants, therapists and centres through the trial

Between December 2006 and December 2008, 169 patients were screened for eligibility. Seventy-six (45%) met the inclusion criteria and were randomised: 42 in the experimental group, 34 in the control group. Flow of participants through the trial and reasons for exclusion are illustrated in Figure 1. Forty-seven participants (30 experimental group, 17 control group) were in the subgroup that underwent range of motion and strength measurements. One participant (experimental group) withdrew consent after the first treatment intervention on day 1 postoperatively and another participant (experimental

group) died on day 23. Baseline data sheets were lost for two participants. Despite repeated attempts to obtain complete data, some participants failed to respond to the mailed-out questionnaires or returned incomplete questionnaires rendering scoring impossible. By 3 months, 31% of the experimental group and 24% of the control group were lost to follow-up.

Baseline demographic and surgical details for participants according to group allocation were similar (Table 1). The median (range) time to drain removal was not significantly different between groups ( $p = 0.90$ ), being 4 (1 to 17) days in the experimental group and 5 (1 to 15) days in the control group. The median (range) length of hospital stay was not significantly different between groups ( $p = 0.87$ ), being 6 (3 to 23) in the experimental group and 6 (4 to 16) days in the control group.

Interventions to the experimental group were provided by ward physiotherapists. Their experience ranged from senior physiotherapists (> 20 years experience) to recent graduates. Approximately 20 physiotherapists provided treatments over the study period, with some working in the unit on a daily basis and others covering occasional weekend duties only. This study was carried out in the Cardiothoracic Surgical Unit, Auckland City Hospital, a tertiary referral hospital in New Zealand.

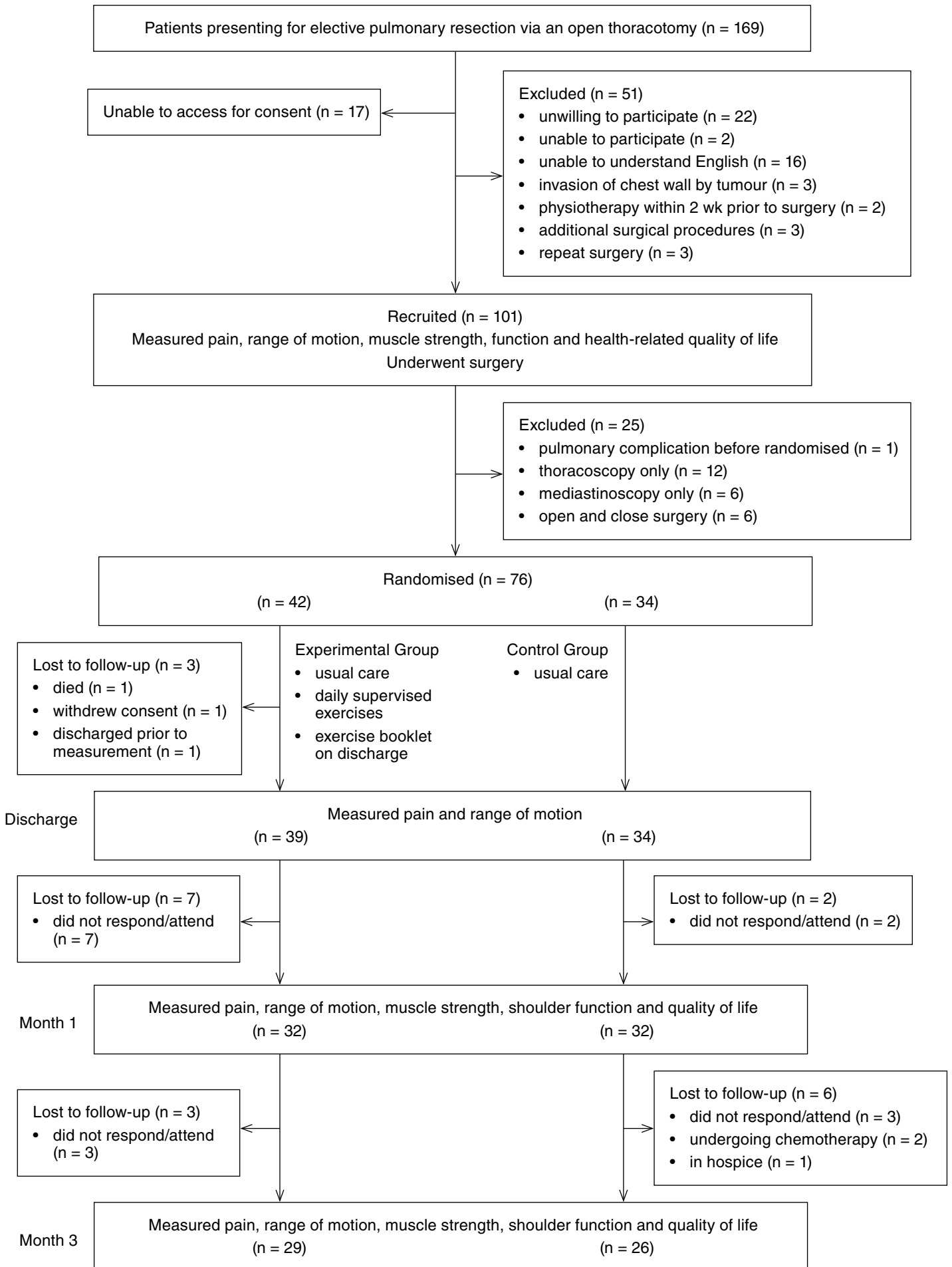
### Compliance with trial method

One control group participant inadvertently received physiotherapy intervention as per the experimental group until discharge from hospital. Another control group participant required physiotherapy input for a postoperative neurological complication, including transfer to a stroke rehabilitation unit, however as the neurological problem was cerebellar, this did not include specific shoulder and thoracic cage exercises. There were no reports of additional shoulder and thoracic cage exercises implemented during the inpatient phase for experimental group participants beyond those in the protocol. Two participants from each group reported that they had independently sought treatment for problems related to their shoulder on the operated side following discharge from hospital. Data from all these participants have been analysed using intention-to-treat principles.

Experimental group interventions were provided as scheduled on 81% of occasions during the inpatient phase of the trial. For the experimental group, the median (range) number of physiotherapy treatment sessions received was 6 (1 to 18) and the median (range) total physiotherapy time per participant in 15-minute units of service was 12 (2 to 47) units.

For the 76 randomised participants, data on pain, shoulder function and quality of life were obtained 83% of the time. Missing data most frequently resulted from non-returned or incomplete questionnaires. For the subgroup of 47 participants who were scheduled to participate in measures of range of motion and strength, data were obtained 82% of the time. Missing data most often resulted from unwillingness or inability to attend for measurement. Exercise diaries were completed by only 8 (19%) of the 42 experimental group participants, so data from the diaries have not been reported.

The physiotherapists who acted as independent assessors were asked to report any episodes of unblinding to group



**Figure 1.** Design and flow of participants through the trial.

**Table 1.** Characteristics of participants.

Characteristic	Randomised (n = 76)	
	Exp (n = 42)	Con (n = 34)
Gender, n male (%)	26 (62)	21 (62)
Age (yr), mean (SD)	63 (13)	65 (11)
Age ≥ 70 yr, n (%)	12 (29)	13 (38)
Ethnicity, n (%)		
NZ European	27 (64)	25 (74)
Maori	11 (26)	3 (9)
Other	4 (10)	6 (18)
Previous history of shoulder/ neck problem on operated side, n yes (%)		
Shoulder	13 (31)	13 (38)
Neck	2 (5)	0 (0)
Operative procedure, n (%)		
Lobectomy	27 (64)	22 (65)
Pneumonectomy	6 (14)	3 (9)
Other simple	7 (17)	7 (21)
Other complex <sup>a</sup>	2 (5)	2 (6)
Method of analgesia, n (%)		
PCA	7 (17)	6 (18)
PCEA/epidural	15 (36)	11 (32)
Combination	20 (48)	17 (50)

PCA = patient controlled analgesia, PCEA = patient controlled epidural analgesia, <sup>a</sup>sleeve lobectomies or lobectomies extending to surrounding structures other than the chest wall

allocation. Five reports of inadvertent unblinding were received from the 122 follow-up assessment occasions (4%): 2 of these episodes occurred at the time of discharge, and 3 episodes occurred at the 3 months postoperative follow-up. When unblinding occurred, an alternative blinded assessor performed the outcome measures on all subsequent occasions.

**Effect of intervention**

Group data at baseline and follow-up are shown in Table 2 for pain and range of motion and in Table 3 for muscle strength, shoulder function and quality of life. Individual data for all outcomes are provided in Table 4 (see eAddenda for Table 4).

The experimental group had significantly less shoulder pain at discharge than the control group, by 1.3 units (95% CI 0.3 to 2.2). The experimental group also had significantly less total pain than the control group at discharge, by 2.2 units (95% CI 0.2 to 4.3). Total pain scores remained lower in the experimental group by a similar amount at 1 and 3 months. The differences between groups in all range of motion and muscle strength measures were small and statistically non-significant.

The total Shoulder Pain and Disability Index score at 1 month was 5.7% (95% CI 0.0 to 11.4) lower (better) for the experimental group than the control group. The total score at 3 months was 7.6% (95% CI 1.7 to 13.6) lower for the experimental group than the control group, indicating

**Table 2.** Mean (SD) for pain and range of motion outcomes for each group, mean (SD) difference within groups, and mean (95% CI) difference between groups.

Outcome	Groups						Difference within groups						Difference between groups								
	Baseline		Discharge		Month 1		Month 3		Discharge minus baseline		Month 1 minus baseline		Month 3 minus baseline		Discharge minus baseline		Month 1 minus baseline		Month 3 minus baseline		
	Exp	Con	Exp	Con	Exp	Con	Exp	Con	Exp	Con	Exp	Con	Exp	Con	Exp	Con	Exp	Con	Exp	Con	
Pain	(n = 41)	(n = 33)	(n = 38)	(n = 34)	(n = 31)	(n = 31)	(n = 27)	(n = 26)													
Shoulder (0-10)	0.4 (1.7)	0.2 (0.9)	0.5 (1.2)	1.5 (2.3)	0.8 (2.2)	0.9 (1.8)	0.4 (1.4)	0.5 (1.3)	0.0 (1.5)	1.3 (2.3)	0.6 (2.0)	0.6 (2.2)	0.2 (0.6)	0.2 (1.8)	0.2 (0.6)	0.2 (1.8)	-1.3 (-2.2 to -0.3)	-0.1 (-1.2 to 1.0)	0.0 (-0.8 to 0.7)		
Total (0-30)	1 (3)	1 (2)	3 (3)	5 (4)	3 (4)	4 (4)	2 (3)	3 (4)	2 (4)	4 (5)	2 (4)	4 (4)	1 (2)	3 (5)	1 (2)	3 (5)	-2 (-4 to 0)	-2 (-4 to 0)	-2 (-4 to 0)		
Range	(n = 30)	(n = 17)	(n = 28)	(n = 17)	(n = 22)	(n = 16)	(n = 19)	(n = 11)													
Flexion	158 (20)	162 (15)	143 (23)	136 (36)	166 (14)	155 (14)	169 (11)	168 (11)	-16 (20)	-26 (34)	6 (22)	-7 (18)	7 (14)	9 (16)	11 (11)	11 (11)	-6 (-6 to 27)	13 (-1 to 27)	-2 (-13 to 10)		
Abduction	151 (21)	153 (28)	138 (25)	128 (36)	158 (19)	154 (20)	166 (12)	163 (14)	-14 (29)	-14 (43)	6 (25)	-4 (25)	6 (19)	10 (21)	11 (11)	11 (11)	-11 (-11 to 32)	9 (-8 to 27)	4 (-12 to 19)		
External rotation	60 (20)	67 (12)	56 (16)	52 (16)	65 (15)	60 (16)	58 (14)	64 (23)	-5 (21)	-14 (17)	3 (21)	-6 (18)	-8 (17)	-4 (22)	9 (9)	9 (9)	-4 (-4 to 22)	9 (-5 to 23)	-4 (-18 to 11)		
				n = 16																	

Exp = experimental group, Con = control group

**Table 3.** Mean (SD) for strength, shoulder function, and quality of life for each group, mean (SD) difference within groups, and mean (95% CI) difference between groups.

Outcome	Groups						Difference within groups						Difference between groups			
	Baseline		Month 1		Month 3		Month 1 minus baseline		Month 3 minus baseline		Month 1 minus baseline		Month 3 minus baseline		Exp minus Con	Exp minus Con
	Exp	Con	Exp	Con	Exp	Con	Exp	Con	Exp	Con	Exp	Con	Exp	Con		
Muscle strength (kg)	(n = 29)	(n = 17)	(n = 21)	(n = 16)	(n = 17)	(n = 11)										
Flexion	12 (6)	11 (1)	13 (6)	12 (5)	16 (6)	13 (5)	0 (7)	-1 (6)	3 (5)	1 (5)	1 (-4 to 5)	2 (-2 to 6)				
Abduction	12 (5)	11 (5)	13 (6)	11 (5)	16 (6)	12 (5)	0 (6)	-2 (5)	3 (5)	1 (3)	2 (-2 to 5)	2 (-1 to 5)				
Extension	13 (5)	11 (4)	12 (5)	11 (4)	15 (5)	11 (3)	-2 (7)	-2 (4)	1 (5)	0 (4)	0 (-4 to 4)	2 (-2 to 6)				
Internal rotation	11 (4)	10 (4)	11 (4)	10 (3)	15 (5)	11 (3)	-1 (5)	-1 (4)	2 (4)	0 (3)	1 (-2 to 3)	2 (-1 to 5)				
SPADI (0 to 100)	(n = 41)	(n = 33)	(n = 30)	(n = 31)	(n = 29)	(n = 26)										
Pain	6 (15)	2 (6)	13 (13)	18 (15)	5 (9)	12 (16)	6 (18)	16 (15)	-2 (15)	8 (16)	-10 (-19 to -1)	-10 (-18 to -1)				
Disability	2 (4)	3 (5)	6 (7)	9 (7)	2 (3)	7 (13)	4 (8)	7 (7)	0 (5)	5 (11)	-3 (-7 to 1)	-6 (-10 to -1)				
Total	4 (9)	3 (4)	9 (9)	13 (10)	3 (5)	9 (13)	5 (12)	11 (9)	-1 (9)	7 (13)	-6 (-11 to 0)	-8 (-14 to -2)				
SF-36v2 (T score)	(n = 38)	(n = 33)	(n = 27)	(n = 30)	(n = 29)	(n = 24)										
Physical component	52 (7)	50 (9)	38 (9)	34 (8)	46 (8)	41 (10)	-14 (9)	-16 (10)	-5 (9)	-10 (9)	2 (-3 to 7)	5 (0 to 10)				
Mental component	48 (11)	47 (13)	46 (13)	48 (11)	50 (11)	50 (10)	-2 (14)	0 (11)	1 (11)	-1 (9)	-2 (-9 to 5)	2 (-4 to 7)				

Exp = experimental group, Con = control group, SPADI = Shoulder Pain and Disability Index, SF-36v2 = Medical Outcomes Study Short Form 36-item version 2 (New Zealand) survey

significantly better function. Similar changes were seen for the subscale scores, with the experimental group having significantly lower pain subscale scores than the control group at 1 and 3 months and a significantly lower disability subscale score at 3 months.

The differences between groups for the SF-36 summary scores were non-significant, although the physical component score showed a strong trend to be higher for the experimental group than the control group at 3 months. No adverse effects resulting from experimental group interventions were reported.

## Discussion

This is the first study to investigate whether a physiotherapy exercise program improves pain, range of motion, muscle strength, shoulder function, and quality of life of patients after open thoracotomy. All measures showed deterioration after surgery, with most returning to preoperative levels by 3 months. Statistically significant benefits were found for the experimental group over the control group for shoulder pain and total pain and function, but no statistically significant differences were found between groups for range of motion, muscle strength or quality of life.

There are no data from similar trials to which our estimates of the treatment effects can be compared. However, our findings of an increase in pain and deterioration in shoulder range of motion at discharge from hospital and improvement over 1 to 3 months concur with previous research (Akcali et al 2003, Hazelrigg et al 1991, Landreneau et al 1993, Li et al 2003, Li et al 2004).

Although the sample size was directed by considerations of the primary outcome (Reeve et al 2010), statistical power was more than sufficient to detect a 15° difference in range of motion between groups. Our sample appeared representative of those who commonly undergo this type of surgery (Bonde et al 2002, Gosselink et al 2000, Stephan et al 2000). While the control group received the standard clinical pathway used at Auckland City Hospital, this pathway did not include shoulder or thoracic cage exercises, nor any interventions provided by a physiotherapist. The experimental group received their exercise program from a physiotherapist during hospitalisation. After discharge, however, this took the form of an exercise sheet and diary. While it may have been preferable for the experimental group to have received regular out-patient physiotherapy to monitor and progress the exercises, this was not feasible due to the geographical distance between most participants' homes and the hospital. Furthermore, the provision of exercise advice at discharge rather than outpatient rehabilitation is consistent with management across Australia and New Zealand (Reeve et al 2007).

Are the results of our study clinically important? While the differences between groups for shoulder function (ie, the Shoulder Pain and Disability Index) were significant at 1 and 3 months, in favour of the experimental group, the confidence intervals spanned the reported minimum clinically important differences of 8.0% to 13.2% (Paul et al 2004, Schmitt and Di Fabio 2004) and therefore their clinical importance is not absolutely certain. However, these minimum clinically important differences were calculated for a different patient population and thus may not be generalisable to post-thoracotomy patients. The mean difference in favour of the experimental group at

discharge for shoulder pain (1.3 units) was significant and exceeded the minimum clinically important difference of 1.1 units for pain numerical rating scales (Mintken et al 2009). This suggests the difference between groups at discharge was clinically important, however, the confidence interval included smaller benefits than this, so we cannot be certain that this result is clinically worthwhile. While no significant between-group differences were found for the quality of life summary scores, the experimental group's physical component score at 3 months was 4.8 points higher than the control group's score, which exceeds the minimum clinically important difference of 3 points noted by Swigris and colleagues (2010). However, given that the confidence intervals widely spanned the minimum clinically important difference for the physical component summary scores, this warrants further investigation. The differences between groups for all range of motion and strength measures were small, statistically non-significant, and below the likely minimum clinically important differences. However, of note, most of the results for range of motion had confidence intervals that extended well into what would be considered a beneficial range, and, importantly, essentially excluded the possibility of clinically meaningful harm resulting from the experimental intervention. In summary, a physiotherapy exercise program provides some benefits such as early relief of pain, shoulder function and, perhaps, the physical components of quality of life. Further investigation could more precisely determine the clinical worth of these effects. Based on these findings, we recommend that physiotherapists provide an inpatient postoperative exercise program aimed at reducing shoulder dysfunction and pain, incorporating progressive shoulder and thoracic cage mobility exercises and an associated home-based discharge program.

There are a number of factors which mean caution should be used when extrapolating our findings to other centres. Factors unique to our unit (eg, ethnicity, clinical pathway) may have influenced our results. We excluded patients unable to understand English. Because of the poor return rate for the exercise diaries, we were unable to assess the adherence of experimental group participants with their exercise program. While the physiotherapy intervention for the experimental group included thoracic cage mobility exercises, we did not attempt to assess thoracic cage mobility because of the complexity of doing so and the extensive range of outcome measures already being performed. While assessors were blinded, participants were aware of whether or not they received physiotherapy intervention, introducing a potential source of bias. Medical and nursing staff were not informed of participants' group allocations, but it is acknowledged that this may have become apparent to them and influenced their care. As all participants received a booklet preoperatively, this, and their consent to participate in a study, may have resulted in a Hawthorne effect. Despite every effort to maximise retention (ie, repeated attempts to contact non-responders, scheduling outpatient follow-up appointments after work hours or to coincide with surgical unit outpatient appointments), loss to follow-up was fairly high, particularly at 3 months, which may have biased our results.

Further research should be undertaken in other centres to attempt to confirm our findings and to further refine the clinical importance of the treatment effects. Research to evaluate the effect of a similar postoperative exercise program on thoracic cage mobility and chronic incisional pain after open thoracotomy would also be worthwhile.



Whilst a formal cost benefit analysis was not performed, the costs associated with the physiotherapy interventions provided to experimental group participants across their hospital stay were minimal and, arguably, appeared to be of clinical benefit. Future research to formally quantify costs is recommended. Additionally, research could be undertaken to evaluate whether the provision of a formal out-patient rehabilitation program for patients following discharge after open thoracotomy would increase functional benefits and quality of life. ■

**Footnotes:** <sup>a</sup>Plurimeter-V inclinometer, <sup>b</sup>Lafayette instruments, <sup>c</sup>SF Health Outcomes™ Scoring Software.

**eAddenda:** Appendix 1, 2, and 3, and Table 4 available at [www.JoP.physiotherapy.asn.au](http://www.JoP.physiotherapy.asn.au)

**Ethics:** The Northern X Regional Ethics Committee, New Zealand, approved this study. Participants gave written informed consent before data collection began.

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**Correspondence:** Julie Reeve, Division of Rehabilitation and Occupation Studies, Faculty of Health and Environmental Studies, Private Bag 92006, AUT University, Auckland 1080, New Zealand. Email: [julie.reeve@aut.ac.nz](mailto:julie.reeve@aut.ac.nz)

## References

- Akcali Y, Demir H, Tezcan B (2003) The effect of standard posterolateral muscle-sparing thoracotomy on multiple parameters. *Annals of Thoracic Surgery* 76: 1050–1054.
- Bonde P, Papachristos I, McCraith A, Kelly B, Wilson B, McGuigan J et al (2002) Sputum retention after lung operation: prospective randomised trial shows superiority of prophylactic minitracheostomy in high risk patients. *Annals of Thoracic Surgery* 74: 196–203.
- Bot SD, Terwee CB, van der Windt DA, Bouter LM, Dekker J, de Vet HC (2004) Clinimetric evaluation of shoulder disability questionnaires: a systematic review of the literature. *Annals of the Rheumatic Diseases* 63: 335–341.
- Gerner P (2008) Post-thoracotomy pain management problems. *Anesthesiology Clinics* 26: 355–367.
- Gosselink R, Schrever K, Cops P, Witvrouwen H, De Leyn P, Troosters T et al (2000) Incentive spirometry does not enhance recovery after thoracic surgery. *Critical Care Medicine* 28: 679–683.
- Hazelrigg SR, Landreneau RJ, Boley TM, Priesmeyer M, Schmaltz RA, Nawarawong W et al (1991) The effect of muscle-sparing versus standard posterolateral thoracotomy on pulmonary function, muscle strength, and postoperative pain. *Journal of Thoracic and Cardiovascular Surgery* 101: 394–401.
- Kutlu CA, Akin H, Olcmen A, Biliciler U, Kayserilioglu A, Olcmen M (2001) Shoulder-girdle strength after standard and lateral muscle-sparing thoracotomy. *Thoracic and Cardiovascular Surgeon* 49: 112–114.
- Landreneau RJ, Hazelrigg SR, Mack MM, Dowling RD, Burke D, Gavlick J et al (1993) Postoperative pain-related morbidity: video-assisted thoracic surgery versus thoracotomy. *Annals of Thoracic Surgery* 56: 1285–1289.
- Li WWL, Lee RLM, Lee TW, Ng CSH, Sihoe ADL, Wan IYP et al (2003) The impact of thoracic surgical access on early shoulder function: video-assisted thoracic surgery versus posterolateral thoracotomy. *European Journal of Cardiothoracic Surgery* 23: 390–396.
- Li WWL, Lee TW, Yim APC (2004) Shoulder function after thoracic surgery. *Thoracic Surgery Clinics* 14: 331–343.
- Mintken P, Glynn P, Cleland J (2009) Psychometric properties of the shortened disabilities of the Arm, Shoulder, and Hand Questionnaire (QuickDASH) and Numeric Pain Rating Scale in patients with shoulder pain. *Journal of Shoulder and Elbow Surgery* 18: 920–926.
- Paul A, Lewis M, Shadforth M, Croft P, van der Windt D, Hay E (2004) A comparison of four shoulder-specific questionnaires in primary care. *Annals of the Rheumatic Diseases* 63: 1293–1299.
- Reeve J, Denehy L, Stiller K (2007) The physiotherapy management of patients undergoing thoracic surgery: a survey of current practice in Australia and New Zealand. *Physiotherapy Research International* 12: 59–71.
- Reeve JC, Nicol K, Stiller K, McPherson KM, Denehy L (2008) Does physiotherapy reduce the incidence of postoperative complications in patients following pulmonary resection via thoracotomy? A protocol for a randomised controlled trial. *Journal of Cardiothoracic Surgery* 3: 48.
- Reeve JC, Nicol K, Stiller K, McPherson KM, Birch P, Gordon IR et al (2010) Does physiotherapy reduce the incidence of postoperative pulmonary complications following pulmonary resection via open thoracotomy? A preliminary randomised single-blind clinical trial. *European Journal of Cardiothoracic Surgery* 37: 1158–1167.
- Roach KE, Budiman-Mak E, Songsiridej N, Lertratanakul Y (1991) Development of a shoulder pain and disability index. *Arthritis Care and Research* 4: 143–149.
- Schmitt J, Di Fabio R (2004) Reliable change and minimum important difference (MID) proportions facilitated group responsiveness comparisons using individual threshold criteria. *Journal of Clinical Epidemiology* 57: 1008–1018.
- Schulte T, Schniewind B, Dohrmann P, Küchler T, Kurdow R (2009) The extent of lung parenchyma resection significantly impacts long-term quality of life in patients with non-small cell lung cancer. *Chest* 135: 322–329.
- Stephan F, Boucheseiche S, Hollande J, Flahault A, Cheffi A, Bazelly B et al (2000) Pulmonary complications following lung resection: a comprehensive analysis of incidence and possible risk factors. *Chest* 118: 1263–1270.
- Stratford PW, Balsor BE (1994) A comparison of make and break tests using a hand-held dynamometer and the Kin-Com. *Journal of Orthopaedic and Sports Physical Therapy* 19: 28–32.
- Swigris JJ, Brown KK, Behr J, du Bois RM, King TE, Raghu G et al (2010) The SF-36 and SGRQ: validity and first look at minimum important differences in IPF. *Respiratory Medicine* 104: 296–304.
- Zehr K, Dawson P, Yang S, Heitmiller R (1998) Standardized clinical care pathways for major thoracic cases reduce hospital costs. *Annals of Thoracic Surgery* 66: 914–919.