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The Effect of Preoperative Chest Physiotherapy on Oxygenation and Lung Functions among Open Heart Surgery Patients

Ph.D. Dissertation

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DEDICATION

I would like to dedicate this dissertation to my parents, Abd al-Rahman and Majd, the reason for who I am today. Thank you for raising me to believe that anything is possible and for your constant support and prayers for me.

To my brother Ragheed, thank you for believing in my abilities and supporting me in following my dreams.

To my younger brother Waseem, thank you for your endless love and care.

I would also like to dedicate this thesis to my husband Saleh, Thank you for your support, especially on this journey.

To my children, Jana and Rayan, the shining light in every difficult moment I went through.

Contents

Abbreviations:

ABG	**Arterial blood gases**
ACC	**American college of cardiology**
ADA	**Americans with disabilities act**
AHA	**American heart association**
ARDS	**Acute respiratory distress syndrome.**
AVR	**Aortic valve replacement**
BMI	**Body mass index**
CABG	**Coronary artery bypass grafting**
CAD	**Coronary artery disease**
CE	**Continuous exercise**
CIMT	**Carotid intimal medial thickness**
CKD	**Chronic kidney disease**
CPT	**Chest physical therapy**
CPAP	**Continuous positive airway pressure**
CR	**Cardiac rehabilitations**
CTR	**Chest tube removal**
CVDs	**Cardiovascular diseases**
DM	**Diabetes mellitus**
ET	**Endurance training**
EU	**European union**
FEV1	**Forced expiratory volume in 1s**
FMD	**Flow-mediated dilation**
FVC	**Forced vital capacity**
HDL	**High-density lipoprotein**
HTN	**Hypertension**
ICU	**Intensive care unit**
IMT	**Inspiratory muscle training**
IPPB	**Intermittent positive pressure breathing**
LITA	**Left internal thoracic artery**
IMT	**Inspiratory muscle training**
LIMA	**Left internal mammary artery**
MI	**Myocardial infarction**
MRI	**Magnetic resonance imaging**
MVR	**Mitral valve replacement**
NAFLD	**Non-alcoholic fatty liver disease**
PCI	**Percutaneous coronary intervention**

PIEP	**Preoperative individualized exercise prescription.**
Pi-max	**Maximum inspiratory pressure**
PPC	**Postoperative pulmonary complication**
PRISMA	**Preferred reporting items for systematic reviews and meta-analyses**
RH-PAT	**Reactive hyperemia- peripheral arterial tonometry**
RA	**Rheumatoid arthritis**
RCT	**Randomized controlled trial**
RMT	**Respiratory muscle training**
SMCs	**Smooth muscle cells**
SpO2	**Oxygen saturation**
SLE	**Systemic lupus erythematosus**
Qol	**Quality of life**
WHO	**World health organization**

Chapter1: Introduction

Postoperative pulmonary complications

In spite of the recent developments in the field of preoperative care, postoperative pulmonary complications (PPCs) remain a principal reason for operation-related morbidity and mortality. PPCs are the respiratory system disorders that typically occur during the first postoperative week. These PPCs range from lung atelectasis to respiratory failure (Miskovic and Lumb, 2017).

The surgery and anesthesia impose factors that predispose the occurrence of PPCs. Surgery may cause depressed lung function, as the surgical pain impacts normal breathing. Anesthesia elicits adverse intraoperative, and, to a lesser extent, postoperative effects on pulmonary functions (Makhabah et al., 2013).

PPCs are predictors of the postoperative health outcomes of patients and increase the risk of admission to the intensive care units (ICUs), the prolongation of hospital stay length, and mortality (Fernandez-Bustamante et al., 2017).

Patients undergoing cardiac surgery are particularly vulnerable for developing PPCs. During cardiac surgery, several factors act integrally and are implicated in the occurrence of PPCs. These include general anesthesia, mechanical ventilation duration, cardiopulmonary bypass, and the sternotomy incision (Naveed et al., 2017).

The use of cardiopulmonary bypass (CPB) and general anesthesia is a main factor influencing the patient outcome in cardiac surgeries. Post-operative pulmonary complications (PPCs) have been attributed to several factors related to CPB. In part, substance-related factors; blood being exposed to artificial materials, or other factors including variability in body temperature, ischemia-reperfusion of organs, surgical trauma, and endotoxins release, all of these elicit acute inflammatory response (De Backer et al., 2009). As regards anesthesia, they possibly predispose to PPCs through reducing the functional residual capacity and vital capacity and widening the alveol-arterial oxygen gradient, with subsequent hypoxemia and atelectasis. In fact, the anesthetic drugs are predisposing to PPCs via immunity dysfunction, which

subsequently yields to lung injury (Justus et al., 2019).

In this regards, there are several postoperative techniques controlling lung function and maintaining the normal function of several organs those can be applied for the patients who had CABG. These postoperative techniques could therefore reduce the mortality rate among patients. The techniques include mucous suction, exercise producing positive pressure and physiotherapy that could potentially increase the level of respiratory volumes and oxygen saturation (Westerdahl et al., 2005).

Role of Physiotherapy

Taking into consideration the postoperative pulmonary complications (PPC) that may develop, physiotherapists pre-surgery should identify those patients at-risk and prevent or minimize the possibility of complications. Moreover, Physiotherapists have a role in improving physical activity in all phases of cardiac rehabilitations (CR) (Themistocleous et al., 2017).

Pre-surgical physiotherapy

Preoperative physiotherapy in patients undergoing CABG includes different interventions such as inspiratory muscle training (IMT), respiratory exercises, aerobic exercise, education and counselling. The IMT interventions are addressed to improve oxygen saturation, gas exchange and to reduce postoperative complications while psycho-emotional strategies based on education and counselling seem to contribute to a reduction in preoperative anxiety and depression (Perelló-Díez and Paz-Lourido, 2018).

Physiotherapists are involved in the preparation of cardiac patients before surgery Weakness of the inspiratory muscles in the pre-surgical phase is a risk factor for the development of pulmonary complications post-surgery (Miranda et al., 2011).

Pre-surgical physiotherapy interventions aim to assess patient's functional capacity and educate on the exercises. Physiotherapists educate patients on how to get out of bed and chair, demonstrate and inform them about huffing, coughing techniques, breathing exercises and lower limb mobilization (Leguisamo et al., 2005). Common techniques that are currently applied, include deep breathing exercises, such as incentive spirometry, hyperinflation therapy including intermittent positive

pressure breathing (IPPB), continuous positive airway pressure (CPAP), and insufflation/exsufflation, and chest physical therapy (CPT) (often combined with aerosolized mucolytic administration, coughing exercises, postural drainage, and percussion and vibration) (Groom, 2012).

Wound management and protection necessary immediately after the operation, should be taught to the patient during pre-surgical physiotherapy. In the first three days' post-surgery, protection involves placing the hands on the sternum during coughing, without applying excessive pressure to the skin. Later than three days' patient is instructed to place the hands into the armpits and gently stabilize the thorax. Moreover, overweight patients or those with severe cough are trained to use a stabilizing belt which offers an additional protection (Themistocleous et al., 2017).

Post-surgical physiotherapy

Following cardiac surgery, the inspiratory muscle strength and the functional capacity of the lungs decrease occurs (Moreno et al., 2011). Post-surgery pain may be responsible for the reduced functional capacity and impairment of ventilation. As a result, the majority of these individuals may have PPC which are responsible for longer duration of hospitalization, morbidity and mortality (Perelló-Díez and Paz-Lourido, 2018).

Phase I of cardiac rehabilitation

The inpatient stage is often referred to as phase I (acute) which is important in assisting patient's pathway to recovery. This phase includes patient's assessment, education and mobilization. It was suggested that patients should receive a graded mobilization and exercise program so that by discharge time the patient is ambulant and be able to attend the ADL. Kinesiotherapy is useful in phase I, as patients often struggle with pain, thus develop poor postural habits, abnormal motor control and decreased endurance due to activity avoidance (Themistocleous et al., 2017).

Phase I occurs over a variable time frame (usually 1-14 days) that depends on the severity of the cardiac event and the length of time that the patient remains an inpatient. Phase I incorporates a combination of supportive counseling and reassurance for risk factor modification, medication adherence and education on when and how to resume daily living activities. This is complemented by early mobilization

to prevent the deleterious effects of bed rest and to initiate a progressive increase in activity to allow for, at the minimum, basic self-care at discharge from the hospital. Evidence suggests that active engagement in CR at an inpatient stage may improve uptake of phase II programs by as much as 93% (Ting et al., 2014).

Phase II of cardiac rehabilitation

The second phase is the initial post-discharge stage. At this stage patients may feel isolated and insecure and may present elevated anxiety signs. Phase II usually involves patients attending a hospital-based program as an outpatient, weekly or twice weekly over a 6- to 12-week period (Abell et al., 2016). Phase II programs provide initial physical, psychological, and social assessments to facilitate return to everyday function, and education regarding cardiovascular disease risk factors, and exercise and lifestyle changes that may have long-term cardioprotective effects (Woodruffe et al., 2014).

Exercise consultation is advantageous at this stage in order to enhance adherence to both lifestyle modification and maintenance of exercise in phase II and future phases of CR. Moreover, physiotherapists at this phase should prescribe individualized home-walking programs and help patients to progress to phase III (Themistocleous et al., 2017).

Phase III of cardiac rehabilitation

This phase is traditionally the outpatient education and structured exercise program component of CR, lasting for 6-12 weeks. The key component of this phase is mainly the physical exercise, however, education and psycho-social counseling regarding risk factors and lifestyle modification are important. health and fitness benefits from exercise have a direct dose–response relationship and therefore patients prior to phase III should undertake a risk stratification assessment as it is essential for their participation into an exercise program. The purpose of the risk-stratification is to identify patient's risk factors and place them in a risk category based on an increased likelihood of adverse effects (Proudfoot, 2006).

Phase III is community-based and aims to maintain activity beyond the period of subacute care to provide long-term benefits of exercise and minimise the risk for secondary events (secondary prevention). Current evidence suggests that participation in phase III is highly beneficial in reducing major adverse cardiac events. Although

the improvements in cardiorespiratory fitness, haemodynamic, and muscle functions during early rehabilitation are clear, it is essential to continue with lifelong exercise training as these benefits are all but lost within 3 months of training cessation (Onishi et al., 2010).

During the program, physiotherapists should initially and continuously monitor and evaluate patients in order to ensure their safety and effectiveness of exercise. The monitoring level is based on individual's needs. Physiotherapists can monitor patients' exercise intensity using a combination of: heart rate response, blood pressure response, rate pressure product, RPE, observation and oxygen saturation levels. Moderate physical activity most of the days with a duration of 30 minutes is beneficial and may alter the CVD risk factors. However, continuous exercise (CE) may be very challenging for a patient with CHD, therefore, it is advisable to include "recovery" stations into the exercise program (Themistocleous et al., 2017).

Novel findings and significance of the topic

Given the ongoing prevalence of postoperative morbidity and mortality, especially those attributed to the PPCs after elective cardiac surgery, it appears that standardization of the postoperative physiotherapy alone is not sufficient to preclude, or even minimize, the PPCs and the irrelated morbidity and mortality.

Despite the well-documented importance of postoperative physiotherapy, little is established on the value of preoperative intervention in patients undergoing cardiac surgery. Very limited studies have been published investigating the potential effects of preoperative physiotherapy on the cardiorespiratory and musculoskeletal traits after CABG surgery. The preoperative techniques have the main goal for mitigating the potential PPCs after heart surgery. In turn, such techniques could reduce the mortality among those patients.

Thus, in this work, we performed a clinical trial and conducted a systematic review and meta-analysis in an attempt to obtain any evidence derived suggesting potential benefits that could aid in the prophylaxis against the development PPCs.

The previously conducted pooled analyses either evaluated the effect of the preoperative intervention on patients undergoing any type of major surgery, or did not specify chest physiotherapy as the intervention procedure. Hence, we believe that, in

order to fill this gap in the postoperative care and in the literature, a meta-analysis regarding the original articles addressing such issues is required.

Aim of the Work

The overall aim of this study was to assess the importance of applying preoperative chest physiotherapy on patients undergoing open heart surgery.

Aim 1:

Does Preoperative Chest Physiotherapy Affect the Postoperative Pulmonary Complications and Lung Functions in Patients undergoing Elective Cardiac Surgery? A Systematic Review and Meta-Analysis

- We aimed to assess the value of preoperative chest physiotherapy in patients undergoing elective cardiac surgeries through reviewing and meta-analyzing the articles investigating this issue.

Aim 2

The Effect of Preoperative Chest Physiotherapy on Oxygenation and Lung Functions among Open Heart Surgery Patients: A Randomized Controlled Trial.

- We aimed to investigate the role of preoperative chest physiotherapy on pulmonary functions and the length of staying at the hospital among patients undergoing open heart surgeries.

Aim 3

The preoperative chest physiotherapy and the amount of oxygen needed after CABG surgery: A randomized controlled trial

- We aimed to assess the relationship between the preoperative chest physiotherapy and participants' characteristics with the average O_2 supplementation needed for CABG patients.

Aim 4

The effect of cold application on pain due to chest tube removal

- We aimed to examine the effect of cold application on pain intensity during chest tube removal

Chapter 2: Study 1

Effectiveness of Preoperative Chest Physiotherapy in Patients Undergoing Elective Cardiac Surgery, a Systematic Review and Meta-Analysis

Methods

Study design

This is a systematic review and meta-analysis that was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement. The review was registered in the Research Registry (reviewregistry1278).

Literature Search Strategy

The included studies were those evaluating the preoperative chest physiotherapy value in adult patients who undergo elective cardiac surgery. The search was performed using the electronic resources; the Cochrane Central Register of Controlled Trials, the PubMed central database, and Embase.

Selection Strategy and Criteria

The search was conducted with the restriction limiting results to original articles published from January 2000 to December 2021. The search was performed using the following keywords: “preoperative care” OR “preoperative” OR “preoperational” OR “pre-habilitation” OR “pre-habilitation” OR “before operation” OR “ before surgery” AND “coronary artery disease” OR “CAD” AND “chest” OR “respiratory” OR “lung” OR “pulmonary” AND “physiotherapy” OR “physical therapy” OR “muscular training” OR “muscle training” OR “muscle exercise” OR “muscular exercise” OR “muscle strength” AND “cardiac surgery” OR “open cardiac surgery” OR “open heart surgery” OR “heart surgery” OR “coronary artery bypass graft” OR “coronary artery bypass grafting” OR “CABG” AND “postoperative” OR “following operation” OR “after” OR “after cardiac operation” AND “pulmonary complications” OR “lung complications” OR “lung impairment” OR “respiratory failure” OR “respiratory impairment” OR “impaired respiratory functions” OR “impaired lung functions.” The

search was performed by two independent reviewers (the first and second authors). Then articles were matched and screened to ensure eligibility.

Inclusion Criteria

Original articles available in English were included. According to PICO, we included the studies meeting the following criteria: study design—all original articles that included randomized controlled trials or observational studies from 2000 until conducting the analysis (mid-2021), participants—patients undergoing elective cardiac surgery, intervention—preoperative chest physiotherapy, control—patients undergoing elective cardiac surgery without preoperative chest physiotherapy, outcome measures—the effect of intervention on PPCs and any other effect.

Exclusion Criteria

Animal studies, studies completed prior to the year 2000, commentaries, or general discussion papers whose authors did not present original data were excluded. Studies assessing physiotherapy regimens other than chest physiotherapy and those applying postoperative physiotherapy programs other than the routine therapies were also excluded.

Data Extraction, Data Collection, and Analysis

Each article was read carefully and any relevant data were extracted (including the study setting, design, research questions, sample size, patients' demographic data, medical history, baseline preoperative data, type and details regarding the intervention, description of the intervention; type, time, duration, rate, and the used device, lung function tests, muscle strength, operative events, length of hospital stay, the occurrence of postoperative pulmonary complications, and the study conclusions). The extracted data were registered, tabulated, and analyzed.

Bias

Methodological quality check lists were used as tools for bias risk assessment. The included studies were assessed for potential bias using the Cochrane Collaboration's tool for assessing the risk of bias.

Summary Measures

The primary outcomes were the incidence of postoperative complications and the changes in the lung function parameters, and the secondary outcomes were the surgery duration, the length of stay in the ICU and hospital, and the time of mechanical ventilation.

The assessed lung function parameters were:

- FEV1% $_{\text{predicted}}$: forced expiratory volume (FEV1%) of the patient divided by the average FEV1%.
- FVC% $_{\text{predicted:}}$ forced vital capacity (FVC%) of the patient divided by average FVC%.
- Pi-max: maximum inspiratory pressure.

Data about the ongoing RCTs related to the study topic was evaluated and described in the Discussion section.

Statistical Analysis

The retrieved data were presented as mean and standard deviation (SD) for numerical data, and frequency and percentage for categorical data. The meta-analysis and bias assessment were accomplished using the Review Manager software (RevMan version 5.4, the Cochrane Collaboration, London, UK). The choice of this software was based on established validity by Cochrane Collaboration. Review Manager (RevMan) is Cochrane's software for preparing and maintaining Cochrane reviews. RevMan Web has been designed to integrate with other systematic review software and new features and updates are added regularly (Revman, 2022). https://training.cochrane.org/online-learning/core-software/revman

Dichotomous data were expressed as a risk ratio, with 95% confidence intervals (CIs) to compare intervention and control groups at the study level. For continuous outcomes, the mean differences in effects between the intervention and control groups were computed at the study level and pooled into weighted mean differences (WMDs).

Results

The search of the electronic resources first yielded a total of 24,106 records.

After duplication adjustment, the search provided 1123 results. Based on the title, 898 publications were excluded. Then, after checking abstracts, another 199 publications were found not to meet the eligibility criteria, so they were further excluded. After checking the full texts, an additional 16 articles were excluded. Thus, 10 studies were finally eligible for this systematic review (Figure 1).

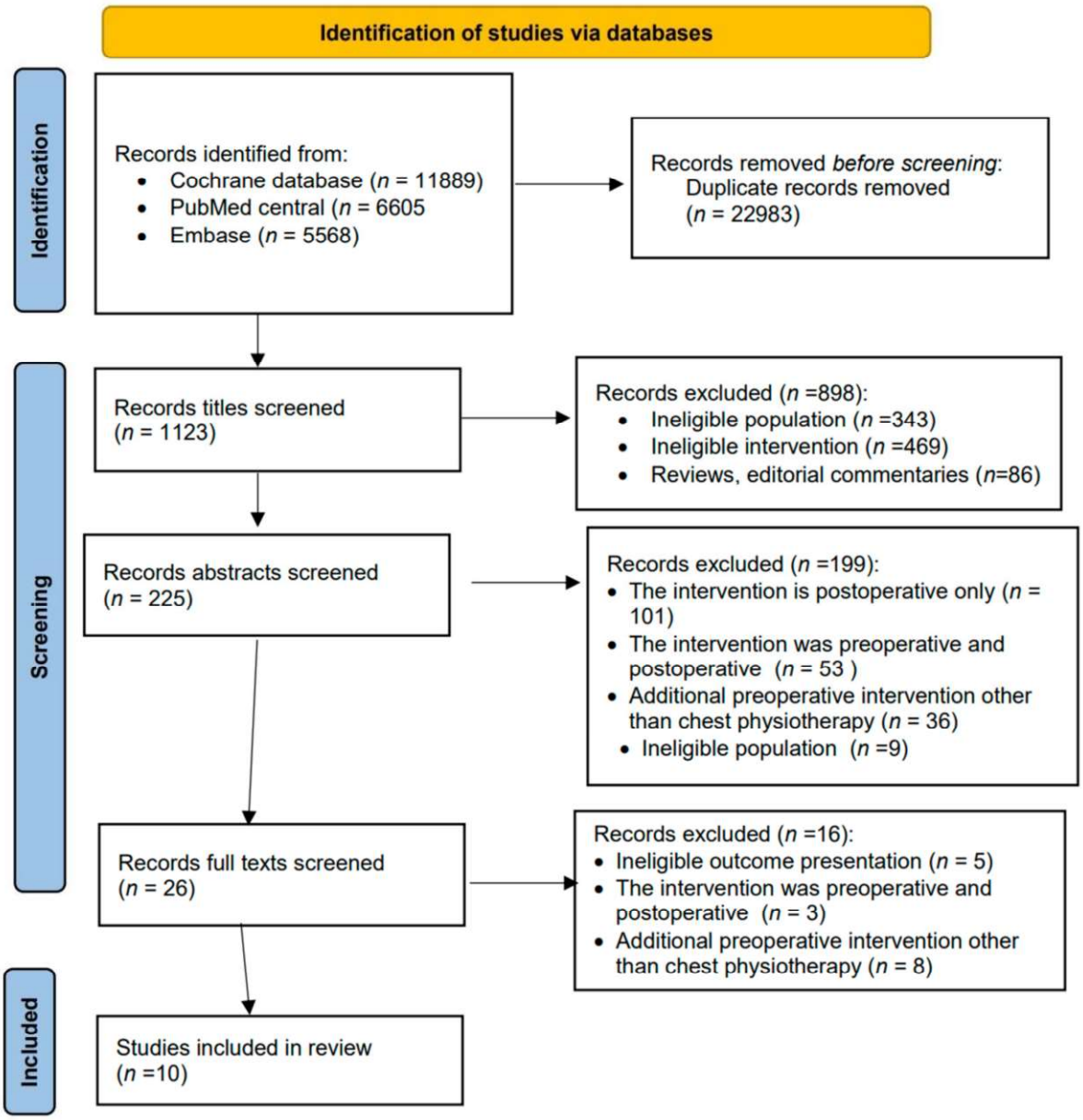

Figure 1: PRISMA study selection flow chart.

The included articles were published from 2006 to 2019. The populations were patients scheduled for elective CABG/cardiac surgery in the Netherlands, Turkey, Taiwan, Iran, Brazil, Pakistan, and China (Table 1).

Table 1: The included studies, the place of their performance, design and the objected patients

Study	Study place	Study design	Objected patients
Hulzebos et al., 2006 a	Netherland	RCT	Patients planned for elective CABG
Hulzebos et al., 2006 b	Netherland	RC pilot study	Patients planned for elective CABG, with high risk to develop PPCs.
Savci et al., 2011	Turkey	RCT	Patients planned for elective CABG
Tung et al., 2012	Taiwan	RC pilot study	Patients planned for open cardiac surgery
Vakenet et al., 2013	Netherlands	Observational cohort study	Patients planned for elective CABG, with high risk to develop PPCs
Sobrinho et al., 2014	Brazil	RCT	Patients planned for elective CABG
Shakuri et al., 2015	Iran	RCT	Patients planned for open cardiac surgery
Fayyaz et al., 2016	Pakistan	RCT	Patients planned for elective CABG
Vakenet et al., 2017	Netherlands	2ry analyses of RCT.	Patients planned for elective CABG
Chen et al., 2019	China	RC pilot study	Patients planned for open cardiac surgery.

The included studies had a total population number of 1458. They were classified into two groups: the interventional (I) group, involving 651 patients, and the control (C) group involving, 807 patients. Five studies investigated a sample size of <100 (Hulzebos et al., 2006 b, Savci et al., 2011, Tung et al., 2012, Sobrinho et al., 2014, Shakuri et al., 2015), and the others investigated a sample size of >100 (Hulzebos et al., 2006 a, Vakenet et al., 2013, Fayyaz et al., 2016Vakenet et al., 2017, Chen et al., 2019).

All patients were adults, with a mean age of 60.36 ± 12.78. Male predominance was noted, as 1019 (69.9%) patients were males, while only 439 patients were females. This dominance was noted in the majority of studies, with only one study reported an equal contribution of both genders (Hulzebos et al., 2006 b) (Table 2).

Table 2: A summary of the sociodemographic data included in the studies.

Study	N (total: I-C)	Mean age (I - C)	Male % (I – C)
Hulzebos et al., 2006 a	276: 139-137	66.5 – 67.3	77.7 - 78.1
Hulzebos et al., 2006 b	26: 14-12	70.14 – 70.5	50 - 50
Savci et al., 2011	43: 22-21	62.82 – 57.48	86.4 – 90.5
Tung et al., 2012	35: 15-20	52.5 – 54.7	93.3 - 70
Vakenet et al., 2013	346: 94-252	66.8 – 68.4	61.7 - 68.3
Sobrinho et al., 2014	70: 35-35	58.9 – 61.4	65.7 – 82.9
Shakuri et al., 2015	60: 30-30	54.4 – 59.3	63.3 - 66.1
Fayyaz et al., 2016	170: 85-85	39.44 - 39.33	--
Vakenet et al., 2017	235: 119-116	66 – 67.5	78.2- 80.2
Chen et al., 2019	197: 98-99	61.86 – 61.86	74.5 – 68.7
Total	1458:651-807	60.36	69.9

The percentages of smokers ranged from 25% to 70% in the review studies, BMI ranged from 25.66 to more than 30, and the comorbidities were mainly diabetes mellitus, hypertension, and hyperlipidemia. Both groups in all studies were matched according to the prevalence of risk factors and the comorbidities (Table 3).

Table 3: The studies patients risk factors and comorbidities

Study	Smoking % (I - C)	BMI mean (I - C)	Comorbidity % (I – C)
Hulzebos et al., 2006 a	32.4 - 38	28.3 – 28.1	HTN: 57 – 54.5 DM: 43.9 – 32.8 COPD: 19.4 – 21.9 Hyperlipidemia: 25.9 - 26.3
Hulzebos et al., 2006 b	29 - 25	26.13 - 28.32	DM: 14 – 25 COPD: 43-17
Savci et al., 2011	70.95 - 71.62	27.49 - 25.73	HTN, DM, hyperlipidemia, alcohol consumption, inactivity, and family history
Tung et al., 2012	60 -70	27.8 - 26.3	<3: 86.7 – 80 >3: 13.3 - 20
Vakenet et al., 2013	--	≥30 (%):27.7 -27.8	DM: 34 – 57.1
Sobrinho et al., 2014	67 - 67	27.08 - 26	--
Shakuri et al., 2015	30 - 33.3	26.8 - 27.7	DM: 36.7 - 26.6
Fayyaz et al., 2016	--	28.36- 26.20	--
Vakenet et al., 2017	34.5 - 36.2	28.6 - 28.1	HTN: 58.8 – 44 DM: 42.9 – 30.2
Chen et al., 2019	44.9 - 37.4	26.07 - 25.66	DM: 25.5 - 27.3

			HTN: 56.1 - 67.7 Hyperlipidemia: 5.1 - 3.0

Concerning the type of preoperative intervention in the included studies, some used respiratory training protocols, with an incentive spirometer (Shakuri et al., 2015; Fayyaz et al., 2016; Tung et al., 2012), one study combined incentive spirometer with a threshold loading device (Valkenet et al., 2017), and others used threshold loading devices for chest physiotherapy (Hulzebos 2006a; Hulzebos et al., 2006b; Savci et al., 2011; Vakenet et al., 2013, Sobrinho et al., 2014, Chen et al., 2019) (Table 4).

The time frame for preoperative intervention application differed considerably among the included studies, ranging from 5 days to 10weeks. The frequency of performing the interventional program ranged from twice a day (Chen et al., 2019), to three times every two weeks (Tung et al., 2012). The duration of training sessions ranged from 20 (Hulzebos et al., 2006 a; Hulzebos et al., 2006 b; Vakenet et al., 2013; Chen et al., 2019) to 60 min (Tung et al., 2012) (Table 4).

Table 4: The type and description of intervention in the included studies

Study	**Preoperative intervention**	**Time frame / frequency**	**Session duration**	**Used tool**
Hulzebos et al., 2006 a	IMT; incentive spirometry, once a week with supervision by a physical therapist.	2 – 10 weeks / daily	20 minutes	Threshold - IMT®
Hulzebos et al., 2006 b	IMT; incentive spirometry, once a week with supervision by a physical therapist.	2 - 4 weeks / daily	20 minutes	Threshold - IMT®
Savci et al., 2011	IMT under the supervision of a physical therapist.	5 days /daily	30 minutes	Threshold IMT, Respironics, Pittsburg, PA, USA).
Tung et al., 2012	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.	2 weeks / once or twice a weak (3 times)	40–60 min	Cycle ergometer, spirometer, SF-36

Vakenet et al., 2013	Unsupervised IMT program at home	2 weeks / daily	20 min/day	Threshold IMT, Respironics, New Jersey, PA, USA).
Sobrinho et al., 2014	Breathing exercises	Daily till surgery, once a day	Not specified	Threshold - IMT®
Shakuri et al., 2015	Exercises and auxiliary activities for extension and rotation of thoracic vertebrae, breathing exercises, exercises to expand lung lobes, aerobic exercises at a constant low speed for all the patients.		25 minutes	flow-incentive spirometer-based (Respiflow™ FS)
Fayyaz et al., 2016	Incentive spirometry	--	--	--
Vakenet et al., 2017	IMT; incentive spirometry; education.	2 weeks / daily		
Chen et al., 2019	IMT.	5 days / twice a day	20 minutes	Threshold IMT device (HS730-010; Philips Respironics, Pittsburgh, PA, USA).

Preoperatively, the control groups underwent the usual management (Hulzebos et al., 2006a; Hulzebos et al., 2006b; Tung et al., 2012; Sobrinho et al., 2014; Valkenet et al., 2013), or usual management in addition to 1 day of chest physiotherapy (Valkenet et al., 2017), limbs and trunk mobilization (Savci et al., 2011), or abdominal breathing training (Chen et al., 2019) (Table 5).

Postoperatively, both groups received chest physiotherapy and mobilization schemes Hulzebos et al., 2006 a; Hulzebos et al., 2006b; Tung et al., 2012; Vakenet et al., 2013; Shakuri et al., 2015; Vakenet et al., 2017), or physiotherapy, as required (Sobrinho et al., 2014) (Table 5).

Table 5: The preoperative procedure in the control group and the postoperative in both groups

Study	Preoperative control group management	Postoperative both groups management
Hulzebos et al., 2006 a	Care as usual the day before surgery (ie, instruction on deep breathing maneuvers, coughing, and early mobilization).	Incentive spirometry, chest physical therapy, and mobilization scheme after operation.
Hulzebos et al., 2006 b	Care as usual the day before surgery (ie, instruction on deep breathing maneuvers, coughing, and early mobilization).	Incentive spirometry, chest physical therapy, and mobilization scheme after operation.
Savci et al., 2011	Mobilization, active exercises of upper and lower limbs, chest physiotherapy.	Chest physical therapy, and mobilization scheme after operation.
Tung et al., 2012	Care as usual the day before surgery (ie, instruction on deep breathing maneuvers, coughing, and early mobilization).	Incentive spirometry, chest physical therapy, and mobilization scheme after operation.
Vakenet et al., 2013	Received usual care (no IMT)	Incentive spirometry, chest physical therapy, and mobilization scheme after operation.
Sobrinho et al., 2014	Only guidelines ward routine before surgery	Physical therapy as needed by staff physiotherapy service.
Shakuri et al., 2015	--	Incentive spirometry, chest physical therapy, and mobilization scheme after operation.
Fayyaz et al., 2016	--	--
Vakenet et al., 2017	Care as usual the day before surgery (ie, instruction on deep breathing maneuvers, coughing, and early mobilization).	Incentive spirometry, chest physical therapy, and mobilization scheme after operation.
Chen et al., 2019	Both groups received both usual care (i.e. education, coughing and early mobilization) and abdominal breathing training before the surgery.	Chest physical therapy, and mobilization scheme after operation.

Regarding studies outcomes, the primary outcome was occurrence of postoperative pulmonary complications (PPCs) in the study of Hulzebos et al., 2006 a, Tung et al., 2012, Vakenet et al., 2013, and Chen et al., 2019, the occurrence of adverse

events, and patient satisfaction and motivation in the study of Hulzebos et al., 2006 b, the inspiratory muscle strength in the studies of Savci et al., 2011 and Sobrinho et al., 2014, spirometry parameters in the study of Shakuri et al., 2015, postoperative oxygenation in the study of Fayyaz et al., 2016 and quality of life assessment in the study of Vakenet et al., 2017. The postoperative stay length was the secondary outcome in 5 studies (Hulzebos et al., 2006 a; Hulzebos et al., 2006 b; Vakenet et al., 2013; Sobrinho et al., 2014; Chen et al., 2019) (Table 6).

Table 6: The included studies outcomes

Study	**Outcome measure**
Hulzebos et al., 2006 a	• The primary outcome: the incidence of PPCs, • The secondary outcome was duration of postoperative hospitalization.
Hulzebos et al., 2006 b	• Primary outcome variables were the occurrence of adverse events, and patient satisfaction and motivation. • Secondary outcome variables were postoperative pulmonary complications and length of hospital stay.
Savci et al., 2011	• Inspiratory muscle strength (cmH2O). • Quality of life was assessed using the Nottingham Health Profile. • Anxiety and depression were measured using the Hospital Anxiety and Depression Scale (HADS).
Tung et al., 2012	• Pulmonary complication-related parameters. • Quality of life assessment using Short Form 36-Health Survey (SF-36).
Vakenet et al., 2013	• The primary outcome measure: postoperative pneumonia. • The secondary outcome measures: ventilation time, postoperative length of stay (LOS) at the intensive care unit (ICU) and total LOS.
Sobrinho et al., 2014	• The respiratory muscle strength. • Pulmonary volumes. • Duration of hospital stay after surgery.
Shakuri et al., 2015	• Spirometry parameters. • ABG parameters.
Fayyaz et al., 2016	• Postoperative oxygenation.
Vakenet et al., 2017	• Quality of life assessment using Short Form 36-Health Survey (SF-36).
Chen et al., 2019	• The primary outcome variable was the occurrence of postoperative pulmonary complications. • The secondary outcome variables were inspiratory muscle strength, lung function and length of hospitalization.

In all studies, the basic preoperative pulmonary functions, respiratory muscle test parameters, and ABGs were comparable in the two groups.

The pooled analysis revealed no significant differences between the interventional and control groups in the surgery time (Figure 2) and the ICU duration (Figure 3) ($p = 0.84$ and 0.92, respectively), with no heterogeneity in the results ($p = 0.06$ and 0.62, respectively).

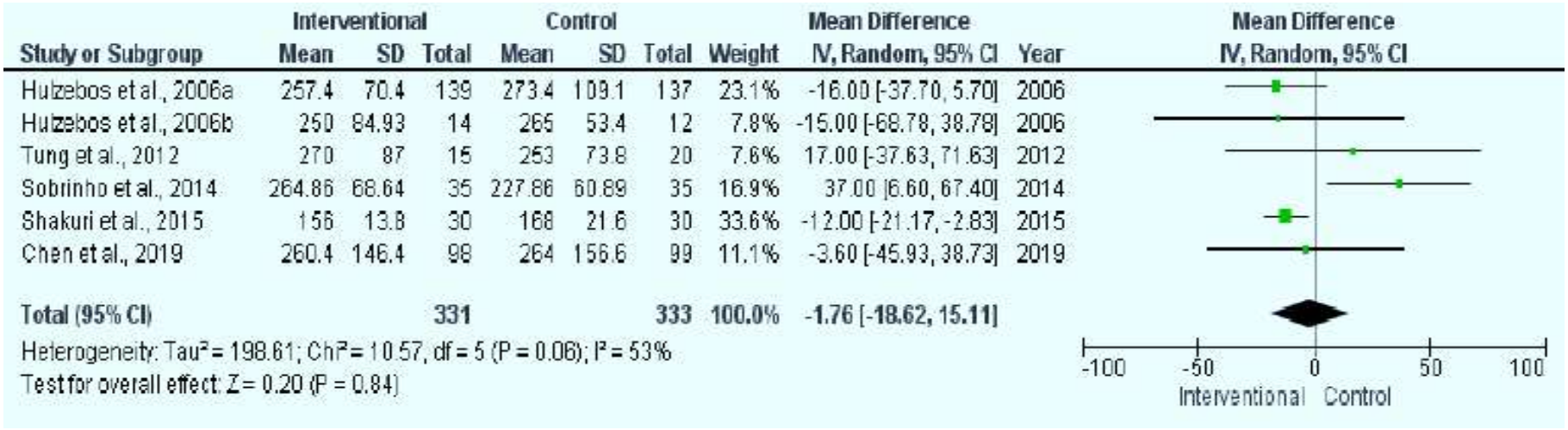

Figure 2: Forest plot evaluating surgery time in the included studies.

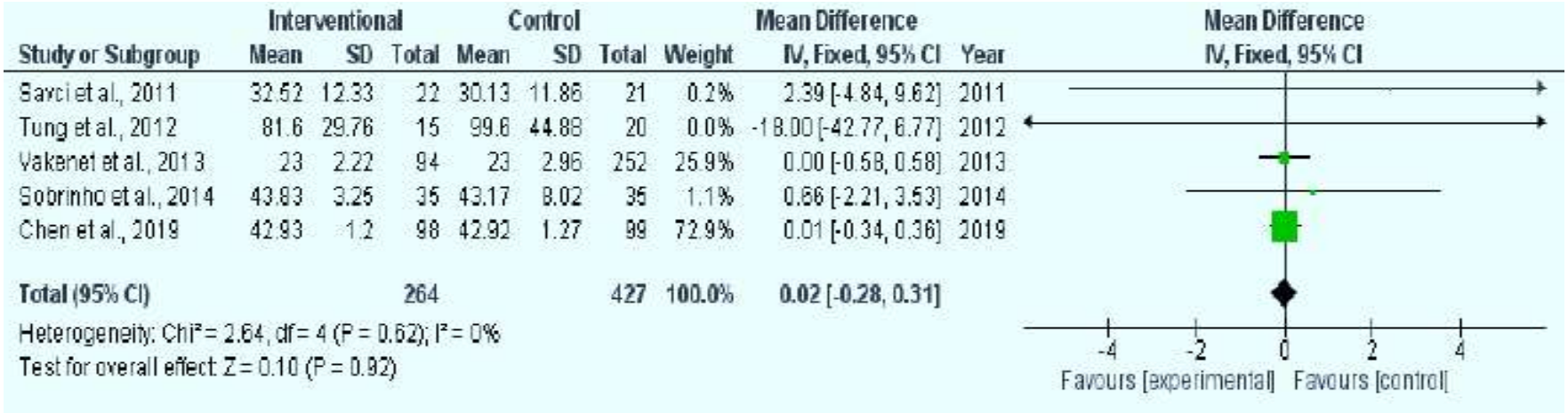

Figure 3: Forest plot evaluating ICU duration stay in the included studies.

There were significant differences between the intervention and control groups in the duration of mechanical ventilation (Figure 4) and the length of hospital stay (Figure 5) ($p < 0.001$), favoring the interventional group. The pooled mean differences between groups were 0.76 h and 1.02 days, respectively. The absence of heterogeneity in the meta-analyses of the length of hospital stay ($p = 0.1$) grants credibility to the results.

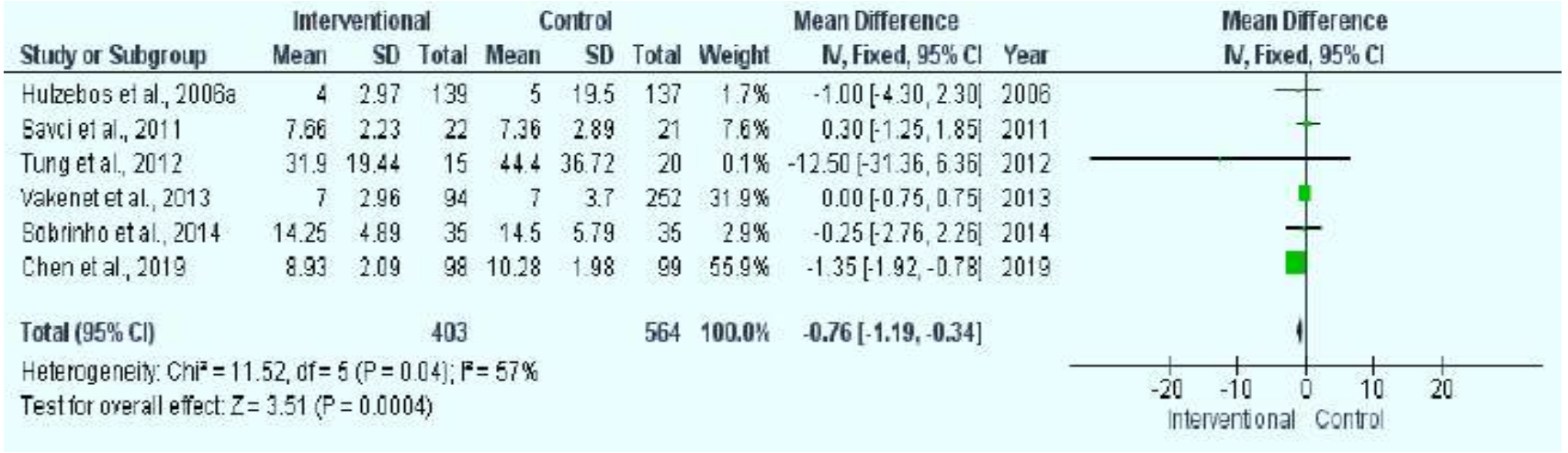

Figure 4: Forest plot evaluating mechanical ventilation duration in the included studies.

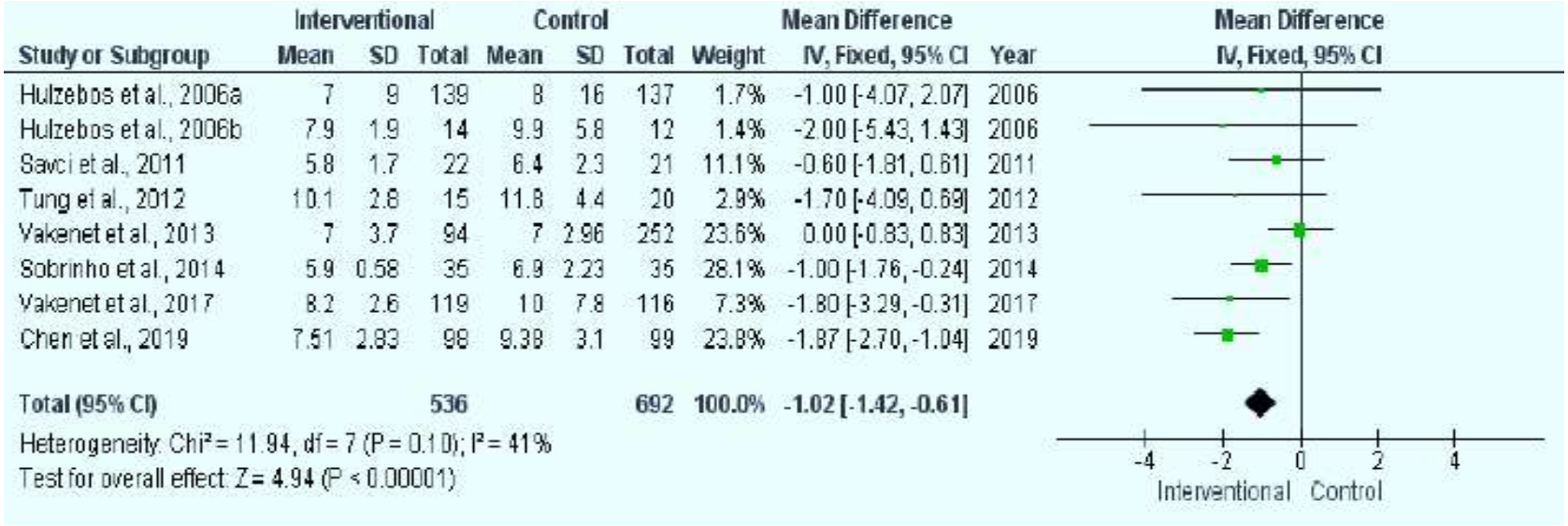

Figure 5: Forest plot evaluating hospital stay length in the included studies.

The meta-analyses revealed significant differences between the interventional and control groups in the FEV1% predicted (Figure 6), FVC% predicted (Figure 7), and Pi-max (Figure 8) ($p < 0.05$), favoring the interventional group. The pooled mean differences were 3.7%, 10.17%, and 17.25 cm H2O, respectively.

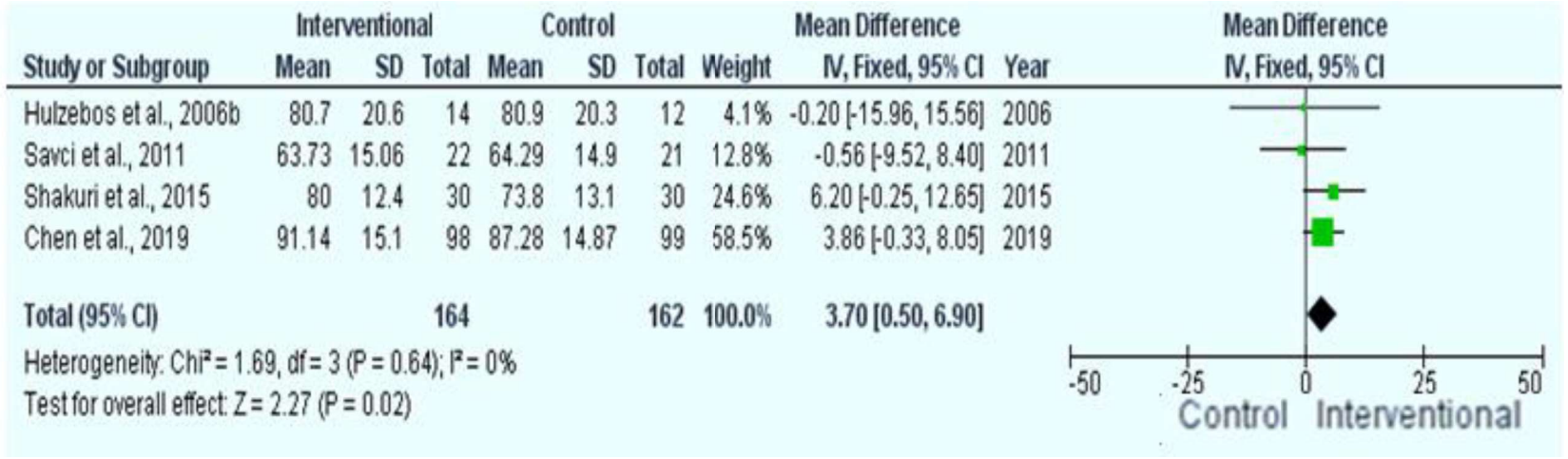

Figure 6: Forest plot evaluating FEV1% $_{predicted}$ in the included studies.

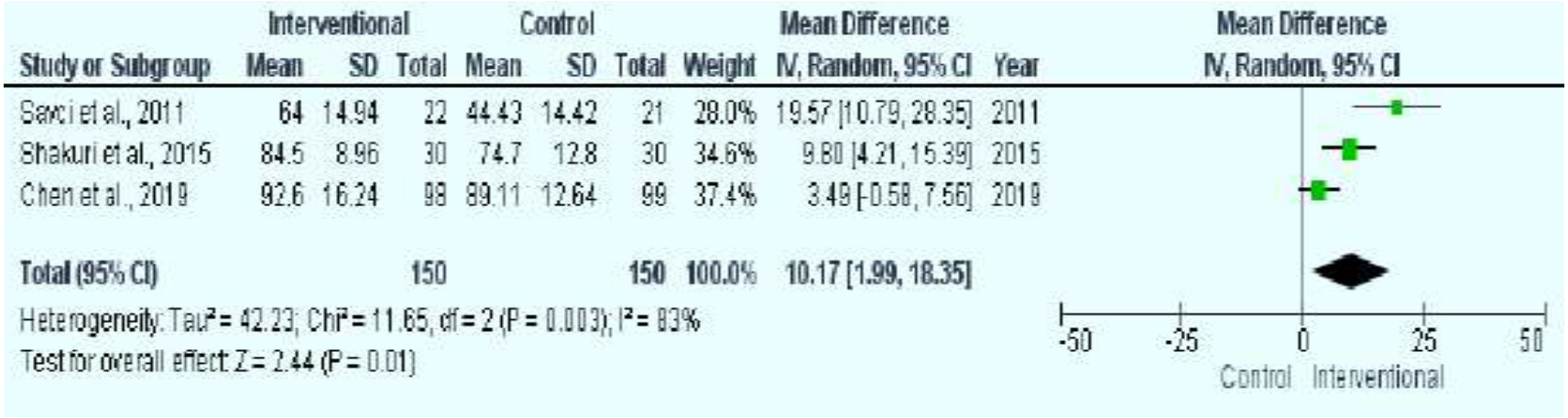

Figure 7: Forest plot evaluating FVC% $_{predicted}$ in the included studies.

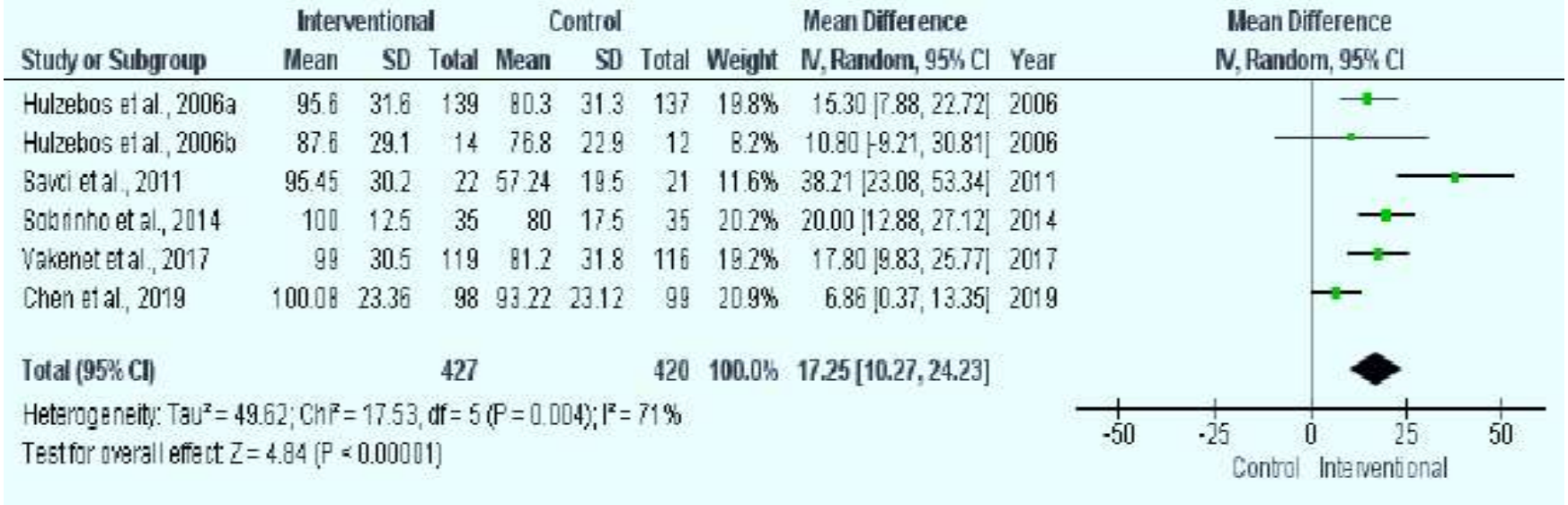

Figure 8: Forest plot evaluating Pi-max in the included studies.

The PPCs meta-analysis demonstrated that the intervention had a protective effect on the occurrence of PPCs. The pooled risk ratio was shown to be 47%, with a 95%CI of 36–62%. The overlap between a part of the CI that was shown in the pooled estimates reflected the absence of statistical heterogeneity (I2 = 0%, p = 0.73) (Figure 9).

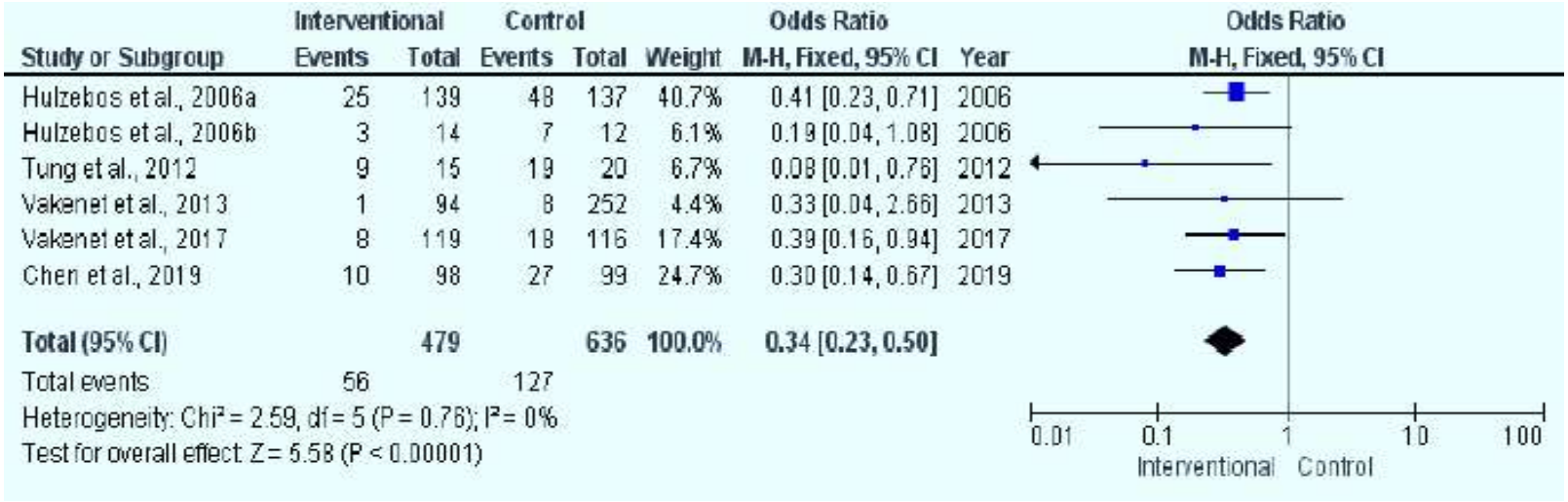

Figure 9: Forest plot evaluating PPCs in the included studies.

A funnel plot was constructed (Figure 10), revealing the symmetry in results, as all the involved studies lay within the confidence interval, with a rather symmetric pattern, ensuring the absence of heterogeneity in the results.

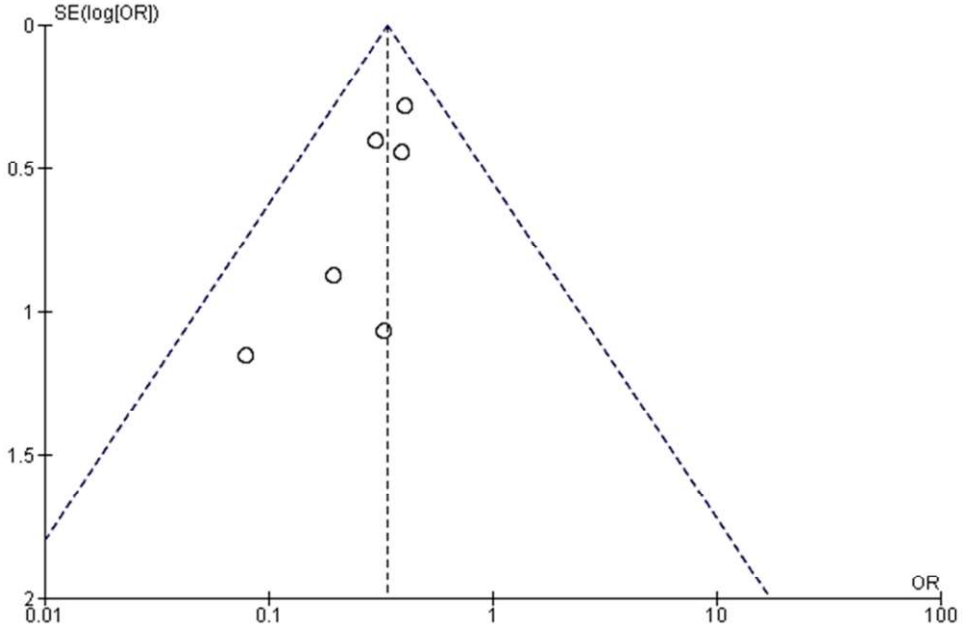

Figure 10: Funnel plot for the PPCs incidences reported by the studies.

Regarding the QoL results in this systematic review, 3 of the 10 included studies introduced at least one QoL parameter, with different scales used by the authors. Vakenet et al. (2017) demonstrated that Qol differences were less in the interventional group compared to the control group, yet with non-statistical significance ($p > 0.05$); the work of Savci et al. (2011) also failed to reveal a statistically significant difference between both groups in the assessed physical component of QoL ($p > 0.05$). In contrast, Tung et al. (2012) noticed an intervention-related significant improvement in the general QoL ($p < 0.001$). Anxiety and depression were evaluated in the study of Savci et al. (2011), which showed that their expressions were lower in the intervention group. However, this difference was significant only in the anxiety component ($p < 0.05$).

A summary of the study outcomes is demonstrated in Table 7.

Table 7: The outcomes summary of the included studies.

Study	Outcome Measure
Hulzebos et al., 2006a	The primary outcome: a statistically significant difference was found between the two groups in the incidence of PPCs ($p = 0.02$). The secondary outcome: a statistically significant difference was found between the two groups in the LOS ($p = 0.02$).
Hulzebos et al., 2006b	Primary outcome: the feasibility of the intervention was good. No adverse events were reported. A statistically significant difference was found between the two groups in the satisfaction scores and the muscle strength. Secondary outcome: a statistically significant difference was found between the two groups in the incidence of PPCs, but not in the LOS ($p = 0.24$)
Savci et al., 2011	Statistically significant difference was found between the two groups in the MIT, the improvement in QoL, and the anxiety score of HADS.
Tung et al., 2012	Significant reduction in the non-invasive ventilator ($p = 0.012$), the time to ambulance, and the PPCs, and better general health scores were shown in the intervention group
Vakenet et al., 2013	Statistically significant difference was found between the two groups in the incidence of PPCs, but not in the LOS
Sobrinho et al., 2014	Statistically significant difference was found between the two groups in the MIT and LOS.
Shakuri et al., 2015	Significant changes in predicted FVC, PEF, and PCO2 concentration in the interventional group compared to the control group.
Fayyaz et al., 2016	Significant postoperative improvement of PO2 and PCO2 in the interventional group compared to the control group.
Vakenet et al., 2017	No significant differences in change of QoL scores over time were found between the intervention and control groups.
Chen et al., 2019	Statistically significant difference was found between the two groups in the incidence of PPCs, the MIT, and LOS.

PPCs: postoperative pulmonary complications; LOS: length of stay; QoL: quality of life; HADS: Hospital Anxiety and Depression Scale.

When examining the conclusions reached by the included studies, there was unanimous agreement on the importance and significance of preoperative chest physiotherapy in patients undergoing elective cardiac surgery.

The critical assessment graph and a summary of the risks of bias within each study are shown in Figure 11 and Figure 12. The study by Fayyaz et al., 2016 shows a number of shortcomings, some shortcomings were also shown in the other studies. However, this is not peculiar during meta-analysis of original articles, and was shown by almost all the published meta-analysis studies.

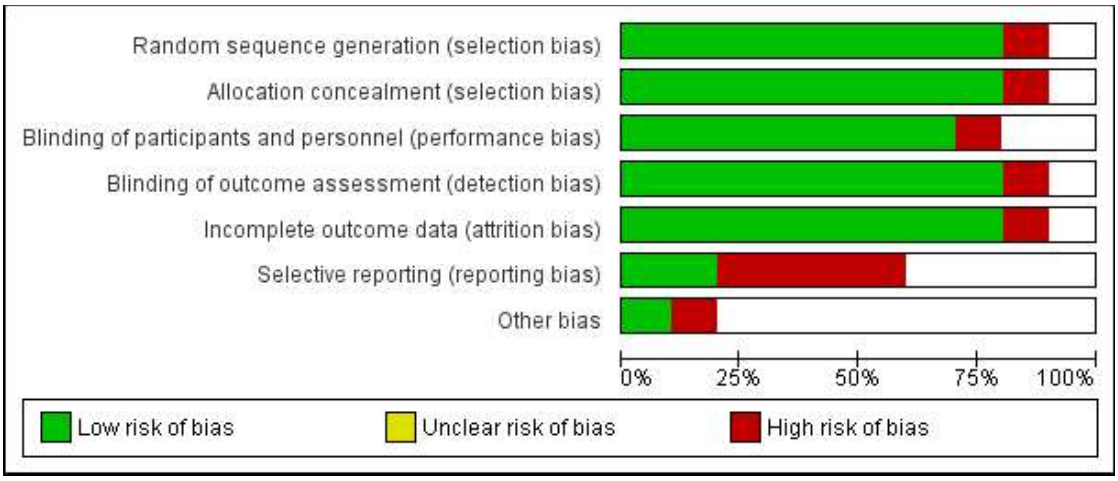

Figure 11: Risk of bias graph of the included studies.

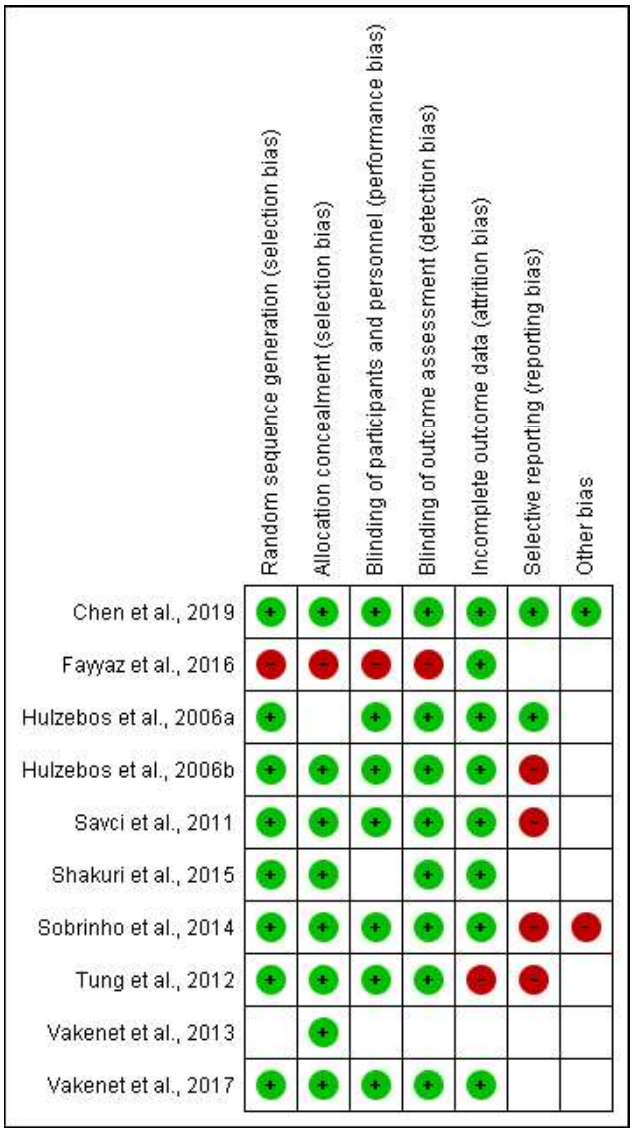

Figure 12: Risk of bias summary of the included studies.

Discussion

The studies included in this review explored variable methods for preoperative chest physiotherapy. Several strategies are created to intervene in an attempt to prevent PPC development. Interventions may be preoperative, to adjust the physiology of respiration, or intraoperative and postoperative, to minimize the adverse events of surgery and anesthesia (Shander et al., 2011). Despite this, there are no established guidelines for preoperative protocols of management. Even if they are present, they are outdated or infrequent (Fleisher et al., 2014). This lack of consensus leads to considerable variation in clinical practice (Odor et al., 2020).

The current study pooled analysis demonstrated that there was no effect of the intervention on the surgery time or the ICU stay duration, while it favorably affected the mechanical ventilation and the length of hospital stay.

The association of preoperative chest physiotherapy with shorter hospital stay was also documented in previous studies (Kundra et al., 2010; Melnyk et al., 2011). Nardi et al. (2019) observed that the length of the postoperative hospital stay in the group that had preoperative training was reduced compared to the control group, but without a statistically significant difference.

The short hospital stay affords the patients the chance to continue the recovery in their familiar home environment, saving the hospital resources for new patients to receive health care services (Santa-Mina et al., 2014; Gomes-Neto et al., 2016).

In contrast with the findings of our study, the previous meta-analyses did not reveal a significant difference between the interventional and control groups in the mechanical ventilation time (Marmelo et al., 2018; Katsura et al., 2015; Hulzebos et al., 2012). However, we can state that the significant difference found in our study could be a quasi-significance, due to the heterogeneity found in the results.

The meta-analysis of this study showed that there was a significant difference between the interventional and control groups in the pulmonary functions, including FEV1% predicted, FVC% predicted, and Pi-max, favoring the interventional group.

However, only the FEV1%predicted showed homogenous results.

The Pi-max was the most commonly tested lung function parameter in the included studies. Pi-max reflects the inspiratory muscles' functional capacity and has been adopted as a reliable indicator for the weaning from mechanical ventilation in many hospitals (Passarelli et al., 2011). In our meta-analysis, the evidence of the intervention's improving effect was weak. Within the same context, in the meta-analysis conducted by Marmelo et al. (2018), the authors found significant improvement of the Pi-max related to the intervention. On the other hand, Katsura et al. (2015) reported no statistically significant effect in a three-articles meta-analysis, in spite of the fact that a tendency toward a favoring effect was found in all three articles.

The current meta-analysis revealed that intervention proved to be protective against the existence of PPCs. Consistent with our findings, the recent meta-analysis conducted by Odor et al. (2020) disclosed evidence of the prophylactic effect of preoperative physiotherapy against the occurrence of PPCs. Our findings were also congruent with the most recent meta-analysis conducted by Rodrigues et al. (2021), which demonstrated that preoperative chest physiotherapy (breathing interventions) helped to improve postoperative respiratory performance in patients undergoing cardiac surgery. Moreover, the authors concluded that such interventions reduced PPCs and the length of hospital stay. Other previous studies affirmed the effect of preoperative intervention on PPCs. This was investigated in patients who underwent oncologic thoracic surgeries (Garcia et al., 2016), cardiac Westerdahl et al., 2005; Marmelo et al., 2018), intra-abdominal (Moron et al., 2016), and cardiac and abdominal surgery (Katsura et al., 2015). In these meta-analyses, a total of 31 studies reported decreased PPCs in the interventional group, while only 8 did not find this relationship. The study of Kamarajah et al. (2019) highlighted that pre-habilitation improved rates of morbidity, including for PPCs, and overall complications after both major abdominal and cardiothoracic surgery.

The recently published work of our group showed supporting findings (Shahood et al., 2022). Our RCT demonstrated overall significant postoperative improvements in lung function and oxygen saturation in the intervention group

compared with the control group. An earlier RCT conducted by Sweity et al. (2021) to assess the effect of preoperative incentive spirometry was compatible with our findings, as the study showed a significant difference between the interventional and control groups in the incidence of postoperative atelectasis, mechanical ventilation duration, and hospital LOS. The median of the amount of arterial blood oxygen and oxygen saturation was significantly improved in the intervention group.

The QoL outcome exhibited heterogeneity in the measured scale and the obtained results. The variability in the used methods makes it difficult to obtain a consensus about the results (Pucci et al. 2012; Peric et al., 2016). The QoL variables' interpretation had to be considered in view of the individual results of the articles assessing this outcome, since we could not conduct a meta-analysis in view of the heterogeneity in the quantification scales. In this regard, Valkenet et al. (2017) reported that the intervention group showed less reduction in QoL values than the control group, but without a statistical significance. Savci et al. (2011) also failed to reveal a statistically significant difference between either groups in the assessed physical component of QoL, while Tung et al. (2012) proved a significant improvement in the general QoL.

The lack of evidence found in this review is in accordance with Marmelo et al. (2018), Katsura et al. (2015), and Santa-Mina et al. (2014), who reported similar findings. Hulzebos et al. (2012) actually found better QoL results in the control groups.

Anxiety and depression was evaluated in the study of Savci et al. (2011), which showed that anxiety and depression tendencies were lower in the intervention group than in the control group. However, this difference was significant only in the anxiety component. In congruence, an earlier study demonstrated that the patients who were preoperatively educated, with guidance on the physiotherapeutic ventilation training, exhibited reduced anxiety levels compared with those did not receive this guidance (Garbossa et al., 2009).

It is worth noting that all the included patients were those scheduled for CABG, except for those in the studies of Tung et al. (2012) and Chen et al. (2019),

which also included patients with valve surgeries. Both types of surgeries are open heart surgeries, with the indicated general anesthesia, median sternotomy incision, cardiopulmonary bypass, and mechanical ventilation. All of these are factors implicated in the predisposition to PPCs and hence, both types of surgeries were included in the analysis.

Working to prevent or reduce the incidence of pulmonary complications occurring in patients after heart surgery is a major goal among health workers. To achieve this goal, it is recommended to educate patients about how important is to learn the physical therapy techniques. These techniques could help improve the respiratory functions and promote the expansion of the lungs, identifying patients at high-risk for the development of pulmonary complications after surgery. In this vein, physical therapy is highly regarded among the basic treatments and should be offered to the patients in intensive care units. This study confirms the potential performance of a rehabilitation program before cardiac surgery, recommending its availability to all patients, if possible, in order to make the post-operative period less traumatic, and to facilitate a faster functional recovery.

Strengths and Limitations

This study is strengthened by including a meta-analysis in addition to the systematic review of the included studies. Moreover, the pooled analysis included a large number of patients, thus yielding a rather firm conclusion. This study is limited by the fact that one of the included ten studies was not an RCT. Moreover, due to the lack of assessment of certain variables in some studies, the highest number of studies included in a meta-analysis was in the hospital stay length (eight studies), and the other variables were analyzed in a fewer number of studies. Moreover, based on the selected publications, the resulting sample was not representative of the Organisation for Economic Co-operation and Development (OECD) countries with advanced health systems since Netherlands and Turkey were the only OCED countries, from where publications were included. The analysis was also limited by the variability in the length of the intervention since it varied between 5-10 weeks and 20-60 minutes per trial. However, this was expected in view that postoperative management is still not standardized among health facilities. We believe that such an

issue could not preclude the conduction of the analysis, and the obtained results could be a preliminary data that shed light on the importance of routine implementation of postoperative chest physiotherapy in patients undergoing cardiac surgery. Furthermore, despite receiving some preoperative and postoperative interventions by the control groups, they still can be considered control groups due to the homogeneity in these received interventions among the included studies. Some shortcomings of the included studies might have impact on the obtained results. However, this is inevitable during meta-analyses conduction. The data obtained can be considered as initial results until more inclusive RCTs are conducted involving a larger meta-analysis.

Conclusions

The current work concluded that preoperative chest physiotherapy can yield better outcomes in patients undergoing elective cardiac surgery.

The meta-analysis demonstrated no significant differences between the interventional and control groups in the surgery time and the ICU duration, but a significant difference in the time of mechanical ventilation and the hospital stay length, favoring the interventional group. A significant difference was shown in the FEV1% predicted, FVC% predicted, and Pi-max, favoring of the interventional group. The most notable significance was shown in the analysis of hospital stay length and the FEV1% predicted. The intervention was proved to be protective against the occurrence of PPCs.

Chapter 3: Study 2

The effect of preoperative chest physiotherapy on oxygenation and lung function in cardiac surgery patients: a randomized controlled study

Patients & Methods

Study design

This randomized controlled study was carried out in the cardiothoracic surgical department, intensive care unit and preoperative outpatient clinic of Pécs Clinical Centre, Heart Institute, Pécs, Hungary between April 2019 and October 2019. The study was approved by the Regional Ethical Committee of Clinical Research (4114. 316-474/KK15/2011). The study is reported according to CONSORT guidelines19 and the protocol was registered on ClinicalTrials.gov (NCT04665024).

Study population and sample size

Adult patients scheduled for open heart surgery were eligible for the study. Patients with a history of strokes, musculoskeletal disorders, or psychological disorders were excluded. The power of the study was estimated using G*Power 3.1.9.4, with a 95% confidence level (Z-score = 1.96), and a margin of error (confidence interval) of +/- 5%. According to the previous study performed by Manzano et al. (2008), the minimum required sample size, calculated based on an O^2 saturation estimated a mean difference of 2% (standard deviation of 1.9), was 20 participants in each group. Informed written consent was obtained from each patient.

Blinding and randomization

Eligible patients were randomly allocated to the intervention or control during their outpatient visit after being scheduled for cardiac surgery. The study was blinded by an independent hospital employee who prepared opaque sealed envelopes containing either number 1 (intervention group) or number 2 (control group). The patient then chose one of the opaque envelopes and was assigned to that group by the same employee.

Interventions

The intervention group underwent breathing exercises preoperatively after weaning from the ventilator, while the other group underwent the postoperative exercise only. Both were monitored for seven days after surgery. In the outpatient clinic, all patients received guidance on surgery and possible postoperative conditions. Patients in the intervention group received a standard educational paper about breathing exercise, written in an easily understandable language with pictures and shapes that describe the preoperative program elements (appendix). In the outpatient clinic, two experienced registered physical therapy specialists explained how to perform chest physiotherapy exercises, and trained patients on the breathing exercise. These two physiotherapists were well-trained on the intervention exercise protocol that was presented in a written form to ensure standardization of the introduced intervention. The breathing exercises were performed as demonstrated in appendix 1 with added training on using an incentive spirometer (Respiflo FS, https://www.oxygen-ium.gr/en/proionta/respiflo-fs-kendall-2/), and patients were instructed to perform breathing exercises for 30 minutes daily with 0.5 to 1 minute breaks. Each patient practiced the exercises for one week before surgery. The physiotherapists trained each patient three times: once on the first day, on the third day and one day prior to surgery. In both groups, patients underwent routine postoperative daily chest physiotherapy until discharge.

Anthropometric measurement of each subject was performed by trained nurses in the morning after fasting for at least 8 hours. Participants wore light clothing without shoes during collection of anthropometric data. Weight was measured in kg (to the nearest 100 grams) using an electronic digital scale and its accuracy was periodically verified using reference weights. Height was measured in cm (measured to the nearest mm) on scales with height, the subject standing with the back against the gauges and feet on the weighing platform. Weight and height were recorded. Body mass index (BMI) was calculated as kg/m^2.

Outcome measures

The primary outcome measures were differences between the groups in

respiratory function and oxygen saturation. Forced vital capacity (FVC), forced expiratory volume in the first second (FEV1%) and oxygen saturation (SpO_2) were measured in the outpatient clinic (first measurement), one day before surgery (second measurement) and for 7 consecutive days after surgery. Spirometry was performed using an Otthon 2.0 - Mobile Handheld Spirometer (https://www.healthcarehk.com/product/thor-2-0-mobile-handheld-spirometer/). Calibration check was used to regularly validate the calibration of the device, as required by the latest recommendations of the American Thoracic Society (ATS) and European Respiratory Society (ERS) for standardization of spirometry (Graham et al., 2019). The measurement was performed with the patient in a sitting position according to the ATS recommendations. The value recorded was the best of three consecutive attempts. Oxygen saturation was measured by pulse oximeter (FaceLake FL400 Pulse Oximeter, https://facelake.com/products/fl400-pulse-oximeter). The validity of measures was secured since the used device was created according to FDA standards (FDA 510(k) Number: K082641, suitable for use by medical professionals). The secondary outcome measure was the difference in the length of postoperative hospital stay between groups.

Statistical Analysis

Numerical values were tested for normality using Shapiro–Wilk test, which confirmed data normality, then accordingly, numerical data were presented as mean and standard deviation, while categorical data are presented as number and percentage. The chi-square test was used to compare the categorical data. The t test (unpaired) was used to compare differences in FVC, FEV1 and SPO_2. ANOVA was used to compare differences in repeated measures across the pre- and postoperative days using IBM SPSS version 22.0 program. $P \leq .05$ was chosen as the level of statistical significance.

Results

Of 122 patients enrolled, 12 patients were excluded based on eligibility criteria, leaving 110 patients in the study population; 55 in each group. Nine patients from the intervention group and 1 patient in the control group did not complete the study, leaving 100 patients, 46 in the intervention group and 54 in the control group (Figure

13).

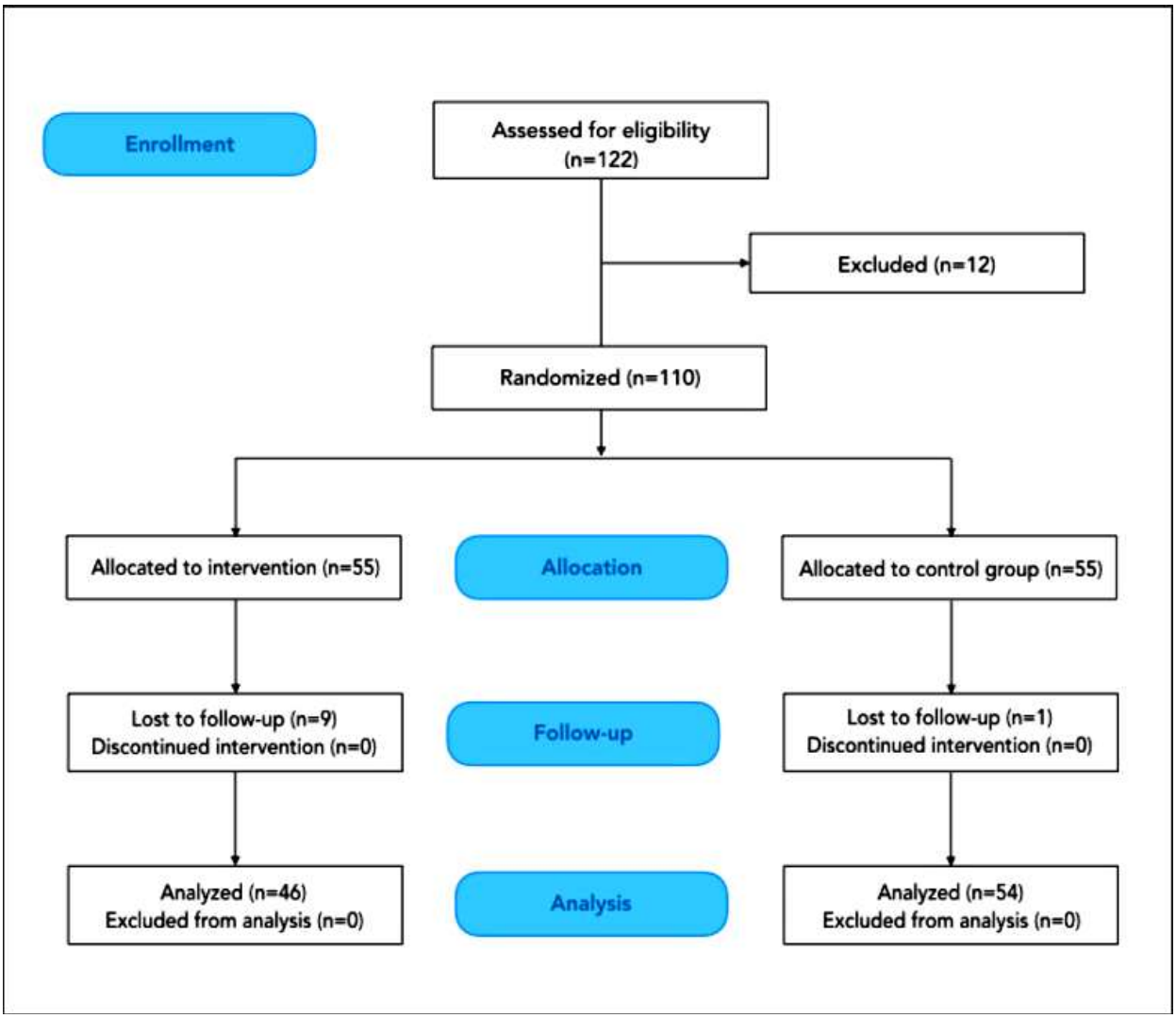

Figure 13: CONSORT flow diagram.

Ages ranged from 40 and 83 years, and males comprised 61% with no statistically significant differences between groups in clinical and demographic characteristics (Table 8).

Table 8: Distribution of patients regarding their characteristics

Characteristics		**Group 1 45**		**Group 2 55**		X^2	***P***
Age (years)		**N**	**%**	**N**	**%**	.146	*.985*
40 - <51		2	4.4	3	5.5		
51 - <62		10	22.2	11	20		
62 - <73		20	44.4	24	43.6		
73- 83		13	28.9	17	30.9		
Gender							
Male		28	62.2	33	60	.051	*.82*
Female		17	37.8	22	40		
Weight (kg)						.059	*.97*
47- <70		13	28.9	16	29.1		
70-<93		23	51.1	27	49.1		
93- 114		9	20	12	21.8		
Height (cm)							
150-< 162		11	24.4	13	23.6	.01	*.99*
162-< 174		22	48.9	27	49.1		
174- 185		12	26.7	15	27.3		
BMI							
Normal weight		11	24.5	11	20	2.02	*.57*
Overweight		22	48.8	25	45.45		
Obese		8	17.9	16	29.1		
Extreme obese		4	8.8	3	5.45		
Previous Diseases							
Hypertension		25	55.6	36	65.45	1.02	*.31*
Diabetes		15	33.4	16	29.1	.12	*.74*
COPD		5	11.1	10	18.18	.97	*.32*
Pulmonary Fibrosis		2	4.4	1	1.82	.59	*.44*
Chronic Bronchitis		3	6.7	10	18.18	2.9	*.088*
Smoking							
Yes	Current smokers	9	20	17	30.9	2.49	*.11*
	Ex-smokers	3	6.7	6	10.9		
No		33	73.4	32	58.2		
Type of surgery							
CAB G	On-pump	25	62.2	30	65.45	.4	*.82*
	Off-pump	3		6			
Valve surgery		13	29	13	23.55		
CABG + Valve surgery		4	8.8	6	10.9		

The most common operation was coronary artery bypass graft (64%). There were no significant differences between groups in respiratory function or O_2 saturation in the

preoperative outpatient clinic or day 0, while differences in these measures were found for the postoperative 7 day measurements were evident. ANOVA tests confirmed the statistically significant changes in the measures variables across the follow-up days ($p<0.001$) (Tables 9, 10, Figures 14-16).

Table 9: The mean of percentage of lung function measures in studied groups

	Group 1 Mean (SD)	Group 2 Mean (SD)	T test	*P value*
FVC (%predicted)				
Outpatient clinic	93.6 (17.7)	91.9 (18.4)	2.22	*0.054*
day 0	96.8 (17.5)	91.32 (15.8)	3.67	*.068*
day 1	36.98 (6.88)	29.67 (5.98)	6.036	*.000***
day 2	48.76 (13.27)	35.28 (8.17)	5.646	*.000***
day 3	64.00 (16.2)	36.6 (5.51)	5.56	*.001***
day 4	68.5 (22.4)	45.38 (10.66)	3.060	*.018**
day 5	72.2 (14.5)	50 (11.1)	6.37	*.000***
day 6	78.8 (11.53)	60.1 (9.46)	9.58	*.000***
day 7	87.9 (11.1)	65.02 (10.3)	11.9	*.000***
ANOVA test	78.698	229.694		
P value	*.000***	*.000***		
FEV1 (%predicted)				
Outpatient clinic	96.3 (18.15)	95.31 (16.6)	2.94	*.065*
day 0	98.67 (18.01)	96.76 (17.36)	3.886	*.057*
day 1	40.24 (9.11)	31.3 (7.5)	5.414	*.000***
day 2	52.72 (15.2)	39.31 (9.044)	4.575	*.000***
day 3	68.38 (17.9)	38.36 (6.41)	5.18	*.001***
day 4	65.1 (20.4)	47.67 (6.28)	1.89	*.116*
day 5	74 (11.2)	53.2 (10.04)	7.47	*.000***
day 6	82.3 (12.8)	62.8 (8.11)	9.02	*.000***
day 7	91.04 (11.9)	67.2 (9.4)	11.74	*.000***
ANOVA test	75.11	269.36		
P value	*.000***	*.000***		

Table 10: The mean of O_2 saturation (%) in studied groups

O_2 saturation (%)	**Group 1 Mean (SD)**	**Group 2 Mean (SD)**	**T test**	***P value***
Outpatient clinic	97.3 (1.15)	97.15 (1.4)	.692	*.492*
day 0	97.41 (.933)	97.43 (1.08)	.564	*.913*
day 1	96.65 (1.69)	94.77 (1.02)	2.16	*.041**
day 2	97.73 (1.66)	96.3 (.952)	4.57	*.000***
day 3	97.33 (1.8)	96.11 (.78)	2.23	*.046**
day 4	96.21 (1.6)	95.41 (.753)	1.975	*.048**
day 5	97.44 (.98)	96.11 (1.07)	4.761	*.000***
day 6	98.1 (.877)	95.7 (1.37)	8.45	*.000***
day 7	98.4 (.88)	95.63 (.974)	13.97	*.000***
ANOVA test	11.41	43.35		
P value	*.000***	*.000***		

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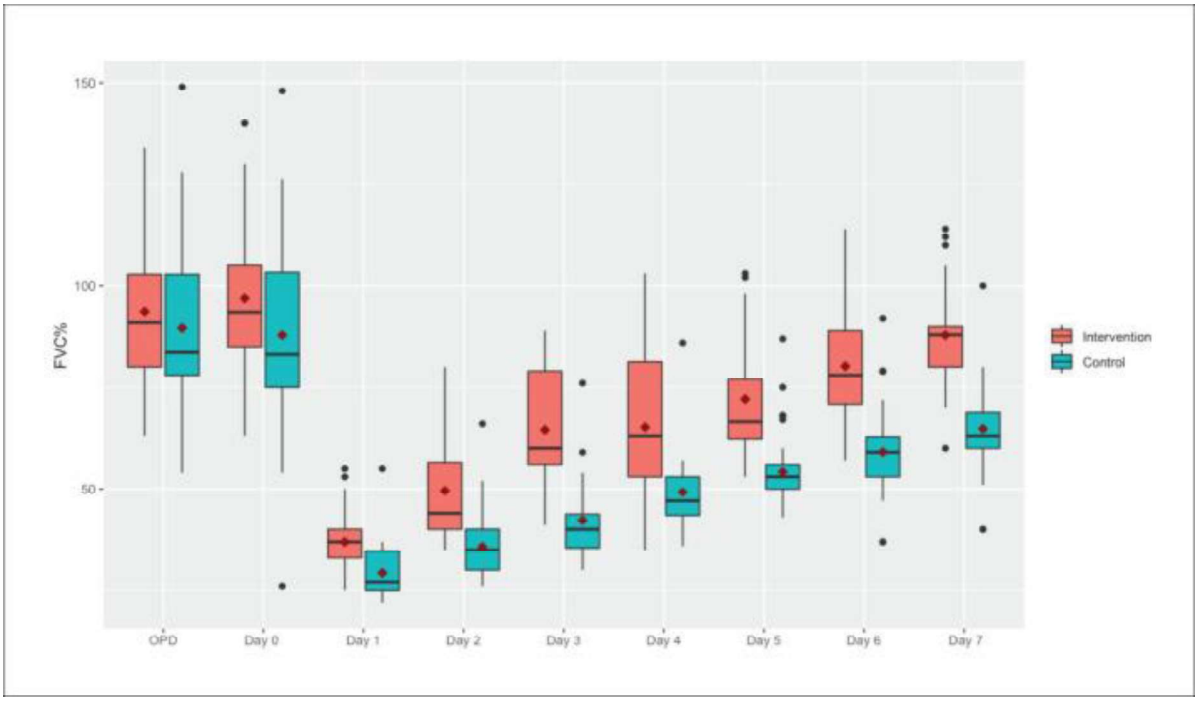

Figure 14: Median, interquartile range and mean (red diamond) of forced vital

capacity (FVC%) in the intervention and control groups.

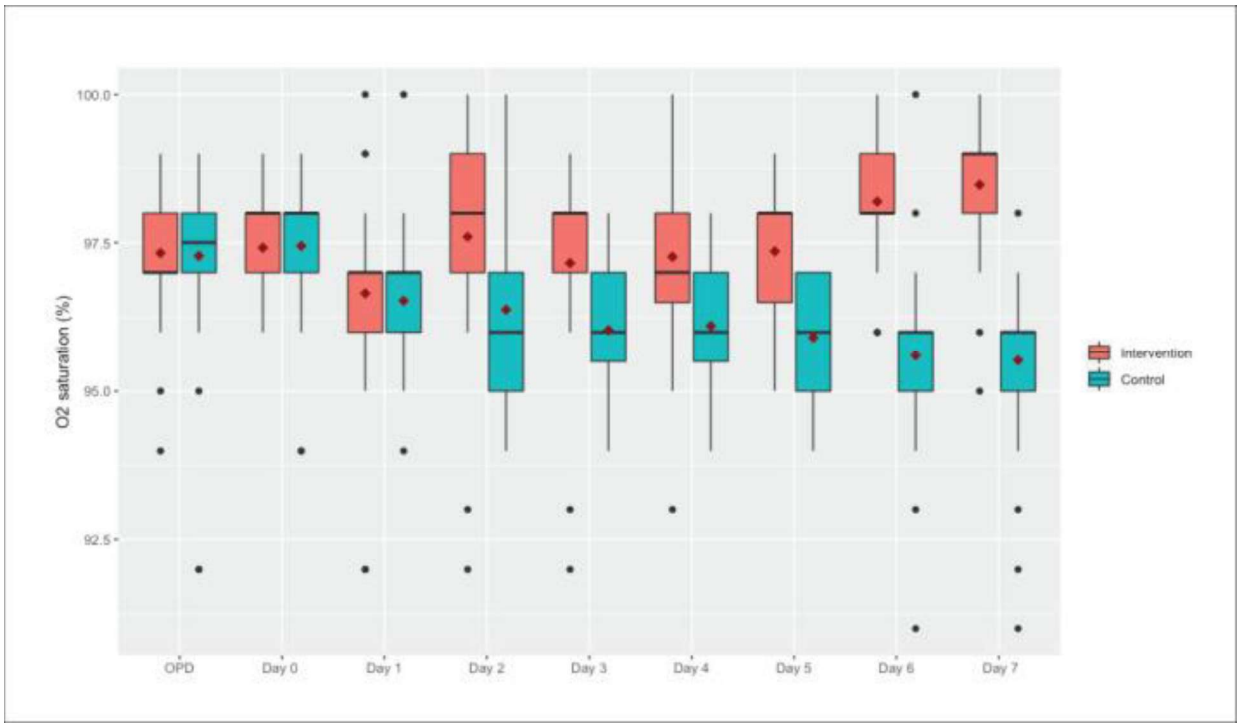

Figure 15: Median, interquartile range and mean (red diamond) of O_2 saturation (%) in the intervention and control groups.

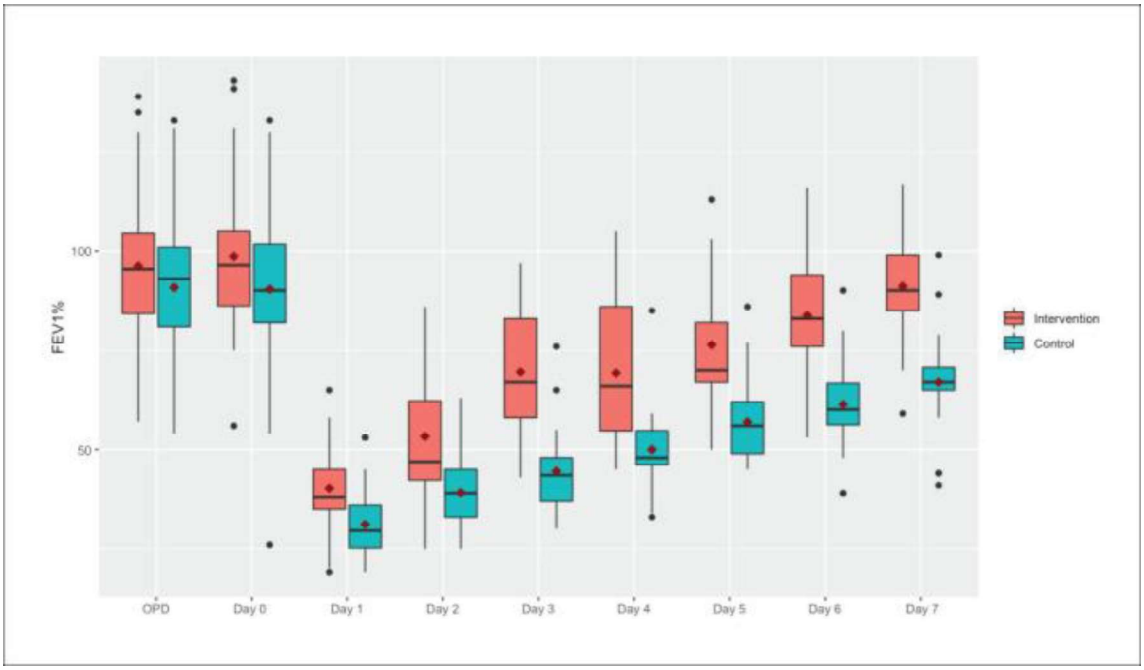

Figure 16: Median, interquartile range and mean (red diamond) of forced expiratory volume in first second (FEV1%) in the intervention and control groups.

The postoperative hospital stay length ranged from 7 to 20 days, with statistically significant longer stay in the control group (Table 11).

Table 11: The distribution of patients' postoperative hospital stay length between the two groups

		Group 1 n (%)	Group 2 n (%)	X^2	*P value*
Hospital stay (days)					
7- <12		45 (100)	39 (70.9)	$X^2 = 6.711$	*.000***
12- <16		0 (0)	10 (18.2)		
16-20		0 (0)	6 (10.9)		
Mean ± SD		7.82 ± .72	11.42 ± 3.01	T = - 8.57	*.000***
Mechanical ventilation time (hours)					
2-7		26 (57.78)	25 (45.45)	$X^2 = 1.5$	*.22*
7-15		19 (42.22)	30 (54.55)		
Lung complications					
Yes	Atelectasis	1 (2.22)	4 (7.27)	$X^2 = 3.7$	*.052*
	Pneumonia	0 (0)	3 (5.55)		
	Total	1 (2.22)	7 (12.73)		
No		44 (97.78)	48 (87.27)		

Discussion

Postoperative pulmonary complications are a principal contributor to morbidity and mortality in patients undergoing major surgery despite advances in perioperative care. PPCs are disorders of the respiratory system such as atelectasis and respiratory failure that occur within the first postoperative week (Sabaté et al., 2014). Interventions used for prevention of postoperative PPCs include preoperative measures to support the respiratory system, and intraoperative or postoperative measures to eliminate anesthesia-associated adverse events (Shander et al. 2011). Compared with measures taken to minimize postoperative cardiovascular complications, interventions for respiratory disorders are outdated and clinical practices are not standardized (Fleisher et al., 2014; Odor et al., 2020).

Physical training for the prevention of PPCs include endurance training (ET), respiratory muscle training (RMT) or both. Preoperative RMT strengthens inspiratory muscles by improving neural control and increasing the diaphragm thickness with enhancement of the aerobic mechanical performance (Downey et al., 2007; Jaenisch et al., 2017). Strengthening the respiratory muscles sustains an elevated ventilation workload in the early postoperative period. It also helps in atelectasis prevention and gas exchange improvement (Assouline et al., 2021). ET has been shown to improve early cardiovascular adaptation by means of an increase in blood volume and enhanced vasodilatation, sympathetic neural drive relief and improved ventricular relaxation. All these factors facilitate the delivery and uptake of oxygen to accommodate the demand of energy within active skeletal muscle (Murias et al., 1985; Roman et al., 2016). In addition, ET elevates ventilation load and physiological adaptive alterations within the respiratory muscles, which may confer higher strength and resistance to fatigue (Assouline et al., 2021). Chest physiotherapy is one of the procedures applied to eliminate PPCs after cardiac surgery, although there is no evidence to confirm the efficacy of these techniques (Herdy et al., 2008). No consensus has been reached on the most appropriate and effective treatment (Saglam et al., 2008). Therefore, this study was an attempt to investigate the role of preoperative chest physiotherapy on pulmonary function and length of stay in patients undergoing open heart surgery.

In our study, respiratory physiotherapy was effective in improving lung function and oxygenation of the blood. There were statistically significant differences in measures of respiratory function in the postoperative days, suggesting that preoperative chest physiotherapy expanded the lungs, promoted circulation of air to all pulmonary regions, increased the expiratory volume, improved the movement of the rib cage, and increased vital capacity. An increase in inspiratory muscle strength that occurred in the preoperative period could be responsible for higher functional capacity compared to individuals with weak muscles before surgery (Melly et al., 2018; Valkenet et al., 2011). The findings of our study are consistent with previous studies (Shakuri et al., 2015; Nardi et al., 2017; Snowdon et al., 2014; Westerdahl et al., 2001; Felcar et al., 2008). Nardi et al reported improved physical and respiratory conditions in patients who underwent pre-operative respiratory exercises. These

findings have also been confirmed (Melly et al., 2018). A systematic review of these studies showed improvements in functional capacity and decreased PPC in postoperative outcome in cardiac surgery patients (Hulzebos et al., 2012). Moreover, the breathing exercise alone demonstrated efficiency in decreasing PPCs after cardiac surgery (Thybo et al., 2018).

The postoperative hospital stay length in our study ranged from 7 to 20 days, but most did not exceed 12 days of hospital stay (84%). There was a statistically significant difference between groups in the length of hospital stay. Nardi et al also reported shorter lengths of hospital stay in the group treated preoperatively, but without statistical significance. The association of breathing exercise with less hospital stay length has also been documented in other studies (Felcar et al., 2008; Kundra et al., 2010; Melnyk et al., 2011; Arthur et al., 2000).

A recent meta-analysis analyzed a total of 12 randomized controlled trials (RCTs) involving the application of respiratory physiotherapy in patients undergoing abdominal and thoracic surgery (Odor et al., 2020). Physiotherapy protocols included both preoperative and postoperative interventions. They concluded that physiotherapy protocols reduced the incidence of PPCs. The largest and best quality RCT that included both preoperative and postoperative physiotherapy exercises revealed a statistically significant difference in developing PPCs postoperatively.

Strength and limitations

The strength of our study is that it was a prospective RCT that emphasizes the effect of preoperative and postoperative physiotherapy on patients needing cardiac surgery. A limitation of this study is that it may be difficult to generalize the findings of the present study due to the relatively small number of subjects. The different types of surgery is also a limitation of the present study.

Conclusion

This study concluded that preoperative chest physiotherapy is effective in improving respiratory functions following the open heart surgery.

Chapter 4: Study 3

The preoperative chest physiotherapy and the amount of oxygen needed after CABG surgery: A randomized controlled trial

Patients & Methods

This is a randomized controlled prospective study that was conducted after the approval of the Regional Ethical Committee of Clinical Research (4114. 316-474/KK15/2011), in the period from April 2019 to October 2019. The study setting was the preoperative outpatient clinic, cardiothoracic surgery department, and the intensive care unit of the University hospital. This study was reported according to CONSORT guidelines (Figure 17) (Schulzet al., 2010) and the protocol was registered on ClinicalTrials.gov (NCT04665024).

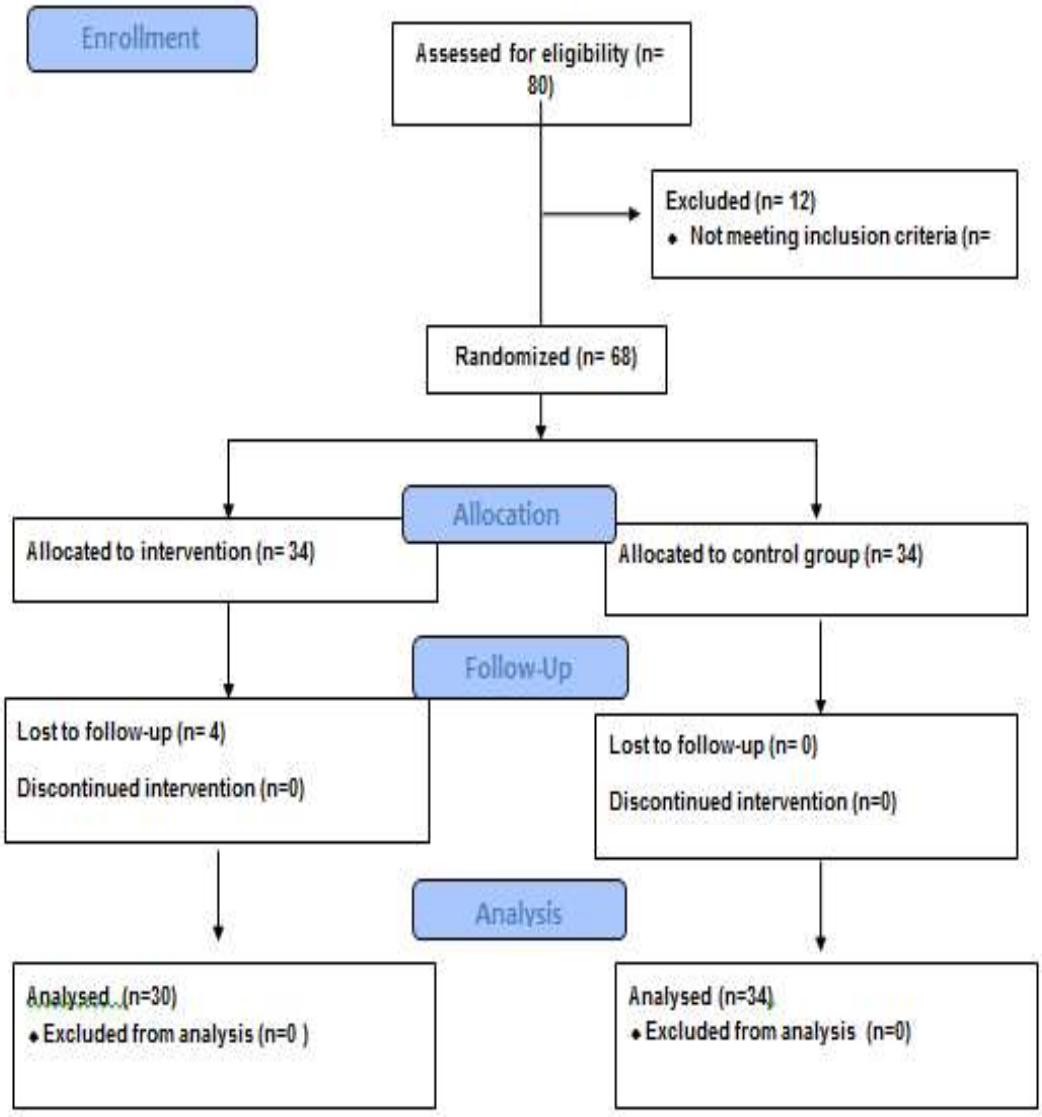

Figure 17: CONSORT flow diagram.

Study population and sample size

Eighty adult patients planned for CABG surgery were enrolled in this study. An informed written consent was requested form each patient. Patients with musculoskeletal diseases, central nervous system, or psychological diseases were excluded. Twelve patients were excluded based on eligibility criteria, then finally, 68 patients were the study population; they were allocated equally into two groups; group 1 (intervention group): received preoperative chest physiotherapy program and group 2 (control group): did not receive the preoperative chest physiotherapy. Both groups underwent the routine care and the postoperative chest physiotherapy. Four patients

from the interventional group did not complete the study. Therefore, the interventional group included 30 patients and the control group included 34 patients.

Blinding and randomization

The patients were allocated to their groups blindly and randomly after choosing on of opaque sealed envelopes those were prepared by an independent person who further conducted the patient recruiting to their suitable group.

Interventions

In the outpatient clinic, all patients were informed about surgery and the possible postoperative complications. Patients received a standard educational paper, describing the program elements, written in an easily understandable language with pictures and shapes. Physiotherapists educated the patient's how to perform chest physiotherapy exercises and informed them to practice the exercises daily for one week preoperative. The patients in group one achieved physiotherapists' supervision for the training program three times a week, once at the first day, second in the third day and the last at one day prior to the operation.

For both groups, a post-operative daily chest physiotherapy program was introduced in accordance with the hospital's policy until the patient's discharge. The pre and postoperative chest physiotherapy program were the same. Both were carried out according to the previously described protocol (Shakouri et al. 2015) and the hospital guidelines.

Outcome measures

Primary outcome measures

The primary outcome measure in this study was the difference between both groups in the average O_2 supplementation needed postoperatively.

Statistical Analysis

All statistical methods were applied using version 22.0 of SPSS software (Beaver, 2014) and $p< 0.05$ was chosen as a level of significance. Numerical values

were tested for normality using Shapiro–Wilk test, which confirmed data normality, then accordingly, numerical data were presented as mean and standard deviation, while categorical data are presented as number and percentage. The descriptive statistics were used in describing the study participants' characteristics. To discover group differences in the baseline data, chi-square test was used for the categorical variables (gender, smoking, previous diseases, and type of surgery) and t-tests was used for the continuous variables (age and BMI). The bivariate correlation was used to investigate the significant associations in the studied variables. Then, regression test was used to find out the predictors of the dependent variable (amount of the oxygen needed). The independent-samples T-test test was used to compare the average amount of O_2 needed for CABG patients between patients who had preoperative chest physiotherapy and those who haven't receive a preoperative chest physiotherapy.

Results

The mean age of participants was 67.7, the average BMI was 28.1. The average amount of O_2 needed over the seven postoperative days was 3.3 Litre/minute. Around 65.6% of the study participants were male patients, 37.5% were smokers. The CABG surgery for 14.1% of the participants was accompanied by either an aortic valve replacement (AVR) or mitral valve replacement (MVR), while majority of the participants (85.9%) had just a CABG surgery. No significant differences were found in the participants' characteristics between both groups (Table 12).

Table 12: Participants' characteristics (N=64)

Variable	Control group n=34		Experimental group n=30		*P*-value
	mean	**SD**	**mean**	**SD**	
Age	68.14	8.15	67.21	6.78	0.62
BMI	28.70	3.96	27.27	4.98	0.21
	n	**%**	**n**	**%**	***P*-value**
Gender					0.99
Male	22	64.7%	20	66.7%	
Female	12	35.3%	10	33.3%	
Smoking					0.65
No	21	61.7%	20	66.7%	
Yes	13	38.3%	10	33.3%	
Previous diseases					0.14
No	2	5.9%	5	16.7%	
Yes	32	94.1%	25	83.3%	
Surgery					0.99
CABG	29	85.3%	26	86.7%	
CABG with AVR or MVR	5	14.7%	4	13.3%	

The results of bivariate correlation showed a significant association between the average amount of O_2 needed and the type of open-heart surgery performed. The CABG patients, whose surgeries were accompanied by either AVR or MVR, needed higher mean postoperative O_2 needed than other patients with just a CABG. Most importantly, a negative significant correlation was found between the average amount of O_2 needed and chest physiotherapy before the open-heart surgery. Patients who had chest physiotherapy needed lower average amounts of O_2 than patients who hadn't chest physiotherapy (table 13).

Table 13: Bivariate correlations between the average O_2 needed and participants' characteristics

	Age	Gender	BMI	Smoking	Prev. D	Op.	CP
gender	0.05	1.00					
BMI	0.11	-0.03	1.00				
Smoking	-0.3**	0.15	-0.02	1.00			
Prev. D	0.07	-0.04	0.16	0.07	1.00		
Op.	0.12	-0.19	-0.05	-0.18	-0.24*	1.0	
CP	-.10	0.00	-0.18	-0.06	-0.18	0.0	1.00
O_2 mean	0.08	-0.15	0.02	0.07	0.13	0.31*	-0.30*

Prev.D: previous diseases, Op.: operations, CP: chest physiotherapy, *: statistically significant

Linear regression analysis was run to find out the significant model to predict participants' average amount of O_2 needed. Univariate regression analysis revealed that only preoperative chest physiotherapy was a significant predictor for the O2 supplementation need (p=0.026). Implementing variables of preoperative chest physiotherapy and and the operation type (because p<0.1) in a model demonstrated that these predicting variables all together significantly predicted the average amount of O_2 needed (F (2, 61) = 4.51, p = 0.015, $R^2_{Adjusted}$ = 0.1). Within the model predicting the average amount of O_2 needed, it was found that the significant predictor was the chest physiotherapy (β = -0.28, p <0.05) (Table 14).

Table 14: Regression analysis for prediction of the needed O_2 needed

Univariate linear regression analysis							
Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
	B	Std. Error	Beta			Lower Bound	Upper Bound
Smoking	0.34	0.424	0.102	0.809	0.421	-0.504	1.19
Age	0.02	0.028	0.099	0.783	0.437	-0.033	0.077
gender	-0.31	0.432	-0.089	-0.705	0.483	-1.169	0.559
CP	-0.91	0.398	-0.279	-2.284	0.026*	-1.703	-0.113
Op	-0.97	0.532	-0.226	-1.824	0.073	-2.035	0.093
Prev. D	0.77	0.653	0.148	1.179	0.243	-0.535	2.076
Multivariate linear regression analysis							
Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
	B	Std. Error	Beta			Lower Bound	Upper Bound
Op	-0.973	0.514	-0.226	-1.892	0.063	-2.001	0.056
CP	-0.909	0.39	-0.279	-2.333	0.023*	-1.689	-0.13

Prev.D: previous diseases, Op.: operations, CP: chest physiotherapy, *: statistically significant

The results of the independent-samples T-test showed significantly higher average amounts of O_2 needed post CABG surgery in patients who didn't any chest physiotherapy than those who had preoperative chest physiotherapy (Table 15).

Table 15: The Independent-Samples T-test

	Mean (SD) (Control group n=34)	**Mean (SD) (Experimental group n=30)**	***t***	***p***
The average amount of O2 needed post CABG surgery	3.8 (1.6) L/min	2.8 (1.5) L/min	2.3*	0.013*

Discussion

The aim of this study was to assess the relationship between the preoperative chest physiotherapy and participants' characteristics with the average O2 supplementation needed for CABG patients.

The results showed some significant associations between the preoperative chest physiotherapy and participants' characteristics with the average O2 supplementation needed for CABG patients. For instance, the average amount of O_2 needed and the type of open-heart surgery performed were associated. In other words, the average amount of O_2 needed postoperatively was higher in patients who had CABG surgeries with either AVR or MVR than other patients with just a CABG. This finding can be explained that those patients with more complicated surgeries will experience more postoperative complications. Moreover, they will need more O2 to recover from these complications. This study finding is incongruent with the findings reported by Chan et al. (2012) who reported that the O2 consumption significantly improved in the patients with CABG plus MVR, while the CABG only group did not show a significant change in the amount of oxygen supplementation. However, in their study, they did not apply preoperative chest physiotherapy, which could be a contributing factor in such controversy (Chan et al., 2012).

In addition, a negative significant relationship was found between the average amount of O_2 needed postoperatively and chest physiotherapy before the CABG. Furthermore, the results of regression analysis showed that the preoperative chest physiotherapy is a significant predictor for the average amount of O_2 needed post CABG. So, patients who had chest physiotherapy prior to their CABG surgeries needed lower average amounts of O_2than patients who hadn't chest physiotherapy. This result is explainable by the fact the chest physiotherapy is effective in improving

the respiratory function and oxygenation.

To the best of our knowledge, no previous studies investigated the effect of preoperative chest physiotherapy on post CABG O2 supplementation. However, within the same context, the most recent meta-analysis conducted by Odor et al. (2020), in which a total of 12 RCTs including 1345 patients, concluded an overall benefit of prophylactic physiotherapy in reducing the development of PPCs (Odor et al., 2020).

This study also aimed to compare the average amount of O_2 needed for CABG patients between patients who had preoperative chest physiotherapy and those who haven't receive a preoperative chest physiotherapy. Our study found a significant difference in the average amounts of O2 needed post CABG surgery; higher average amounts of O2 needed in patients who didn't any chest physiotherapy than those who had preoperative chest physiotherapy. This result showed that the preoperative chest physiotherapy is essential in enhancing the postoperative oxygenation and recovery of the patient undergoing CABG. Furthermore, poor oxygenation and more O2 supply are expected to be needed for CABG patients who didn't receive a preoperative chest physiotherapy. In consistency with our finding, it was observed that a low rate of postoperative pulmonary complications in the treated groups of patients in comparison with the control group, and this was associated with better SaO2 values (Nardi et al., 2019). These findings were also confirmed by other former studies (Valkenet et al., 2013).

Limitations

This study is limited by non-measuring the respiratory muscles strength at the end of the chest physiotherapy program, as well as the lack of patients' long term follow up analysis, both elements would yield more a firm conclusion. It is important to note that the intervention (chest physiotherapy) was responsible for 10% of the oxygen demand in total according to the regression model, the oxygen demand being determined by 90% by other variables not measured by the study. This 10% explanation therefore indicates that chest physiotherapy is not the strongest variable in the model predicting oxygen demand.

Conclusion

Significant associations between the preoperative chest physiotherapy and participants' need for O2 supplementation were concluded. This emphasizes the chest physiotherapy improving effect on the respiratory function and oxygenation.

Chapter 5: Study 4

The effect of cold application on pain due to chest tube removal

The literature has highlighted the need to assess the importance of physiotherapy in practice. In addition to physiotherapy, great emphasis should be placed on pain relief during procedures associated with cardiac surgeries.

Patients & Methods

Design

A semi experimental design (study - control) was used

Setting

The current study was conducted at the Cardiothoracic Surgical Department and Intensive Care Unit at Pécsi Tudományegyetem Klinikai Központ Szívgyógyászati Klinika, Pecs, Hungary. Between November 2017 July 2018.

Sample

A convenient sample of 100 patients hospitalized in the Cardiothoracic Surgical Department and Intensive Care Unit (ICU) and who had chest tubes for duration at least 24 hours after cardiac-thoracic surgery. Patients were assigned to two groups Study group Applied cold application with soft ice pack gel which comprised 50 patients, Control group without application with ice bag which comprised 50 patients

Inclusive criteria:

- 18 years old or older.
- Patients with normal vital signs.
- Able to report pain.
- 6 hours after the last painkiller administration, for experimental group.
- Have one or two mediastinal, pericardial or pleural tubes.

Exclusive criteria:

- Mechanical ventilation support.

- Communication problems.
- Psychiatric disorder / Mental disabilities or with communication problems.

Tools of Data Collection

First Part: Demographic information was collected from the patients' medical records regarding: gender, age, surgical procedure, and length of surgery, type of chest tube, number of days chest tube was inserted, indication of chest tube insertion, skin temperature, heart rate, systolic, and diastolic blood pressure.

Second Part: The Visual Analogue Scale is an instrument used to measure the intensity of pain. Scores are based on self-reported measures of symptoms that are recorded with a single handwritten mark placed at one point along the length of a 10-cm line that represents a continuum between the two ends of the scale—"no pain" on the left end (0 cm) of the scale and the "worst pain" on the right end of the scale (10 cm) (Alexander, 2007).

Methods:

The study group:

- The researcher measured the patients' vital signs and asked the patients to mark the pain they feel with the chest tube in place on the VAS and measured the skin temperature of the area where the ice was applied (**1st measurement**).

- The researcher placed a single layer of sterile gauze pad around the area of insertion to skin of the chest tubes and placed an ice pack on top of them. The researcher kept the patient in the same position throughout the ice application and stayed with the patient to prevent the slippage of ice pack from its place**.**

- The researcher terminated the ice application when the skin temperature reached 13 ^{0}C and give the patient the VAS one more time asking him/her to mark the pain. It took average nine minutes for the skin to reach 13 ^{0}C (**2nd measurement**)**.**

- Immediately after the chest tube removal (CTR) by the physicians, the researcher measured the skin temperature of the areas and asked the patient to mark the pain he/she felt during the removal of the chest tube on the VAS (**3rd measurement**).

- Five to Ten minutes after the CTR, researcher measured the skin temperature of the patient for the last time and recorded both the pain measurements as well as the skin temperatures which terminate the application (**4th measurement**).

The Control Group

- The control group received Analgesics before two hours of chest tube removal.

- The researcher measured the patients' vital signs and asked the patients to mark the pain they feel with the chest tube in place on the VAS and measured the skin temperature of the area around the chest tube (**1st measurement**).

- Immediately after the CTR by the physicians, the researcher measured the skin temperature of the areas and asked the patient to mark the pain he/she felt during the removal of the chest tube on the VAS (**2nd measurement**) .

- Five to Ten minutes after the CTR, researcher measured the skin temperature of the patient for the last time and recorded both the pain measurements as well as the skin temperatures (**3rd measurement**).

Data Analysis

In the statistical analysis, for the descriptive analysis, the categorical data were arranged in tables of absolute and relative frequencies. Numerical values were tested for normality using Shapiro–Wilk test, which confirmed data normality, then accordingly, numerical data were presented as mean and standard deviation, while categorical data are presented as number and percentage. The independent t- test was

used to compare the means of continuous independent variables relative to the groups. In all of the analyses, standard 0.05 p-values and 95% confidence intervals were applied.

Result:

Table 15 illustrates that one hundred chest tubes were inserted to patients in study group and control group (Study Group: 50 patients using ice pack during chest tube removal, while Control Group: 50 patients without using ice-pack during chest tube removal). This table shows that (30.0%) of patients were female and (70.0%) were male in study group. In control group (84.0%) were male and (16.0%) were female. The mean age was 65.4±7.1 years old in study group and 60.4±7.3 years old in control group. It can be seen that the mean duration of chest tube was 25.6±5.8 hours in study group and 27.8±9.9 hours in control group.

Table 16: Socio- Demographic Characteristics of the control and Studied Groups

Characteristics	Study Group (n=50)		Control Group (n=50)	
	No	%	No	%
Gender				
Male	42	84.0	35	70.0
Female	8	16.0	15	30.0
Age (in years)				
Mean ±SD	60.4±7.9		62.4±7.1	
Type of Chest Tubes				
Mediastinal & Pericardial	24	48.0	45	90.0
Mediastinal, Pericardial or Pleural	26	52.0	5	10.0

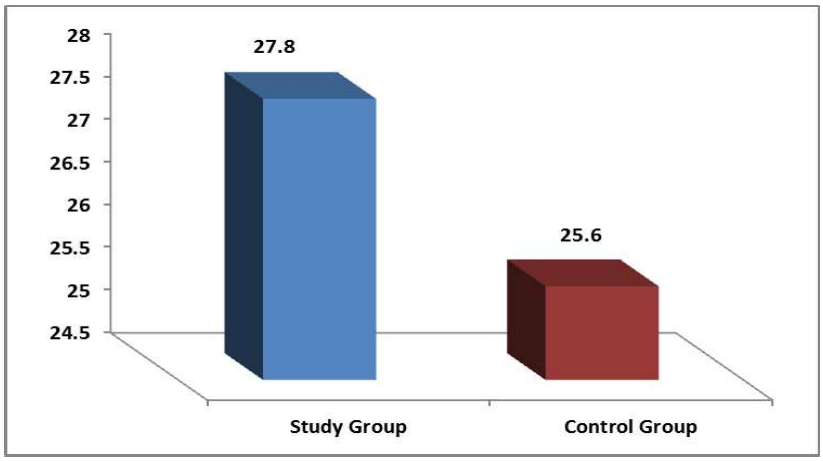

Figure 18: Duration of Chest Tube Insertion/Hours

Table 16 illustrates the pain intensity between the two groups before, immediately after, and 5-10 min after removal. The means of pain intensity scores before chest tube removal were 2.4 ±2.8 for study group, while 2.6 ±2.1 for control group, pain intensity was insignificantly different between the two groups before intervention (P > 0.05). The means of pain intensity scores immediately after removal were 2.3±2.2 for study group, while 7.4±2.0 for control group, pain intensity was significantly different between the two groups immediately after removal (P < 0.01). The means of pain intensity scores after 5-10 min removal were 0.1±0.4 for study group, while 1.1±1.3.0 for control group, pain intensity was significantly different between the two groups 5-10 min after removal (P < 0.01).

Table 17: Pain Intensity Scores over Time

Pain Intensity	Study group		Control group		t	P
	Mean	±SD	Mean	±SD		
Pain (Immediately before Removal)	2.4	2.8	2.6	2.1	0.40	0.69
Pain(Immediately after Removal)	2.3	2.2	7.4	2.0	12.12	0.0001
Pain (5-10 min after Removal)	0.1	0.4	3.2	1.3	16.12	0.0001

Significant level at P < 0.05

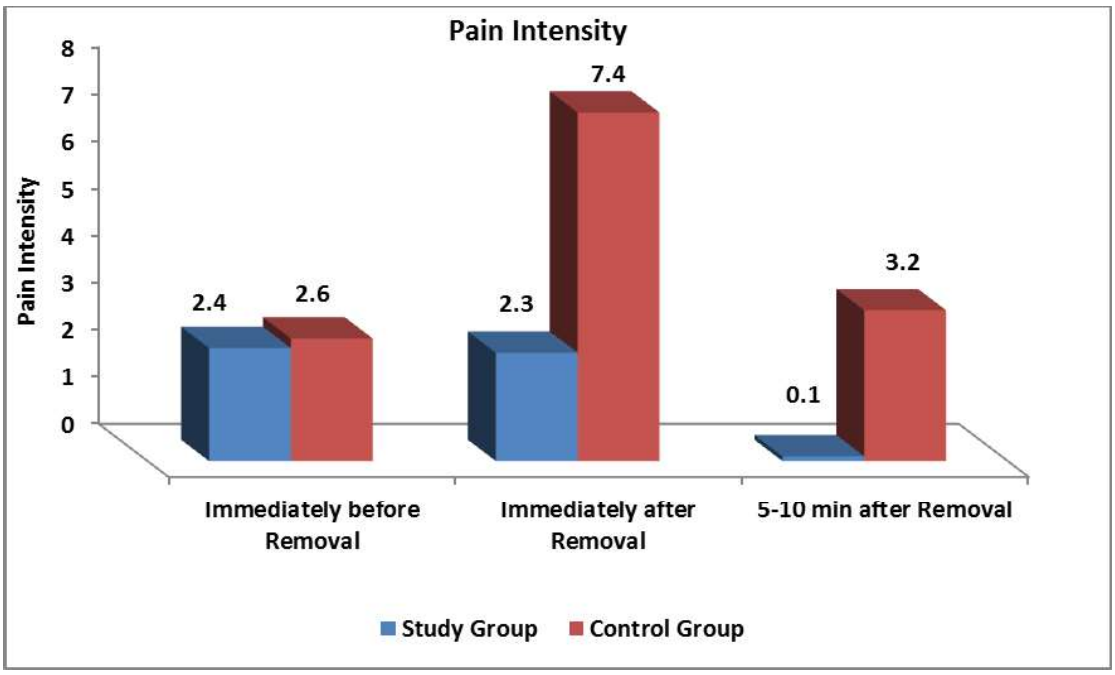

Figure 19: Pain Intensity Visual Analog Scale (VAS)

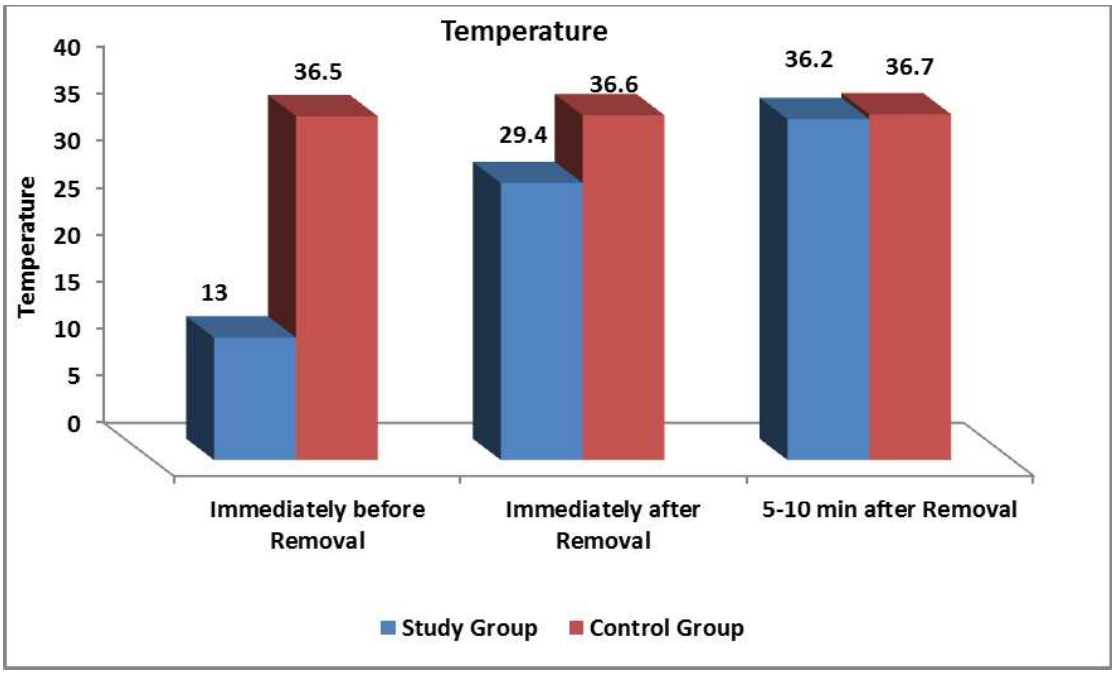

Figure 20: Temperature over Time (Celsius).

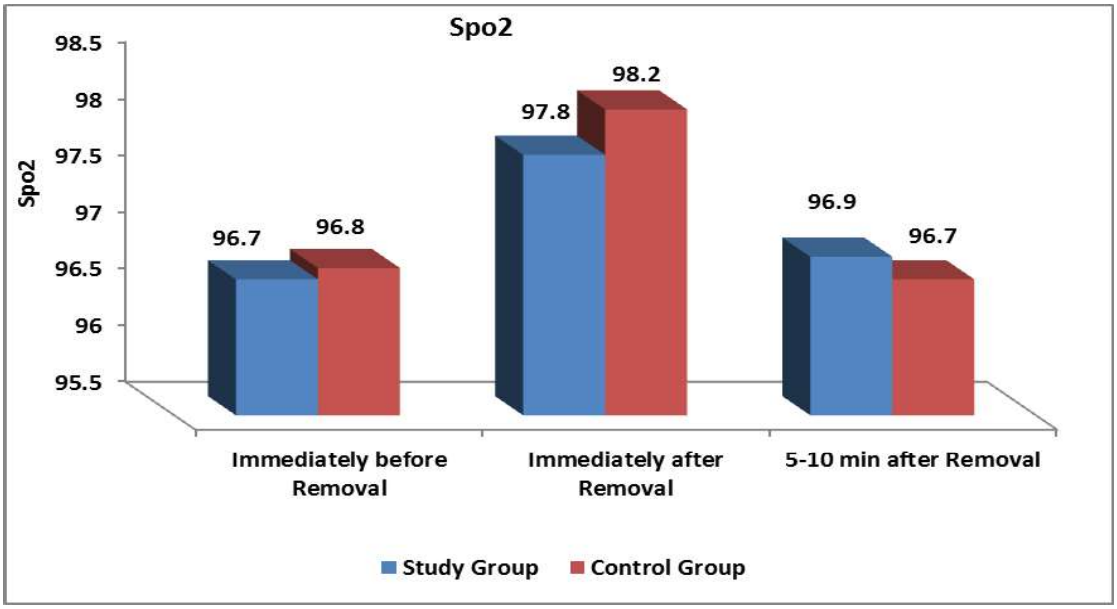

Figure 21: SPO2 over Time (%).

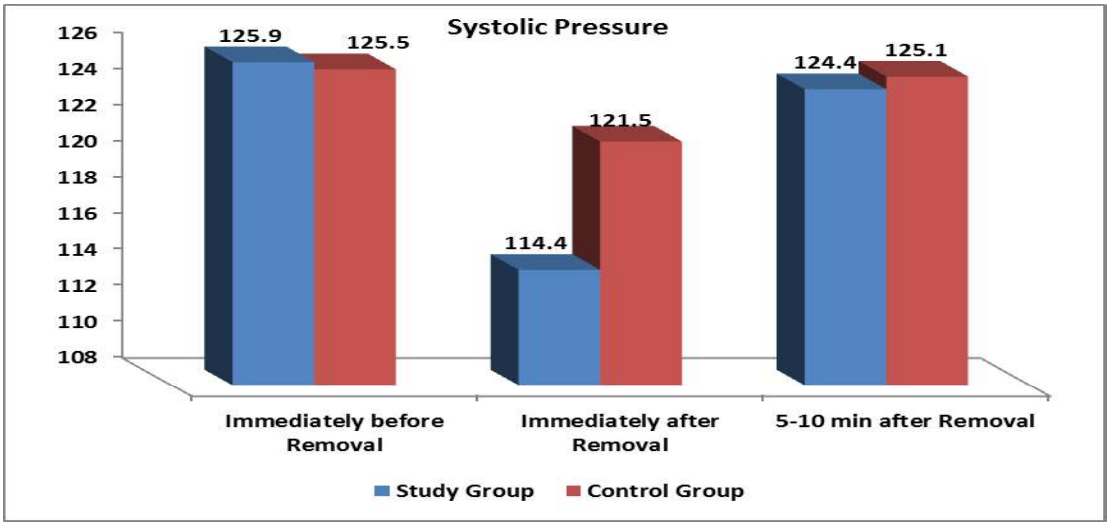

Figure 22: Systolic Pressure over Time (mmHg).

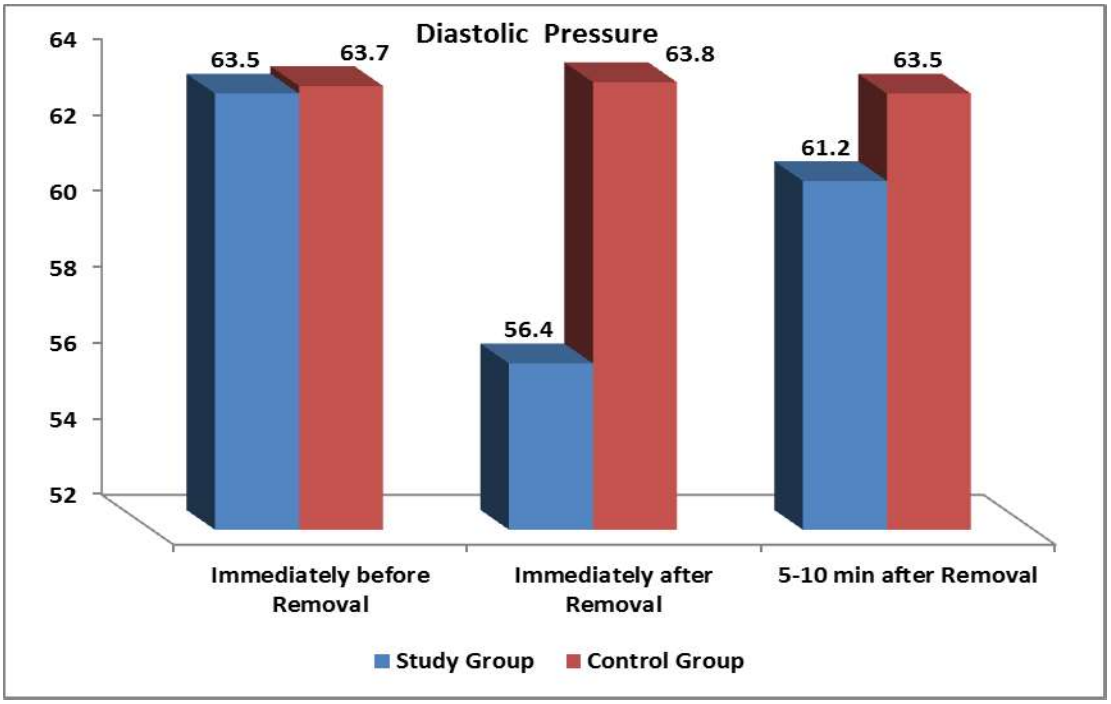

Figure 23: Diastolic Pressure over Time (mmHg).

Discussion

Experiencing pain is a major considered issue in hospitalized patients. several efforts are exerted to manage pain and to reduce it as far as possible (Charnock and Evans, 2009). The CTR causes pain for parietal pleura, pectoral muscle and other type of fibers, including inter-costal nerve fibers (Friesner et al., 2006).

In the present investigation, it was observed that the visual analogue score obtained immediately before chest tube removal were mild in study group and was higher than other score gotten for other time points in control group. The VAS scores got immediately after chest tube removal were moderate in control group, while it was mild in study group. The VAS scores got 5-10 minutes after CTR in cold application group produced the most enhancement in pain and was the most effective in relieving the pain association with CTR. The findings of the current study were in agreement with Ertug and Ulker (2012) who conducted a controlled clinical trial, to survey impact of cold application on pain because of chest tube removal. Cold was applied to the study group and the skin temperature and pain intensity was measured 4 times; prior to the application of cold, before removing chest tube, not long after the removal of chest tube, five minutes after the removal of the chest tube. The visual analogue scale score was measured immediately after the removal of the tube in the experimental group was 3.8, compared with 5.6 in the control group. There was significant difference in pain between the two groups. Similar study was conducted by Abdoullah et al. (2013(who agreed with our examination and found correlation between control and study groups as regards to pain intensity measurement observed that the visual analogue score obtained immediately after chest tube removal were mild in study group and was higher than other score obtained for other time points in control group. The VAS scores got 15 minutes after CTR in cold application group produced the most enhancement in pain and was effective in relieving the pain association with CTR. Also, perceived pain was the most intense during CTR (VAS 2) in control group. Also, the study of Demir and Khorshid (2010) who found that cold application reduced patients' intensity of pain due to CTR. On contrast of the study done by Miller et al. (2008) who expressed that the finding of his investigation don't support that pain intensity scores & pain distress scores were not significantly different between the patients who received ice and the one who received tap water. A 10 minutes use of ice brought about subcutaneous tissue cooling and absence of pain in a few investigations. The results of the current study incongruity with study conducted by Sauls (2002) indicate that ice compression was ineffective in relieving the CTR pain. The inconsistency of our results with those of study may be due to some differences in the methodologies of the studies.

The findings of the present examination uncovered that there is a statistically significant decrease in pain intensity at the two measurement points after chest tube removal in the studied group compared to the control group. The findings of the current study are similar to what was reported by Mohamed et al. (2017) who found that, there is a statistically significant decrease in pain intensity at the three measurement points in the studied groups (cold application group, breathing exercise group and cold application and breathing exercise combined group) compared to the control group. The findings of the current investigation are like what was reported by Gorgi et al. (2017) and Mazloum et al (2012) whom examined the effect of cold application combined with a breathing exercises technique on pain intensity during chest tube removal and found that utilizing cold application joined with breathing exercises technique was effective in decreasing pain intensity. However, the study findings are different from what was reported by Mohamed et al. (2017) who found that cold therapy was not very efficient in diminishing pain. The patients in the cold application group reported that pain intensity at 15 and 30 minutes after chest tube removal was like to the control group. The study findings are different from what was reported by Rafii (2010) who examined utilizing the cold bag and breathing technique to diminish anxiety level at 30 minutes after chest tube removal.

Limitation of the study:

- This study was conducted among a limited number of patients undergoing open heart surgery. Therefore, the findings cannot be generalized to other patients who experience CTR.

- In this study, patients might have responded differently to pain based on their physical condition, emotional and cultural states.

Recommendations

The study recommends the following for future research

1. The study can be conducted with a larger group in different setting for better generalization.

2. A comparative study can be done to assess the effectiveness of ice application with other non -pharmacological interventions.

3. Nurses and patients need to understand that non-pharmacological pain management

4. Incorporation of theoretical and practical non-pharmacological pain management methods in nursing Curricula.

5. In-service training programs for nurses in ICU about the utilization of non-pharmacological approaches

Conclusion

Based on the study findings, it could be concluded that the application of ice pack during CTR appears to have a remarkable effect on pain intensity. Thus it can be used as a non-pharmacological intervention as it provides a safe and effective reduction in pain without side effects.

Chapter 6: Summary of novel findings and clinical implications

Summary of novel findings

- The preoperative chest physiotherapy intervention favoably affected the time of the mechanical ventillation and the length of the hospital stay.
- Preoperative physiotherapy proved to be protective against the existence of PPCs.
- Preoperative physiotherapy caused significant improvement of the postoperative pulmonary functions.
- Preoperative physiotherapy caused improvement in the postoperative oxygenation of the blood and decreased the need for oxygen supplementation.
- The application of ice pack during chest tube removal appears to have a remarkable effect on pain intensity. Thus it can be used as a non-pharmacological intervention as it provides a safe and effective reduction in pain without side effects.

Clinical implications

- Working to prevent or reduce the incidence of pulmonary complications that are occurring in patients after heart surgery is a major goal among health workers. To achieve this goal, it is recommended to educate patients about how important is to learn the physical therapy techniques. These techniques could help improving the respiratory functions, and promoting the expansion of the lungs, and identifying the high - risk patients for the development of pulmonary complications after surgery. In this vein, physical therapy is highly regarded among the basic treatments and should be offered to the patients in intensive care units.
- This study is confirming the potential performance of the rehabilitation program before cardiac surgery, and recommending its achievement to all

patients if possible, in order to make the post-operative period less traumatic, and to facilitate a faster functional recovery.

- Preoperative physical therapy techniques could to reduce the need for oxygen supplementation, which reflects improving the respiratory functions. This further emphasizes the importance for implication preoperative physiotherapy as a routine preoperative preparation for patients undergoing cardiac surgeries.

- This study findings suggest considering the use of cold application as a standardized technique during chest tube removal to reduce the patient pain and help to diminish procedure associated distress that may affect patient outcome.

References

Abdoullah R, Mokabel F, AL-Ghuneimy Y. The Effect of Cold Application on Pain and Anxiety during Chest Tube Removal. Journal of American Science. 2013;9(7)

Alexander I: Electronic medical records for the orthopaedic practice. Clin Orthop Relat Res 2007;457:114-119.

Arthur HM, Daniels C, McKelvie R, Hirsh J, Rush B. Effect of a preoperative intervention on preoperative and postoperative outcomes in low-risk patients awaiting elective coronary artery bypass graft surgery. A randomized, controlled trial. Ann Intern Med. 2000 Aug 15;133(4):253-62.

Charnock Y, Evans D. Nursing management of chest drains: a systematic review. Australian Critical Care. 2009;14: 156–160.

Chen X, Hou L, Zhang Y, Liu X, Shao B, Yuan B, et al. The effects of five days of intensive preoperative inspiratory muscle training on postoperative complications and outcome in patients having cardiac surgery: a randomized controlled trial. Clinical Rehabilitation. 2019 May;33(5):913-922.

De Backer D, Dubois MJ, Schmartz D, Koch M, Ducart A, Barvais L, Vincent JL. Microcirculatory alterations in cardiac surgery: effects of cardiopulmonary bypass and anesthesia. Ann Thorac Surg. 2009;88(5):1396-403.

Demir Y, Khorshid L. The effect of cold application in combination with standard analgesic administration on pain and anxiety during chest tube removal: a single-blinded, randomized, double-controlled study. Pain Manag Nurs. 2010; 11(3):186-96.

Downey AE, Chenoweth LM, Townsend DK, Ranum JD, Ferguson CS, Harms CA. Effects of inspiratory muscle training on exercise responses in normoxia and hypoxia. Respir Physiol Neurobiol. 2007;156(2):137-146.

Ertug N, Ulker S. The effect of cold application on pain due to chest tube removal. J Clin Nurs. 2012; 21:784-90.

Fayyaz A, Furqan A, Ammar A, Ahmad RA, Ahmad S. Pre-operative incentive spirometry: effectiveness to improve post-operative oxygenation in patients undergoing CABG surgery. The Professional Medical Journal. 2016 Nov 10;23(11):1368–72.

Felcar JM, Guitti JC, Marson AC, Cardoso JR. Preoperative physiotherapy in prevention of pulmonary complications in pediatric cardiac surgery. Rev Bras Cir Cardiovasc. 2008;23(3):383-8. English, Portuguese.

Fernandez-Bustamante A, Frendl G, Sprung J, Kor DJ, Subramaniam B, Ruiz R, Lee Ja, Henderson WG, Moss A, Mehdiratta N. Postoperative Pulmonary Complications, Early Mortality, and Hospital Stay Following Noncardio-thoracic Surgery: A Multicenter Study by the Perioperative Research Network Investigators. JAMA Surg. 2017, 152, 157–166.

Fleisher LA, Fleischmann KE, Auerbach AD, et al. 2014 ACC/AHA guideline on perioperative cardiovascular evaluation and management of patients undergoing noncardiac surgery: executive summary: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines. Circulation. 2014;130:2215-45.

Friesner S, Curry D, Moddeman R. Comparison of two pain-management strategies during chest tube removal: Relaxation exercise with opioids and opioids alone. Heart & Lung - The Journal of Acute and Critical Care. 2006;35(4): 269-276.

Garbossa A, Maldaner E, Mortari D. Et al. Effects of physiotherapeutic instructions on anxiety of CABG patients. Braz J Cardiovasc Surg. 2009, 24, 359–366.

Gomes-Neto M, Saquetto M, Silva C, et al. Impact of exercise training in aerobic capacity and pulmonary function in children and adolescents after congenital heart disease surgery: A systematic review with meta-analysis. PediatrCardiol 2016; 37: 217–224.

Gorgi HM, Nesami BM, Ayyasi M, Ghafari R, Yazdani J. Comparison of ice packs application and relaxation therapy in pain reduction during chest tube removal following cardiac surgery. North Am J Med Sci. 2014; 6: 19-24.

Graham BL, Steenbruggen I, Miller MR, Barjaktarevic IZ, Cooper BG, Hall GL, et al. Standardization of Spirometry 2019 Update. An Official American Thoracic Society and European Respiratory Society Technical Statement. Am J Respir Crit Care Med. 2019 Oct 15;200(8):e70-e88.

Grooms DA. Postoperative Pulmonary Complications. Clinical Foundations: A Patient Focussed Evaluation Program for Respiratory Care Professionals. 2012.

Herdy AH, Marcchi PL, Vila A, Tavares C, Collaço J, Niebauer J, et al. Pre- and postoperative cardiopulmonary rehabilitation in hospitalized patients undergoing coronary artery bypass surgery: a randomized controlled trial. Am J Phys Med Rehabil. 2008;87(9):714-9.

Hulzebos E, Smit Y and Helders P. Preoperative physical therapy for elective cardiac surgery patients. Cochrane Database Syst Rev 2012; 11: CD010118.

Hulzebos EH, Helders PJ, Favié NJ, De Bie RA, Brutel de la Riviere A, Van Meeteren NL. Preoperative intensive inspiratory muscle training to prevent postoperative pulmonary complications in high-risk patients undergoing CABG surgery: a randomized clinical trial. JAMA. 2006 Oct 18;296(15):1851-7.

Hulzebos EHJ, van Meeteren NLU, van den Buijs BJWM, de Bie RA, Brutel de la Rivière A, Helders PJM. Feasibility of preoperative inspiratory muscle training in patients undergoing coronary artery bypass surgery with a high risk of postoperative pulmonary complications: a randomized controlled pilot study. Clinical Rehabilitation. 2006 Nov;20(11):949–59.

Jaenisch RB, Bertagnolli M, Borghi-Silva A, Arena R, Lago PD. Respiratory Muscle Training Improves Diaphragm Citrate Synthase Activity and Hemodynamic Function in Rats with Heart Failure. Braz J Cardiovasc Surg. 2017;32(2):104-110.

Justus G, Walker C, Rosenthal LM, Berger F, Miera O, Schmitt KR. Immunodepression after CPB: cytokine dynamics and clinics after pediatric cardiac surgery – a prospective trial. Cytokine 2019: 122: 1510018.

Kamarajah SK, Bundred J, Weblin J, Tan BHL. Critical appraisal on the impact of preoperative rehabilitation and outcomes after major abdominal and cardiothoracic surgery: A systematic review and meta-analysis. Surgery. 2020;167(3):540-549.

Katsura M, Kuriyama A, Takeshima T, et al. Preoperative inspiratory muscle training for postoperative pulmonary complications in adults undergoing cardiac and major abdominal surgery – review. Cochrane Database Syst Rev 2015; 5: CD010356

Kundra P, Vitheeswaran M, Nagappa M, Sistla S. Effect of preoperative and postoperative incentive spirometry on lung functions after laparoscopic cholecystectomy. Surg Laparosc Endosc Percutan Tech. 2010 Jun;20(3):170-2.

Leguisamo CP, Kalil RA, Furlani AP. Aefetividade de umapropostafisioterapêuticapré-operatóriaparacirurgia de revascularização do miocárdio. RevistaBrasileira de Cirurgia Cardiovascular. 2005; 20(2): 134-141.

Makhabah DN, Martino F, Ambrosino N. Peri-operative physiotherapy. MultidiscipRespir Med. 2013; 8(4).

Manzano RM, Carvalho CR, Saraiva-Romanholo BM, Vieira JE. Chest physiotherapy during immediate postoperative period among patients undergoing upper abdominal surgery: randomized clinical trial. Sao Paulo Med J. 2008 Sep;126(5):269-73.

Marmelo F, Rocha V, Moreira-Gonçalves D. The impact of prehabilitation on post-surgical complications in patients undergoing non-urgent cardiovascular surgical intervention: Systematic review and meta-analysis. European Journal of Preventive Cardiology. 2018 Mar;25(4):404-17.

Melly L, Torregrossa G, Lee T, Jansens JL, Puskas JD. Fifty years of coronary artery bypass grafting. J Thorac Dis. 2018;10(3):1960-1967.

Melnyk M, Casey RG, Black P, Koupparis AJ. Enhanced recovery after surgery (ERAS) protocols: Time to change practice? Can Urol Assoc J. 2011;5(5):342-348.

Miller C, Weber R. The effects of ice massage on an individual's pain tolerance level to electrical stimulation, The Journal of Orthopaedic and Sports Physical Therapy. 2008;12: 105-109.

Miranda R, Padulla S, Bortolatto CR. Respiratory physiotherapy and its application in preoperative period of cardiac surgery.RevistaBrasileira de Cirurgia Cardiovascular. 2011;26(4):647-652.

Miskovic A, Lumb AB. Postoperative pulmonary complications. Br J Anaesth. 2017;118:317-34.

Mohamed N, EL-Sayed I. Cold Application and Breathing Exercises to Reduce Pain and Anxiety During Chest Tube Removal. American Journal of Nursing Science. 2017; 6(4): 285-292

Moran J, Guinan E, McCormick P, Larkin J, Mockler D, Hussey J, et al. The ability of prehabilitation to influence postoperative outcome after intra-abdominal operation: A systematic review and meta-analysis. Surgery. 2016 Nov;160(5):1189-201.

Murias JM, Kowalchuk JM, Paterson DH. Time course and mechanisms of adaptations in cardiorespiratory fitness with endurance training in older and young men. J Appl Physiol (1985). 2010;108(3):621-627.

Nardi P, Pellegrino A, Pisano C, et al. The effect of preoperative respiratory physiotherapy and motor exercise in patients undergoing elective cardiac surgery: short-term results. KardiochirTorakochirurgia Pol. 2019;16(2):81-87.

Odor PM, Bampoe S, Gilhooly D, Creagh-Brown B, Moonesinghe SR. Perioperative interventions for prevention of postoperative pulmonary complications: systematic review and meta-analysis. BMJ. 2020;368:m540.

Passarelli R, Tossella R, Souza H, Gastaldi AC. Assessment of inspiratory muscle strength (IPmax) during weaning from mechanical ventilation in neurological patients admitted to the intensive care unit. Physiotherapy Search.2011; 18: 48–52.

Perelló-Díez M, Paz-Lourido B. Prevention of postoperative pulmonary complications through preoperative physiotherapy interventions in patients undergoing coronary artery bypass graft: literature review. J PhysTher Sci. 2018;30(8):1034-1038.

Peric Z, Desnica L, Durakovic´ N, et al. Which questionnaires should we use to evaluate quality of life in patients with chronic graft-vs-host disease? Croat Med J 2016; 57: 6–15.

Pucci G, Rech C, Ferminio R, et al. Association between physical activity and quality of life in adults. Rev Sau´dePublica 2012; 46: 1–12.

Rafii F, Mohammadi Fakhar F, Jamshidi Orak R, Inanloo M. Effect of Jaw relaxation on pain intensity of burn dressing. Iran J Critical Care Nurs. 2010; 3: 51–6.

RevMan [Internet]. [cited 2022 Dec 24]. Available from: https://training.cochrane.org/online-learning/core-software/revman

Rodrigues SN, Henriques HR, Henriques MA. Effectiveness of preoperative breathing exercise interventions in patients undergoing cardiac surgery: A systematic review. Revista portuguesa de cardiologia. 2021;40(3):229-244.

Roman MA, Rossiter HB, Casaburi R. Exercise, ageing and the lung. Eur Respir J. 2016;48(5):1471-1486.

Sabaté S, Mazo V, Canet J. Predicting postoperative pulmonary complications: implications for outcomes and costs. Curr Opin Anaesthesiol. 2014;27:201-9.

Saglam M, Arikan S, Savci S, Inal-Ince D, Bosnak-Guclu M, Degirmence B, et al. Relationship between respiratory muscle strength, functional capacity and quality of life in pre-operative cardiac surgery patients, Eur Respir Rev. 2008; 17:39–40.

Santa-Mina D, Clarke H, Ritvo P, et al. Effect of totalbodyprehabilitation on postoperative outcomes: A systematic review and meta-analysis. Physiotherapy 2014; 100: 196–207.

Sauls J. The Use of Ice for Pain Associated with Chest Tube Removal. Pain Manag Nurs. 2002; 3:44-52.

Savci S, Degirmenci B, Saglam M, Arikan H, Inal-Ince D, Turan HN, et al. Short-term effects of inspiratory muscle training in coronary artery bypass graft surgery: a randomized controlled trial. Scandinavian cardiovascular journal. 2011 Oct;45(5):286–93.

Schulz KF, Altman DG, Moher D; CONSORT Group. CONSORT 2010 statement: updated guidelines for reporting parallel group randomised trials. BMJ. 2010 23;340:c332.

Sebio Garcia R, Yáñez Brage MI, Giménez Moolhuyzen E, Granger CL, Denehy L. Functional and postoperative outcomes after preoperative exercise training in patients with lung cancer: a systematic review and meta-analysis. Interactive cardiovascular and thoracic surgery. 2016 Sep;23(3):486-97.

Shahood H, Pakai A, Rudolf K, Bory E, Szilagyi N, Sandor A, Zsofia V. The effect of preoperative chest physiotherapy on oxygenation and lung function in cardiac surgery patients: a randomized controlled study. Ann Saudi Med. 2022 Jan-Feb;42(1):8-16.

Shakuri S, Yaghoub S, Taghizadieh A, Sabbagh-Jadid H, Soleymani J, Sahebi L, et al. Effect of respiratory rehabilitation before open cardiac surgery on respiratory function: A Randomized Clinical Trial. J Cardiovasc Thorac Res. 2015; 7: 13–17.

Shander A, Fleisher LA, Barie PS, Bigatello LM, Sladen RN, Watson CB. Clinical and economic burden of postoperative pulmonary complications: patient safety summit on definition, risk-reducing interventions, and preventive strategies. Crit Care Med. 2011;39:2163-72.

Sobrinho MT, Guirado GN, Silva MA. Preoperative therapy restores ventilatory parameters and reduces length of stay in patients undergoing myocardial revascularization. Rev Bras Cir Cardiovasc. 2014;29(2):221-228.

Sweity E, Alkaissi A, Othman W, Salahat A. Preoperative incentive spirometry for preventing postoperative pul-monary complications in patients undergoing coronary artery bypass graft surgery: A prospective, randomized controlled trial. J Cardiothorac Surg. 2021, 16, 1–11.

Thybo Karanfil EO, Møller AM. Preoperative inspiratory muscle training prevents pulmonary complications after cardiac surgery - a systematic review. Dan Med J. 2018;65(3):A5450.

Tung HH, Shen SF, Shih CC, Chiu KM, Lee JY, Liu CY. Effects of a preoperative individualized exercise program on selected recovery variables for cardiac surgery patients: A pilot study. Journal of Saudi Heart Association. 2012 Jul;24(3):153-61.

Valkenet K, de Heer F, Backx FJ, Trappenburg JC, Hulzebos EH, Kwant S, van Herwerden LA, van de Port IG. Effect of inspiratory muscle training before cardiac surgery in routine care.PhysTher. 2013;93:611–619.

Valkenet K, Trappenburg JCA, Hulzebos EH, van Meeteren NLU, Backx FJG. Effects of a pre-operative home-based inspiratory muscle training programme on perceived health-related quality of life in patients undergoing coronary artery bypass graft surgery. Physiotherapy. 2017 Sep;103(3):276-282.

Valkenet K, van de Port IG, Dronkers JJ, de Vries WR, Lindeman E, Backx FJ. The effects of preoperative exercise therapy on postoperative outcome: a systematic review. Clinical Rehabilitation. 2011; 25(2): 99-111.

Westerdahl E, Lindmark B, Almgren SO, Tenling A. Chest physiotherapy after coronary artery bypass graft surgery--a comparison of three different deep breathing techniques. J Rehabil Med. 2001;33(2):79-84.

Westerdahl E, Lindmark B, Eriksson T, Friberg O, Hedenstierna G, Tenling A. Deep-breathing exercises reduce atelectasis and improve pulmonary function after coronary artery bypass surgery. Chest. 2005;128(5):3482-8.

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List of Tables

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Related to the dissertation

1. Shahood H, Pakai A, Kiss R, Eva B, Szilagyi N, Sandor A, Verzar Z. Effectiveness of Preoperative Chest Physiotherapy in Patients Undergoing Elective Cardiac Surgery, a Systematic Review and Meta-Analysis. *Medicina*. 2022; 58(7):911. Impact Factor: 2.948 (2021)

2. Shahood H, Pakai A, Kiss R, Eva B, Szilagyi N, Sandor A, Verzar Z. The effect of preoperative chest physiotherapy on oxygenation and lung function in cardiac surgery patients: a randomized controlled study. *Ann Saudi Med.* 2022 Jan-Feb;42(1):8-16. Impact Factor: 1.707 (2021)

3. Shahood H, Khatatbeh H, Pakai A, Verzar Z. The preoperative chest physiotherapy and the amount of oxygen needed after CABG surgery: A randomized controlled trial (under publication).

4. Shahood H. The Effect of Cold Application On Pain Due To Chest Tube Removal. Paripex - Indian Journal of Research. 2019;8(1).

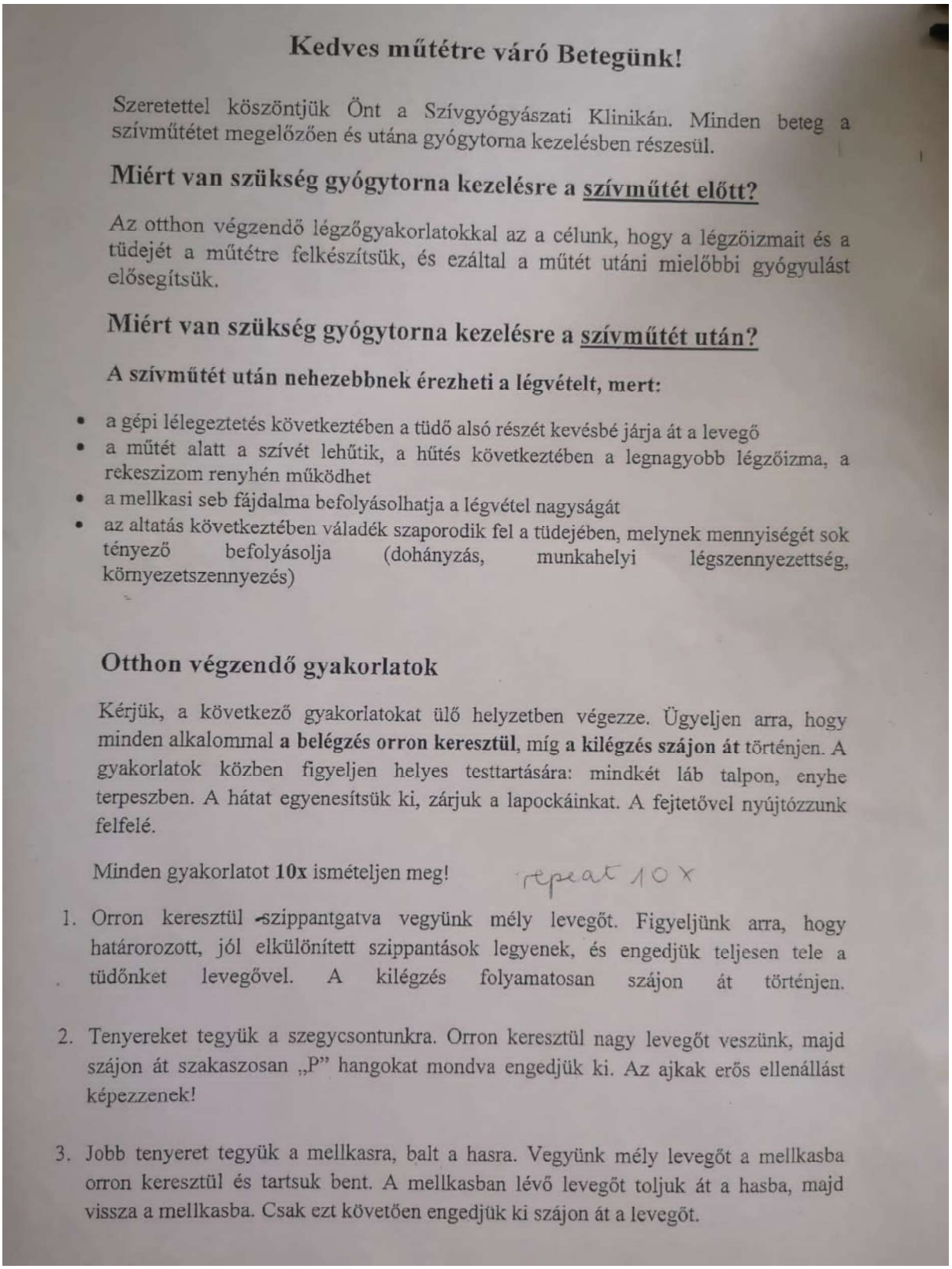
In other topics

1. Pethőné TI, Ahmann M, Shahood H, Bálint C, Pakai A. Trends in ventilator associated pneumonia in context using closed suction system. Nővér (A Hungarian Journal of Nursing Theory and Practice). 2021;34(1):22-29.

2. Pakai A, Verzar Z, Shahood H, Bálint C, Pethőné TI. Factors for Ventilator Associated Pneumonia - Literature Review (under publication).

3. Pakai A, Khatatbeh H, Shahood H. Attitudes toward COVID-19 pandemic and vaccination: A comparison of health and non-health workers in Hungary (under publication).

Breathing exercises



Kedves műtétre váró Betegünk!

Szeretettel köszöntjük Önt a Szívgyógyászati Klinikán. Minden beteg a szívműtétet megelőzően és utána gyógytorna kezelésben részesül.

Miért van szükség gyógytorna kezelésre a szívműtét előtt?

Az otthon végzendő légzőgyakorlatokkal az a célunk, hogy a légzőizmait és a tüdejét a műtétre felkészítsük, és ezáltal a műtét utáni mielőbbi gyógyulást elősegítsük.

Miért van szükség gyógytorna kezelésre a szívműtét után?

A szívműtét után nehezebbnek érezheti a légvételt, mert:

- a gépi lélegeztetés következtében a tüdő alsó részét kevésbé járja át a levegő
- a műtét alatt a szívét lehűtik, a hűtés következtében a legnagyobb légzőizma, a rekeszizom renyhén működhet
- a mellkasi seb fájdalma befolyásolhatja a légvétel nagyságát
- az altatás következtében váladék szaporodik fel a tüdejében, melynek mennyiségét sok tényező befolyásolja (dohányzás, munkahelyi légszennyezettség, környezetszennyezés)

Otthon végzendő gyakorlatok

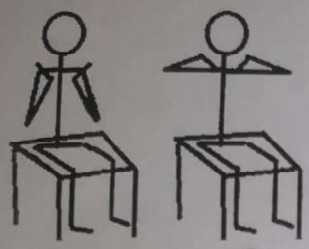
Kérjük, a következő gyakorlatokat ülő helyzetben végezze. Ügyeljen arra, hogy minden alkalommal **a belégzés orron keresztül**, míg **a kilégzés szájon át** történjen. A gyakorlatok közben figyeljen helyes testtartására: mindkét láb talpon, enyhe terpeszben. A hátat egyenesítsük ki, zárjuk a lapockáinkat. A fejtetővel nyújtózzunk felfelé.

Minden gyakorlatot **10x** ismételjen meg! repeat 10 x

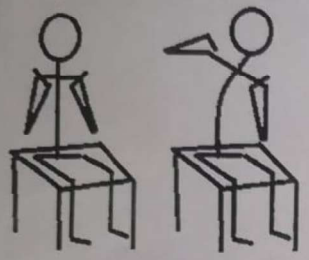
1. Orron keresztül szippantgatva vegyünk mély levegőt. Figyeljünk arra, hogy határorozott, jól elkülönített szippantások legyenek, és engedjük teljesen tele a tüdőnket levegővel. A kilégzés folyamatosan szájon át történjen.

2. Tenyereket tegyük a szegycsontunkra. Orron keresztül nagy levegőt veszünk, majd szájon át szakaszosan „P" hangokat mondva engedjük ki. Az ajkak erős ellenállást képezzenek!

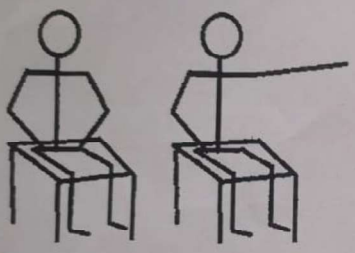
3. Jobb tenyeret tegyük a mellkasra, balt a hasra. Vegyünk mély levegőt a mellkasba orron keresztül és tartsuk bent. A mellkasban lévő levegőt toljuk át a hasba, majd vissza a mellkasba. Csak ezt követően engedjük ki szájon át a levegőt.



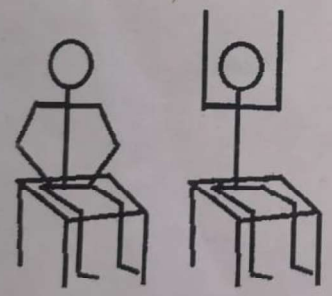
4. Tegyük mindkét kezet vállra, könyökök a törzs mellett helyezkednek el. Innen oldalra vállmagasságig emeljük fel a két könyököt, közben orron keresztül nagy levegőt veszünk, majd a könyököket visszaengedjük a törzsünk mellé miközben szájon át kiengedjük a levegőt.



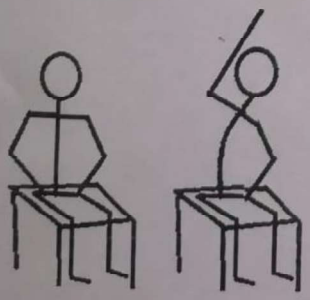
5. A kezek a vállakon vannak, könyökök a törzs mellett helyezkednek el. Jobb könyököt oldalra emeljük fel vállmagasságig miközben törzsünkkel hajoljunk el balra és orron keresztül vegyünk mély levegőt. Kilégzés alatt a könyökünket engedjük vissza a törzsünk mellé és egyenesedjünk ki. Végezzük el a gyakorlatot a másik oldalra is.



6. Mindkét kéz csípőn. Jobb karral nyújtózzunk hátra vállmagasságban, a fej és a törzs kövesse a kar mozgását, közben orron keresztül nagy levegőt veszünk. Kilégzés alatt visszafordulunk, tenyeret ismét csípőre tesszük. Végezzük el a gyakorlatot a másik oldalra is.



7. Mindkét kéz csípőn. Mindkét kart egyenesen felnyújtjuk magasra fül mellé, közben orron keresztül nagy levegőt veszünk. Majd visszaengedjük a kezeket csípőre és szájon át kiengedjük a levegőt.



8. Mindkét kéz csípőn. Jobb karral nyújtózzunk fel fül mellé, és törzzsel hajoljunk balra. Közben orron keresztül erőteljes belégzést végezzünk. Kilégzés alatt törzsünket egyenesítsük ki, és a kezet tegyük vissza csípőre. Végezzük el a gyakorlatot a másik oldalra is.

Kedves Egészségére!

A gyakorlatok végzése napi 2-3x 15 percet vesz igénybe.

Jó felkészülést kívánnak a Szívgyógyászati Klinika gyógytornászai!

Kérdéseire készségesen válaszolunk! Telefon: 72/536-000/5662

Submission of the doctoral dissertation and declaration of the

originality of the dissertation

The undersigned,
Name: **Hadel**
Maiden name: **Hadel**
Mother's maiden name: **Majd**
Place and time of birth: **Syria- Tartous 11/11/1987**

on this day submitted my doctoral dissertation entitled: **The Effect of Preoperative Chest Physiotherapy on Oxygenation and Lung Functions among Open Heart Surgery Patients**

to the
PR-**2**, **Cardiovascular Health Science** Programme
of the Doctoral School of Health Sciences, Faculty of Health Sciences, University of Pécs.
Names of the supervisor(s): **Prof.dr.Verzár Zsófia**
Dr. habil. Annamária Pakai

At the same time, I declare that
- I have not submitted my doctoral dissertation to any other Doctoral School (neither in this country nor abroad),
- my application for degree earning has not been rejected in the past two years,
- in the past two years I have not had unsuccessful doctoral procedures,
- my doctoral degree has not been withdrawn in the past five years,
- my dissertation is independent work, I have not presented others' intellectual work as mine, the references are definite and full, on preparation of the dissertation I have not used false or falsified data.

Dated: **12 .01.2023**

signed by Candidate

Supervisor

Co-supervisor