FULL LENGTH ARTICLE

Effects of a preoperative individualized exercise program on selected recovery variables for cardiac surgery patients: A pilot study

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Objective: **Research on preoperative individualized exercise prescription (PIEP) for heart surgery patients in Taiwan is lacking. Thus, the purpose of this study was to examine the feasibility of a PIEP in the Taiwanese population.**

Method: **A quasi-experimental design, using purposive sampling, was conducted. Thirty-five patients were recruited, of whom 15 chose to participate in the experimental (PIEP training plus usual care) group, and 20 chose to participate in the control (usual care) group. The effects of the intervention were determined by pulmonary complication-related parameters and quality of life.**

Results and conclusion: **The development and process of PIEPs suitable for cardiac patients was described in this study. The results reveal that the two-week exercise-training program contributed to a decreased peak respiratory exchange ratio (RER) after the surgery and earlier ambulation. The effectiveness of PIEPs in improving the quality of life in cardiac surgery patients was validated. This study may also contribute as a reference of the PIEP effect on patients to the healthcare providers.**

Keywords: Preoperative, Exercise prescription, Cardiac surgery, Pulmonary function, Quality of life

Introduction

The World Health Organization (WHO) stated that by 2020 heart disease will be the number one leading cause of death worldwide and estimates that 25 million people per year will suffer from heart disease [1]. In the United States, one-third of individuals have one or more hear

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diseases [2]. In Taiwan, the prevalence of heart disease cases is increasing and since 2008 it has become one of the two leading causes of death [3].

Heart surgery is an effective way to treat severe heart disease that cannot be managed by medication and can prolong life expectancy and improve quality of life [4,2]. Previous research has shown, however, that respiratory muscle function is reduced after heart surgery and that patients sometimes develop phrenic nerve paralysis. Additionally, dysfunction of aspiratory muscles may lead to reduction in total lung capacity and in cough efficiency. Further, the anesthesia given during the operation also may affect cough efficiency and ventilation function. Pain after surgery might lead to the minimization of spontaneous deep breathing and changes in body position and, as such, reduce lung expansion and pulmonary function, which could lead to pulmonary complications [5–7].

Pulmonary complications include atelectasis, pneumonia, bronchitis, pneumothorax, inspiration, bronchospasm, and worsening of underlying chronic lung disease, which can occur up to seven days after surgery [6,8,9]. In addition, pulmonary complications lead to worsened outcomes, increased length of hospital stay, medical consumption, and even post-operative mortality [10,5,9].

Pre-operative exercise training has been shown to prevent post-operative pulmonary complications [5,11–14]. Hulzebos et al. [5] indicated that intervention reduces the incidence of post-operative complications and duration of post-operative hospitalization in patients with an increased probability of undergoing CABG. The findings from Dronkers et al. [11] support those of Hulzebos et al. [5] and in Taiwan, Wang [12] revealed that preoperative exercise training is effective in improving pulmonary function in patients after an abdominal laparotomy. However, inadequate exercise training in individuals with heart disease might cause negative consequences and increase operative complications [14]. Therefore, individualized exercise prescriptions based on the patient's condition provide the safest and most effective way to promote better outcomes ([15].

More exercise is associated with a better quality of life, as revealed in many previous studies [16–19]. Using an experimental design, Lin [19] indicated that patients attending the exercise-training program show significant improvements in symptom distress and quality of life compared to the control group. The results from Arthur et al. [21] confirmed the positive impact of preoperative exercise training on post-operative quality of life.

Overall, the research shows that a preoperative individualized exercise prescription (PIEP) can minimize pulmonary complications and promote better outcomes. However, research on PIEPs for heart surgery patients in Taiwan is limited. Thus, the purpose of this study was to examine the feasibility of a PIEP in this specific population. Our study hypotheses state that heart surgery patients in the PIEP program experience less pulmonary complications and gain better a quality of life, compared to the patients in usual care.

Methods

A quasi-experimental design, using purposive sampling, was conducted. The criteria were that the patients be 18 years of age or older; able to speak and read Chinese; have heart surgery scheduled for at least two weeks later; have had no major surgery within a half-year; have not used inotropic agents or NTGs for 24-h infusion prior to surgery. A total of 35 patients were recruited in one hospital in Taipei, Taiwan, from September 2010 to April 2011, of whom 15 chose to participate in the experimental (PIEP training plus usual care) group, and 20 chose to participate in the control (usual care) group. Two questionnaires (demographic and quality of life), pulmonary complication-related parameters and cardiopulmonary exercise testing (CPET), were used and the data were collected two weeks prior to surgery and two to four weeks after the surgery. The effects of the intervention were determined by pulmonary complication-related parameters and quality of life.

Ethical considerations

The study was approved by the ethics committee of Taipei University of Nursing and Health Sciences and the hospital. Signed informed consent forms were collected from all participants. Patients were informed that they could drop out of the program at any time without any negative consequence. Anonymity and confidentiality were strictly observed throughout the entire research process.

Measurements

(1) Demographic questionnaire. A demographic questionnaire was used to obtain information on age, sex, body mass index (BMI), comorbid condition, educational status, income, and other related outcome parameters: length of stay, first ambula-

tion after operation, sputum culture, and associated lab data.

(2) Pulmonary complication-related parameters. X-rays were analyzed by a radiologist to determine whether the patients had pulmonary complications. Other pulmonary complication-related parameters included pre- and post-operative body temperature, white count, C-reactive protein, BUN, duration of intubation, duration of ventilator use, duration of noninvasive positive pressure ventilator (NIPPV) use after extubation, first ambulation, length of stay in ICU, length of stay, days of antibiotic use, and sputum culture.

(3) Cardiopulmonary exercise testing (CPET). The maximal exercise test, with an electronically braked cycled ergometer (ER900, Jamger), was used and was started at 0 W for 2 min, with a stepwise increment of 5–15 W/min. Oxygen uptake (VO_2), carbon dioxide output (VCO_2), instantaneous expiratory gas concentrations throughout the respiratory cycle, and minute ventilation (VE) were measured continuously on a breath-by-breath basis (CPX/D, MedGraphics). Data recorded during CPET included maximum exercise resistance, duration of completed test, peak VO_2, anaerobic threshold (AT), peak oxygen pulse, peak rate pressure product (RPP), Peak respiratory exchange ratio (RER), Borg RPE (Borg Rating of Perceived Exertion), heart rate, and blood pressure [22].

Peak VO_2 was defined as the highest 30-s average of oxygen uptake in the last minute of exercise. Heart rate and blood pressure (by sphygmomanometer) were measured at rest, during each stage of exercise, and at peak exercise. Borg RPE is an ordinal scale with values from 6 to 20. Verbal anchors are provided as standards for comparisons across individuals and tasks. The greater the exertion felt, the greater the number reported by the individual being tested. This scale increases linearly with physiological measures such as HR and VO_2 as exercise intensity increases [23].

The CPET was discontinued if the following condition occurred during the testing process: achievement of maximum heart rate (220-real age), an abnormality in the ECG (such as ST depressed more than 2 mm), RER more than 1.09, any symptom of discomfort, or the participant's expressing that he or she wanted to stop due to fatigue or any other reason.

(4) Short Form 36-Health Survey (SF-36). The SF-36 was used to measure quality of life. The survey includes 35 closed-ended questions and one general question on the participant's quality of life. The questions are categorized into eight subscales: (1) physical function; (2) role limitation caused by physical problems; (3) role limitation caused by emotional problems; (4) social function; (5) bodily pain; (6) mental health; (7) vitality, energy/fatigue; and (8) general health. The eight scales are grouped into two summary scales: the physical component summary (PCS) and the mental component summary (MCS). Scores range from 0 to 100, with higher scores representing better quality of life. The Taiwan version has been widely used, and its psychometric properties have been confirmed [24,25].

Intervention: preoperative individualized exercise prescription (PIEP)

The intervention group received preoperatively individualized, tailored exercises – PIEP. The PIEP was set at a low intensity, i.e., achieving 50–60% maximal oxygen consumption (VO_2 max) for this population, by an expert panel, which included two cardiovascular surgeons, one thoracic surgeon, one rehabilitation physician, and one physical therapist. The PIEP was carried out at least three times, two weeks prior to the surgery (once or twice per week) and lasted approximately 40–60 min each time.

The PIEP was developed and tailored based on the patient's health condition, rate of perceived exertion scored on the Borg RPE, and heart rate reserve (HRR). A treadmill (9500HR, Life Fitness) was used for exercise, and the PIEP had three components: (a) warm-up phase: 5 min of warm-up, in which the exercise was initiated and the resistance was increased gradually until a low-intensity level was achieved; (b) training phase: approximately 30 min of training at a low-intensity level; (3) cool-down phase: 5 min of cooling down to decrease the treadmill rate and resistance until the treadmill stops. The physical therapist supervised and recorded all relevant data, such as EKG, heart rate, symptoms, if any, and other associated data. All three phases could be modified by RPE, HRR, or VO_2 max, as needed. The phases could be stopped at any time if patients experienced any discomfort [26,27].

Usual care

During the preoperative period, both the experimental and the control groups received care as usual, consisting of a demonstration of (a) deep breathing maneuvers, with the use of an incentive spirometer; (b) coughing and forced expiration techniques (FET); and (c) early mobilization. Nota-

bly, the intervention group received this usual care two weeks before surgery, but the control group received this usual care only one day before surgery. In the post-operative period, both groups received a similar incentive spirometer, chest physical therapy, and mobilization plan.

Data analysis

Demographic data were presented through descriptive statistics. Because the sample was normally distributed, parametric tests were used for significance testing. Study outcomes were the changes in pulmonary complication-related parameters, cardiopulmonary exercise testing, and quality of life from baseline and post-test after the initiation of the intervention. To test the effectiveness of the intervention, paired *t*-tests were used to examine the differences within groups, and independent *t*-tests were used to examine differences for unpaired data. Differences between categorical variables were tested using chi-square analyses and ANOVAs. The significance level was set at $p < .05$ (2-tailed). All data were analyzed using SPSS (Version 17.0 for Windows, Chicago, IL).

Results

Demographics

As seen in Table 1, there were more men than women in both the experimental and control groups. The mean age of the participants in the experimental group was 52.8, and in the control group, 54.7. The majority of the patients in both groups performed little or no exercise.

As presented in Table 2, all of the participants belonged to ASA physical status III. Eighty percent of the patients in the experimental group and eighty-five percent of the patients in the control group were considered NYHS function status I or II. The majority of the patients in both groups did not have a cardiopulmonary bypass during the operation.

Pulmonary complication-related parameters

As seen in Table 3, compared to the experimental group, more participants in the control group used a non-invasive ventilator ($p = .012$). Notably, after the cardiac surgery, participants in the experimental group got out of bed sooner and ambulation was earlier than for participants in the control group (3.26 ± 1.57 vs. 5.15 ± 3.14, $p = .041$). This indicates that cardiac surgery patients who exercised prior to surgery were less likely to use a non-invasive ventilator and were more likely to ambulate earlier compared to those who did not exercise prior to surgery.

Cardiopulmonary exercise testing (CPET)

As presented in Table 4, the changes in peak respiratory exchange ratio (RER) between pre- and post-operation for the control groups were statistically significant (0.09 ± 0.12, $p = 0.004$) but there is no difference between pre- and post-

Table 1. Demographics.

Variables	Experimental ($N = 15$) (%)	Control ($N = 20$) (%)	Total ($N = 35$) (%)	p
Sex				0.199[c]
Male	14(93.3)	14(70)	28(80)	
Female	1(6.7)	6(30)	7(20)	
Age (M ± SD)	52.8 ± 10.89	54.7 ± 10.73	53.8 ± 10.68	0.88[b]
30–50 yr	5(33.3)	6(30)	11(31.4)	
>50 yr	10(66.7)	14(70)	24(68.6)	
BMI (M ± SD)	27.8 ± 5.16	26.3 ± 4.78	27 ± 4.93	0.87[b]
Education				0.41[a]
Elementary	2(13.3)	11(55)	13(37.1)	
High school	6(40)	4(20)	10(28.6)	
Associate degree	7(46.7)	5(25)	12(34.3)	
Tobacco use				0.721[c]
No	6(40)	6(30)	12(34.3)	
Yes	9(60)	14(70)	23(65.7)	

$^{*}p < .05$; $^{**}p < .01$.
BMI: Body mass index.
[a] χ^2 test.
[b] Independent *t*-test.
[c] Fisher's exact test.

Table 2. Medical condition.

Variables	Experimental ($N = 15$) (%)	Control ($N = 20$) (%)	Total ($N = 35$) (%)	p
Cardiac disease related past history				0.274[a]
None	8(53.3)	8(40)	16(45.7)	
CAD	7(46.7)	9(45)	16(45.7)	
Hypertension	0(0)	3(15)	3(8.6)	
Diagnosis				0.49[a]
CAD	9(60)	9(45)	18(51.4)	
Valve disease	2(13.3)	6(30)	8(22.9)	
CAD combine valve disease	4(26.7)	5(25)	9(25.7)	
Cormbid diseases				0.68[c]
<3	13(86.7)	16(80)	29(82.9)	
>3	2(13.3)	4(20)	6(17.1)	
NYHA function status				1[c]
I–II	12(80)	17(85)	29(82.9)	
III	3(20)	3(15)	6(17.1)	
ASA physical status				
III	15(100)	20(100)	35(100)	
Opearation				0.49[a]
CABG	9(60)	9(45)	18(51.4)	
Valve surgery	2(13.3)	6(30)	8(22.9)	
CABG combine Valve surgery	4(26.7)	5(25)	9(25.7)	
Cardiopulmonary bypass unit				0.485[a]
Yes	1(6.7)	4(20)	5(14.3)	
No	14(93.3)	16(80)	30(85.7)	
Time of sedation (M ± SD)	5.6 ± 1.23	5.1 ± 1.27	3.85.32 ± 1.26	0.222[b]
Time of operation (M ± SD)	4.5 ± 1.45	4.2 ± 1.23	4.3 ± 1.31	0.609[b]
Blood loss (M ± SD)	313 ± 117	343 ± 211	330 ± 175	0.622[b]
Pre-opeative albumin (M ± SD)	4.175 ± 0.48	4 ± 0.47	4.08 ± 0.48	0.375[b]
Pre-operative BUN (M ± SD)	21.2 ± 15.7	20.2 ± 7.85	20.6 ± 11.68	0.794[b]
Pre-operative CRP (M ± SD)	6.16 ± 3.87	9.61 ± 9.12	8.13 ± 7.46	0.18[b]

$^{*}p < .05$; $^{**}p < .01$.
CAD: coronary artery disease; NYHA: New York Heart Association; ASA: American Society of Anesthesiologists; CABG: coronary artery bypass grafting.
[a] χ^2 test.
[b] Independent t-test.
[c] Fisher's exact test.

Table 3. Pulmonary complication-related parameters.

Variables	Experimental ($N = 15$) (%)	Control ($N = 20$) (%)	Total ($N = 35$) (%)	p
Pre-operative infiltration	1(6.7)	2(10)	3(8.6)	0.727[a]
Post-operative infiltration at 7th days	6(40)	9(45)	15(42.9)	1[c]
Pre-operative hyperthermia	0(0)	0(0)		
Post-operative hyperthermia at 7th days	2(13.3)	2(10)	4(11.4)	1[c]
Pre-operative abnormal WBC	1(6.7)	1(5)	2(5.7)	1[c]
Post-operative abnormal WBC at 7th days	1(6.7)	1(5)	2(5.7)	1[c]
Post-operative use of NIPPV within 7 days	0 (0)	7(35)	7(20)	0.012[c*]
Days of use ventilator (M ± SD)	1.33 ± 0.81	1.85 ± 1.53	1.62 ± 1.28	0.245[b]
Days of use NG (M ± SD)	1.46 ± 0.91	2.25 ± 3.1	1.91 ± 2.45	0.358[b]
Days of stay in ICU (M ± SD)	3.4 ± 1.24	4.15 ± 1.87	3.85 ± 1.64	0.23[b]
Days of use antibiotics (M ± SD)	4.86 ± 2.72	5.5 ± 3.1	5.22 ± 2.92	0.534[b]
Post-OP first time ambulate (M ± SD)	3.26 ± 1.57	5.15 ± 3.14	4.34 ± 2.72	0.041[b*]
Post-OP Length of stay (M ± SD)	10.13 ± 2.79	11.75 ± 4.36	11.05 ± 3.81	0.192[b]
Post-OP sputum culture	0(0)	3(24.3)	3(8.6)	0.083[b]
Heamophilus	0(0)	1(4.8)	1(2.9)	
Heamophilus/KP	0(0)	1(4.8)	1(2.9)	
KP	0(0)	1(4.8)	1(2.9)	

$^{**}p < .01$.
OP: operation.
* $p < .05$.
[a] χ^2 test.
[b] Independent t-test.
[c] Fisher's exact test.

Table 4. Cardiopulmonary exercise testing (CPET).

Variables	Experimental ($N = 15$) (M ± SD)	p	Control ($N = 20$) (M ± SD)	p	Total ($N = 35$) (M ± SD)	p
MVO_2 (ml/kg/min)						
Pre-op	16.6 ± 3.8		17 ± 7.2		16 ± 4.42	0.861[b]
Post-op[c]	15.8 ± 3.2		16.4 ± 5.2		16 ± 5.9	0.725[b]
Changes	−0.81 ± 2.4	0.229[a]	−0.57 ± 3.7	0.523[a]	−0.6 ± 3.1	0.236[a]/0.853[b]
Anaerobic threshold (AT; ml/kg/min)						
Pre-op	961 ± 387		858 ± 200		903 ± 296	0.262[b]
Post-op[c]	962 ± 345		841 ± 225		894 ± 285	0.24[b]
Changes	1.28 ± 413.4	0.991[a]	−16 ± 181	0.706[a]	−8.6 ± 299.6	0.871[a]/0.818[b]
Resting heart rate (bpm)						
Pre-op	76 ± 16.1		76 ± 12.4		76 ± 13.9	0.921[b]
Post-op[c]	83 ± 12		79 ± 11.4		81 ± 11.7	0.306[b]
Changes	7.21 ± 14.2	0.081[a]	2.6 ± 17	0.517[a]	4.6 ± 15.8	0.106[a]/0.712[b]
Exertion heart rate (bpm)						
Pre-op	126 ± 22		126 ± 25.3		126 ± 23.5	0.797[b]
Post-op[c]	116 ± 16.1		117 ± 21.5		117 ± 19	0.83[b]
Changes	−10 ± 24.5	0.151[a]	−8.6 ± 26.6	0.186[a]	−9.2 ± 25.3	0.048[a, *]/ 0.892[b]
Peak respiratory exchange ratio (RER)						
Pre-op	1.16 ± 0.12		1.09 ± 0.11		1.11 ± 0.12	0.163[b]
Post-op[c]	1.19 ± 0.16		1.18 ± 0.10		1.19 ± 0.12	0.755[b]
Changes	0.03 ± 0.18	0.545[a]	0.09 ± 0.12	0.004[a, *]	0.08 ± 0.15	0.018[a, *]/ 0.22[b]
Resting blood pressure (mmHg)						
Pre-op						
Systolic	113 ± 19.2		120 ± 20		117 ± 19.7	0.296[b]
Diastolic	74 ± 13.8		79 ± 13.5		77 ± 13.6	0.352[b]
Post-op[c]						
Systolic	115 ± 17.1		117 ± 21.8		116 ± 19.6	0.706[b]
Diastolic	74 ± 8.9		76 ± 11.7		75 ± 10.4	0.675[b]
Changes						
Systolic	2.07 ± 17.4	0.665[a]	−2.5 ± 24.6	0.666[a]	−0.5 ± 21.6	0.89[a]/0.831[b]
Diastolic	0.21 ± 10.3	0.939[a]	−2.6 ± 11.9	0.356[a]	−1.4 ± 11.1	0.481[a]/0.836[b]
Exertion blood pressure (mmHg)						
Pre-op						
Systolic	144 ± 33.5		150 ± 34.7		147 ± 33.7	0.734[b]
Diastolic	79 ± 17.5		82 ± 13		81 ± 14.9	0.628[b]
Post-op[c]						
Systolic	163 ± 39		157 ± 25.3		160 ± 31.7	0.558[b]
Diastolic	77 ± 12.8		82 ± 11.1		80 ± 11.9	0.258[b]
Changes						
Systolic	19 ± 35.7	0.068[a]	6.9 ± 41.8	0.491[a]	12.2 ± 39.1	0.087[a]/0.587[b]
Diastolic	−1.57 ± 11.2	0.61[a]	0.66 ± 15.1	0.854[a]	−0.3 ± 13.4	0.896[a]/0.692[b]

[**] $p < .01$.
[*] $p < .05$.
[a] Pair t-test.
[b] Independent t-test.

operation in the experimental group (0.03 ± 0.18, $p = 0.545$). Although not a statistically significant difference, the AT for participants in the experimental group increased after surgery, while the AT of participants in the control group decreased.

Quality of life

As seen in Table 5, participants in the experimental group had better scores for general health, PCS, and MCS after the surgery, while participants in the control group attained higher scores for general health and MCS after the surgery. In regard to changes in quality of life from pre- to post-surgery, there were differences in general health and MCS between the experimental and control groups. This indicates that individuals in the experimental group had more improvement in quality of life than did individuals in the control group.

Table 5. Quality of life.

	Experimental ($N = 15$) (M ± SD)	p	Control ($N = 20$) (M ± SD)	p	Total ($N = 35$) (M ± SD)	p
PF						
Pre-operation	63 ± 19.8		60.76 ± 26.76		61.77 ± 23.76	0.768[b]
Post-operation	71.09 ± 20.21		3.48 ± 14.32		66.44 ± 22.12	0.288[b]
Changes between pre and post	7.98 ± 22.35	0.188[a]	2.19 ± 28.28	0.733[a]	4.67 ± 25.71	0.29[a]/0.504[b]
RP						
Pre-operation	39.4 ± 38.6		42.88 ± 41.46		41.41 ± 39.71	0.805[b]
Post-operation	48.77 ± 38.34		33.76 ± 39.07		40.19 ± 38.92	0.265[b]
Changes between pre and post	9.32 ± 43.64	0.422[a]	−9.12 ± 46.07	0.387[a]	−1.21 ± 45.34	0.875[a]/ 0.236[b]
BP						
Pre-operation	62.9 ± 20.8		64.51 ± 23.87		63.86 ± 22.32	0.846[b]
Post-operation	61.12 ± 16.58		61.93 ± 11.55		61.58 ± 13.71	0.866[b]
Changes between pre and post	−1.86 ± 20.50	0.73[a]	−2.57 ± 27.49	0.68[a]	−2.27 ± 24.41	0.586[a]/ 0.931[b]
GH						
Pre-operation	36.4 ± 21.4		44.65 ± 17.25		41.12 ± 19.30	0.221[b]
Post-operation	69.92 ± 20.74		63.48 ± 14.33		66.24 ± 17.13	0.278[b]
Changes between pre and post	33.45 ± 20.12	<0.001[a,**]	18.85 ± 15.90	<0.001[a,**]	25.11 ± 19.02	<0.001[a,**]/ 0.022[b,*]
VT						
Pre-operation	46 ± 9.25		43.82 ± 10.25		44.75 ± 9.75	0.521[b]
Post-operation	51.11 ± 8.22		48.17 ± 10.42		49.43 ± 9.52	0.374[b]
Changes between pre and post	5.11 ± 9.59	0.058[a]	4.35 ± 13.10	0.154[a]	4.68 ± 11.58	0.023[a,*]/ 0.851[b]
SF						
Pre-operation	20.5 ± 21.1		26.68 ± 21.5		24.05 ± 21.24	0.405[b]
Post-operation	28.51 ± 20.74		24.84 ± 23.19		26.41 ± 21.93	0.632[b]
Changes between pre and post	7.97 ± 23.36	0.207[a]	−1.84 ± 22.43	0.717[a]	2.36 ± 23.03	0.548[a]/ 0.217[b]
RE						
Pre-operation	34.7 ± 13.7		38.26 ± 14.32		36.74 ± 13.97	0.465[b]
Post-operation	36.94 ± 9.71		35.24 ± 13.28		35.97 ± 13.80	0.723[b]
Changes between pre and post	2.23 ± 15.99	0.597[a]	−3.02 ± 17.52	0.45[a]	−0.76 ± 16.85	0.789[a]/ 0.369[b]
MH						
Pre-operation	37.89 ± 11.5		39.62 ± 14.4		38.88 ± 13.17	0.707[b]
Post-operation	36.31 ± 9.71		38.69 ± 7.73		37.67 ± 8.58	0.426[b]
Changes between pre and post	−1.57 ± 12.33	0.628[a]	−0.93 ± 15.53	0.791[a]	−1.21 ± 14.05	0.614[a]/ 0.895[b]
PCS						
Pre-operation	53.42 ± 18.9		51.96 ± 16.91		52.59 ± 17.57	0.812[b]
Post-operation	62.16 ± 19.83		61.4 ± 20.32		61.92 ± 19.82	0.861[b]
Changes between pre and post	9.18 ± 16.17	0.045[a,*]	9.44 ± 22.29	0.074[a]	9.33 ± 19.63	0.008[a,*]/ 0.971[b]
MCS						
Pre-operation	34.75 ± 11.1		40.16 ± 8.43		37.84 ± 9.91	0.111[b]
Post-operation	52.03 ± 10.39		49.62 ± 7.09		50.65 ± 8.60	0.448[b]
Changes between pre and post	17.28 ± 10.35	<0.001[a,**]	9.46 ± 8.12	<0.001[a,**]	12.81 ± 9.82	<0.001[a,**]/ 0.017[b,*]

PF: physical function; RP: role limitation caused by physical problems; BP: bodily pain; GH: general health; VT: vitality; SF: social function; RE: role limitation caused by emotional problems; MH: mental health; PCS: physical component summary; MCS: mental component summary.

[*] $p < .05$.

[**] $p < .01$.

[a] Pair t-test.

[b] Independent t-test.

Discussion

In this study, no patients used a non-invasive ventilator after extubation in experimental group; however, seven patients in the control group did. The findings also demonstrated that exercise prior to surgery can help patients get out of bed earlier. These results support the conclusions of earlier studies [12,5,11] and confirm the efficacy of a preoperative exercise intervention for reducing pulmonary complications.

In regard to cardiopulmonary exercise test results, the peak respiratory exchange ratio (RER) between pre- and post-operation in the control groups was increased significantly but not in the experimental group. This finding indicates patients in the control group might increase effort during aerobic exercise post surgery compared to before surgery. In addition, the anaerobic threshold for patients in the exercise intervention increased without statistical significance. Dronkers et al. [11,28] found that inspiratory muscle recovery and pulmonary function were better in patients who had exercise training. This study's results for cardiopulmonary exercise were inconsistent with those of previous research [11,28].

Chen [29] reported that all of subscales of quality of life prior to cardiac surgery were less than 50, which is considered low [29]. Our study results support Chen's [29] finding that both the preoperative PCS and MCS of the quality of life score for all participants was below 50. With regard to the improvement of quality of life in these two groups, participants who received the preoperative exercise prescription had a significant improvement in quality of life. This is keeping with the results of Arthur et al. [21], whose research was conducted in the West [21]. In addition, the positive relationship between exercise and quality of life was confirmed, in keeping with other studies of cardiac disease [17,19,18,16].

Limitations and recommendations

The most common intervention for cardiac surgery patients is a cardiac rehabilitation program. Most cardiac rehabilitation programs in Taiwan focus on the type of exercise that patients can do after surgery [29,30]. Even though, as shown above, preoperative exercise interventions promote better outcomes, very few of them are conducted in Taiwan. This may be because research on the effectiveness of PIEPs for quality of life in cardiac surgery patients is limited in this country. Therefore, further investigation of such programs is warranted.

Because this study was conducted with a small sample, the use of larger samples is recommended for future research on PIEPs. Another limitation of this study was the short follow-up period. The follow-up data were collected only one month after the intervention, and maintenance of these effects over time is unknown. Therefore, it is essential to continue to follow these patients to assess whether the early positive effects of this intervention continue over time.

Conclusion

The development and process of PIEPs suitable for cardiac patients was described in this study. The results validated the effectiveness of PIEPs for improving quality of life in cardiac surgery patients. The study contributed to healthcare provider knowledge of the impact of using PIEPs. Multidisciplinary teams, including nurses, physical therapists, rehabilitation physicians, and cardiac surgeons, should work together to promote this intervention as part of routine care, creating the most benefit for this specific population of patients. Although PIEP appears feasible and provides some important benefits for cardiac surgery patients, larger studies are required to confirm the benefits of intervention as part of routine care.

Conflict of Interest

Authors have no conflict of interest to declare.

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