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Editorial Board Member of *World Journal of Clinical Cases*, Jina Yun, MD, PhD, Assistant Professor, Division of Hematology-Oncology, Department of Internal Medicine, Soonchunhyang University Bucheon Hospital, Soonchunhyang University School of Medicine, Bucheon 14584, South Korea. 19983233@schmc.ac.kr

AIMS AND SCOPE

The primary aim of *World Journal of Clinical Cases* (*WJCC*, *World J Clin Cases*) is to provide scholars and readers from various fields of clinical medicine with a platform to publish high-quality clinical research articles and communicate their research findings online.

WJCC mainly publishes articles reporting research results and findings obtained in the field of clinical medicine and covering a wide range of topics, including case control studies, retrospective cohort studies, retrospective studies, clinical trials studies, observational studies, prospective studies, randomized controlled trials, randomized clinical trials, systematic reviews, meta-analysis, and case reports.

INDEXING/ABSTRACTING

The *WJCC* is now abstracted and indexed in Science Citation Index Expanded (SCIE, also known as SciSearch®), Journal Citation Reports/Science Edition, Current Contents®/Clinical Medicine, PubMed, PubMed Central, Scopus, Reference Citation Analysis, China National Knowledge Infrastructure, China Science and Technology Journal Database, and Superstar Journals Database. The 2022 Edition of Journal Citation Reports® cites the 2021 impact factor (IF) for *WJCC* as 1.534; IF without journal self cites: 1.491; 5-year IF: 1.599; Journal Citation Indicator: 0.28; Ranking: 135 among 172 journals in medicine, general and internal; and Quartile category: Q4. The *WJCC*'s CiteScore for 2021 is 1.2 and Scopus CiteScore rank 2021: General Medicine is 443/826.

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META-ANALYSIS

Effect of preoperative inspiratory muscle training on postoperative outcomes in patients undergoing cardiac surgery: A systematic review and meta-analysis

Jing Wang, Yu-Qiang Wang, Jun Shi, Peng-Ming Yu, Ying-Qiang Guo

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Jing Wang, Yu-Qiang Wang, Jun Shi, Ying-Qiang Guo, Department of Cardiovascular Surgery, Sichuan University West China Hospital, Chengdu 610041, Sichuan Province, China

Peng-Ming Yu, Rehabilitation Medicine Center, West China Hospital, Sichuan University, Chengdu 610041, Sichuan Province, China

Corresponding author: Ying-Qiang Guo, MD, PhD, Chief Doctor, Doctor, Surgeon, Department of Cardiovascular Surgery, Sichuan University West China Hospital, No. 37 Guoxue Lane, Wuhou District, Chengdu 610041, Sichuan Province, China. drguoyq@wchscu.cn

Abstract

BACKGROUND

Cardiovascular disease is the most prevalent disease worldwide and places a great burden on the health and economic welfare of patients. Cardiac surgery is an important way to treat cardiovascular disease, but it can prolong mechanical ventilation time, intensive care unit (ICU) stay, and postoperative hospitalization for patients. Previous studies have demonstrated that preoperative inspiratory muscle training could decrease the incidence of postoperative pulmonary complications.

AIM

To explore the effect of preoperative inspiratory muscle training on mechanical ventilation time, length of ICU stay, and duration of postoperative hospitalization after cardiac surgery.

METHODS

A literature search of PubMed, Web of Science, Cochrane Library, EMBASE, China National Knowledge Infrastructure, WanFang, and the China Science and Technology journal VIP database was performed on April 13, 2022. The data was independently extracted by two authors. The inclusion criteria were: (1) Randomized controlled trial; (2) Accessible as a full paper; (3) Patients who received cardiac surgery; (4) Preoperative inspiratory muscle training was implemented in these patients; (5) The study reported at least one of the following: Mechanical ventilation time, length of ICU stay, and/or duration of postoperative hospitalization; and (6) In English language.

RESULTS

We analyzed six randomized controlled trials with a total of 925 participants. The pooled mean difference of mechanical ventilation time was -0.45 h [95% confidence interval (CI): -1.59-0.69], which was not statistically significant between the intervention group and the control group. The pooled mean difference of length of ICU stay was 0.44 h (95%CI: -0.58-1.45). The pooled mean difference of postoperative hospitalization was -1.77 d in the intervention group *vs* the control group [95%CI: -2.41-(-1.12)].

CONCLUSION

Preoperative inspiratory muscle training may decrease the duration of postoperative hospitalization for patients undergoing cardiac surgery. More high-quality studies are needed to confirm our conclusion.

Key Words: Preoperative inspiratory muscle training; Cardiac surgery; Heart surgery; Mechanical ventilation; Intensive care unit; Duration of postoperative hospitalization

Core Tip: For cardiac surgery patients, the use of inspiratory muscle training could reduce the incidence of postoperative pulmonary complications according to previous research. Our study demonstrated that it could shorten the duration of postoperative hospitalization and thus may decrease overall costs. More research is needed to explore the effect of inspiratory muscle training on mechanical ventilation time and length of intensive care unit stay.

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INTRODUCTION

Cardiovascular disease (CVD) has a high incidence rate and high mortality worldwide. CVD has been one of the most prevalent causes of death in the United States since 1975, accounting for 25% of all deaths[1]. The World Health Organization reported that in 2015 CVD caused an estimated 17.7 million deaths globally, making CVD the most prevalent cause of death worldwide. The economic burden of CVD is greater than that of Alzheimer's disease and diabetes, with calculated indirect costs of $237 billion per year and a projected increase to $368 billion by 2035[2]. A study reported a national economic loss of $8.8 trillion from 2012 to 2030 due to CVD in China[3]. Cardiac surgery is an important treatment for coronary heart disease and other structural heart diseases. Due to the complex surgical procedures, surgical trauma, and long surgery time, patients often need postoperative mechanical ventilation and intensive care unit (ICU) admission for observation and further treatment. Meanwhile, postoperative pulmonary complications (PPCs) are one of the major causes of prolonged hospitalization and death[4,5]. Indeed, pulmonary complications following coronary artery bypass graft (CABG) operation were reported to be associated with significantly longer hospital stays (8.2 d *vs* 10.0 d, 95% confidence interval [CI]: 0.3-3.3)[6]. The incidence of PPCs prolongs the hospitalization length and thus increases the hospitalization expenses. Vonlanthen *et al*[7] performed a cost analysis of 1200 patients undergoing major surgery and revealed that costs increased with the severity of postoperative complications. This increase in costs is up to 5 times that of a similar surgery without complications. Thompson *et al*[8] included 618495 patients who underwent an intra-abdominal surgery. They found that postoperative hospital-acquired pneumonia increased the mean hospitalization length by 11 d, which translated to a mean increase in total hospital charges of $31000 (study performed in the year 2000). Other studies have also demonstrated that postoperative complications can increase the expense of surgery[9-11].

Preoperative inspiratory muscle training (IMT) has attracted increasing attention from doctors. Previous studies demonstrated that preoperative IMT can reduce the incidence of PPCs. Hulzebos *et al*[12] reported that preoperative IMT reduced the incidence of PPCs and the postoperative stay in hospital in patients at high risk of developing pulmonary complications after CABG surgery. Katsura *et al*[13] found evidence that preoperative IMT was associated with a reduction in postoperative atelectasis, pneumonia, and duration of hospital stay in adults after cardiac and major abdominal surgery. Fagevik Olsén *et al*[14] reported that preoperative physiotherapy education and training sessions can reduce PPC incidence in patients receiving open major abdominal surgery. Boden *et al*[15] confirmed the findings in their trial in 2017. However, there are few studies reporting the effects of preoperative IMT on length of mechanical ventilation, length of ICU stay, and duration of postoperative hospitalization. Our study aimed to answer the following questions: (1) Does preoperative IMT shorten the time of mechanical ventilation and ICU stay; and (2) Does preoperative IMT reduce the duration of postoperative hospitalization and thus save money for patients?

MATERIALS AND METHODS

Literature search

We searched the English literature databases, which included PubMed, Web of Science, Cochrane Library, and EMBASE, and Chinese literature databases, which included China National Knowledge Infrastructure, WanFang, and China Science and Technology journal VIP. Our search strategies were composed of: (1) Patients (experimental: Cardiac surgery/heart surgery); (2) Intervention (preoperative IMT/preoperative respiratory muscle training); (3) Control (-); and (4) Outcome (mechanical ventilation/MV/intensive care unit/ICU/postoperative stay in hospital/duration of postoperative hospitalization). We searched the databases through April 13, 2022. Two researchers independently assessed the eligibility of papers by title and abstract. When there was insufficient information to judge the qualification of the study in the title and abstract, the whole paper was assessed. When the two researchers disagreed, a third researcher was consulted to reach consensus.

Study selection

The inclusion criteria were: (1) Randomized controlled trial; (2) Accessible as full paper; (3) Cardiac surgery patient(s); (4) Preoperative IMT; (5) Data on at least one of the following: Mechanical ventilation time, length of ICU stay, and/or duration of postoperative hospitalization; and (6) In English language.

Quality of study characteristics

We used the Cochrane bias risk assessment tool in Review Manager (RevMan) computer program version 5.4, which is a reliable tool for the assessment of the risk of bias in randomized controlled trials in systematic reviews, to assess the bias risk of the included studies[16].

Data extraction

Data on author, year, journal, and country of the studies were obtained. Data on patient age, patient sex, type of surgery, intervention (including strength, frequency, time), and outcomes (mechanical ventilation time, length of ICU stay, and duration of postoperative hospitalization) were collected. The data were collected from tables or from the main text. For example, we collected the duration of postoperative hospitalization from the study by Hulzebos *et al*[12] and from the main text in the study by Valkenet *et al*[6]. However, some data were reported in ranges or interquartile ranges, such as those in the study of Hulzebos *et al*[12]. For these studies, we used the tool on the website (http://www.math.hkbu.edu.hk/~tongt/papers/median2mean.html) to estimate the sample mean and standard deviation from the sample size, median, range, and/or interquartile range. The data were independently extracted by two authors (Wang J and Wang YQ).

Statistical analysis

This meta-analysis aimed to evaluate the effect of IMT on mechanical ventilation time, length of ICU stay, and postoperative hospitalization in cardiac surgery patients. RevMan5.4 and Stata statistical software (Release 14; StataCorp LP, College Station, TX, United States) were used to perform the statistical analyses; of note, the results obtained from each program were the same. We chose the randomized effects model to analyze the data. The principal summary measurement used was the pooled mean difference (95%CI). We provided forest plots for every outcome.

RESULTS

The flowchart of selected studies is presented in Figure 1. After the initial search, 311 citations were selected. After a review of abstracts and full-text articles, six trials[6,12,17-20] met the inclusion criteria. The risk of bias assessment of the included studies is presented in Figure 2.

Characteristics of included studies

The characteristics of the included trials are presented in Table 1. A total of 925 participants were involved in the six included studies. The sample sizes of the included trials ranged from 43 to 276, consisting primarily of male participants. The integrated age was 66.97 years, and the sex ratio in every study showed no significant effect. The intervention strategies and control methods were similar in each

Table 1 Characteristics of the six included studies

No.	Ref.	Country	Intervention	Control	Intervention group			Control group		
					Patients (male: female)	Mean age	Surgery type	Patients (male: female)	Mean age	Surgery type
1	Hulzebos *et al*[12], 2006	Netherlands	Threshold IMT + incentive spirometry + education in an active cycle of breathing techniques + forced expiration techniques	Usual care (*i.e.* instruction on deep breathing maneuvers, coughing, and early mobilization) + postoperative incentive spirometry, chest physical therapy, and mobilization scheme	139 (108:31)	66.5 (9.0)	CABG: 139	137 (107:30)	67.3 (9.2)	CABG: 137
2	Savci *et al* [17], 2011	Turkey	Threshold IMT + mobilization + active exercises of upper and lower limbs + breathing exercises + coughing techniques	Usual care (mobilization, active exercises of upper and lower limbs, breathing exercises, and coughing techniques)	22 (19:3)	62.82 (8.69)	CABG: 22	21 (19:2)	57.48 (11.48)	CABG: 21
3	Moises *et al*[18], 2014	Brazil	Threshold IMT + breathing exercises + postoperative physical therapy	Guidelines ward routine + postoperative physical therapy	35 (23:12)	58.90 ± 9.53	CABG: 35	35 (29:6)	61.40 ± 8.43	CABG: 35
4	Valken *et al*[6], 2016	Netherlands	Threshold IMT + incentive spirometry + education (deep breathing maneuvers, coughing, and early mobilization)	Postoperative deep breathing maneuvers, coughing, and early mobilization incentive spirometry and chest physical therapy	119 (93:26)	66 (9.2)	CABG: 99; CABG + valve:20	116 (93:23)	67.5 (9.7)	CABG: 87; CABG + valve: 29
5	Chen *et al* [19], 2019	China	Threshold IMT + usual care (education coughing, and early mobilization) and abdominal breathing training + postoperative chest physical therapy and mobilization scheme	Threshold IMT [the intensity was fixed at the minimum load of the device (9 cmH2O)] + usual care (education coughing and early mobilization) and abdominal breathing training + postoperative chest physical therapy and mobilization scheme	98 (73:25)	61.68 ± 8.12	CABG: 69; valve: 18; CABG + valve: 11	99 (68:31)	61.68 ± 7.73	CABG: 70; valve: 21; CABG + valve: 8
6	Weber *et al*[20], 2021	Germany	Threshold IMT + walking below the threshold of subjective exhaustion + mobilization protocol and individual physio-therapy	Postoperative physio-therapy	58 (27:31)	82.2 ± 5.8	TAVR: 58	50 (26:24)	81.7 ± 5.0	TAVR: 50

For threshold inspiratory muscle training, patients must generate a preset pressure to allow airflow for each breath. Once that threshold is achieved, inspiratory flow is not dependent on patient effort. This means that threshold loading is the easiest of these inspiratory muscle training methods to standardize and prescribe for patients. CABG: Coronary artery bypass grafting; IMT: Inspiratory muscle training; TAVR: Transcatheter aortic valve replacement.

trial (Table 2). There was no significant difference in the type of operation. Most patients received CABG, and some of them received valve surgery [including transcatheter aortic valve replacement (TAVR)].

Outcome

Mechanical ventilation time: Three studies[17-19] reported on the duration of mechanical ventilation. The pooled mean difference of -0.45 h (95%CI: -1.59-0.69) and low heterogeneity (I^2 =0) showed no statistically significant effect on mechanical ventilation time (Figure 3).

Length of ICU stay: Data from four studies[17-20] indicated a nonsignificant effect on the length of ICU stay with a pooled mean difference of 0.44 h (95%CI: -0.58-1.45) and low heterogeneity (I^2 = 0) (Figure 4). Excluding patients who received TAVR did not affect the results (Figure 5).

Duration of postoperative hospitalization: A meta-analysis of six trials[6,12,17-20] reporting the length of postoperative hospitalization yielded a pooled mean difference of -1.77 d [95%CI: -2.41-(-1.12)] for the intervention group *vs* the control group. This difference was statistically significant (Figure 6).

Table 2 Inspiratory muscle training used in each study

No.	Ref.	Length	Frequency	Duration	Supervision	Intensity
1	Hulzebos *et al*[12], 2006	≥ 2 wk preoperatively	Once a day	20 mins	6 times a week without supervision and once a week with supervision	30% of MIP. Resistance increases incrementally, based on the RPE scored on the Borg scale
2	Savci *et al* [17], 2011	5 d preoperatively + 5 d postoperatively	Twice a day	30 mins	Each session was under the supervision of a physical therapist	15% of MIP. The resistance was increased incrementally between 15% and 45% based on patient's tolerance in the following days
3	Moises *et al* [18], 2014	Preoperative (length not mentioned)	Once a day	20 mins	Each session was under supervision	40% of MIP. Intensity increase not mentioned
4	Valkenet *et al*[6], 2016	Not mentioned	Once a day	20 min	6 times a week without supervision and once a week with supervision	30% of MIP. Increased incrementally based on the RPE as scored on the Borg scale. If patients recorded an RPE score < 5 after a training session, they were instructed to increase the inspiratory load of the threshold device by 5% before the next training session. The threshold load was unchanged for RPE scores ≥ 5
5	Chen *et al* [19], 2019	5 d preoperatively	Twice a day	20 min	Each session was under the supervision of a physical therapist	30% of MIP. Increased incrementally, based on the RPE scored on the Borg18 scale. If the RPE was less than 5, the resistance of the inspiratory threshold trainer was then increased incrementally by 5%. Training loads were adjusted to maintain 30% of the maximal inspiratory pressure every day
6	Weber *et al* [20], 2021	≥ 2 wk preoperatively	Once a day	20 min	Not mentioned	Not mentioned

MIP: Maximum inspiratory pressure; RPE: Rate of perceived exertion.

Excluding patients who received TAVR did not affect the results (Figure 7).

DISCUSSION

This is the first systematic review and meta-analysis to explore the effect of preoperative IMT on mechanical ventilation time, length of ICU stay, and duration of postoperative hospitalization after cardiac surgery.

Preoperative IMT

A summary of IMT in each study is presented in Table 2. All studies used threshold IMT. Patients received training greater than or equal to 2 wk, once a day, and lasting 20 min in the study of Hulzebos *et al*[12] and that of Weber *et al*[20]. Meanwhile, 5 d of preoperative training, twice a day, and lasting 30 min or 20 min was used in the study of Savci *et al*[17] and that of Chen *et al*[19], respectively. All patients were under supervision of a physical therapist in the studies. Studies by Hulzebos *et al*[12], Valkenet *et al*[6], and Chen *et al*[19] started the training with 30% of the maximum inspiratory pressure. Savci *et al* [17] started training with 15% of maximum inspiratory pressure, and Moises *et al*[18] with 40% of maximum inspiratory pressure. Weber *et al*[20] did not mention the starting intensity. We found no effect of preoperative IMT on mechanical ventilation time or length of ICU stay in cardiac surgery patients. Snowdon *et al*[21] concluded in their systematic review that preoperative intervention shortened the time to extubate from mechanical ventilation by a pooled mean difference of 0.14 d (95%CI: 0.01-0.26), which was different from our result. Interventions in their included studies were diversified and included anesthesia clinics or preadmission clinics, IMT, education booklets, *etc*. This likely explains the differences between our study and theirs. Because of the few studies reporting on these two outcomes, any conclusions should be made with caution.

Our study found that preoperative IMT did have a statistically significant effect on the duration of postoperative hospitalization. Katsura *et al*[13] reported that preoperative IMT could reduce the duration of hospitalization in patients receiving cardiac and major abdominal surgery. However, they included mostly abdominal surgery, which was different from our study. Snowdon *et al*[21] reported that preoperative intervention reduced hospitalization for elderly patients (> 63 years), with a pooled mean difference of -1.32 d [95%CI: -2.36-(-0.28)], similar to our study. Cook *et al*[22] reported that preoperative threshold IMT had the potential to reduce postoperative hospitalization and pulmonary complications after cardiac surgery, which was the same as our study. However, their study did not include the studies of Valkenet *et al*[6] and Weber *et al*[20]. Reducing the duration of hospitalization may

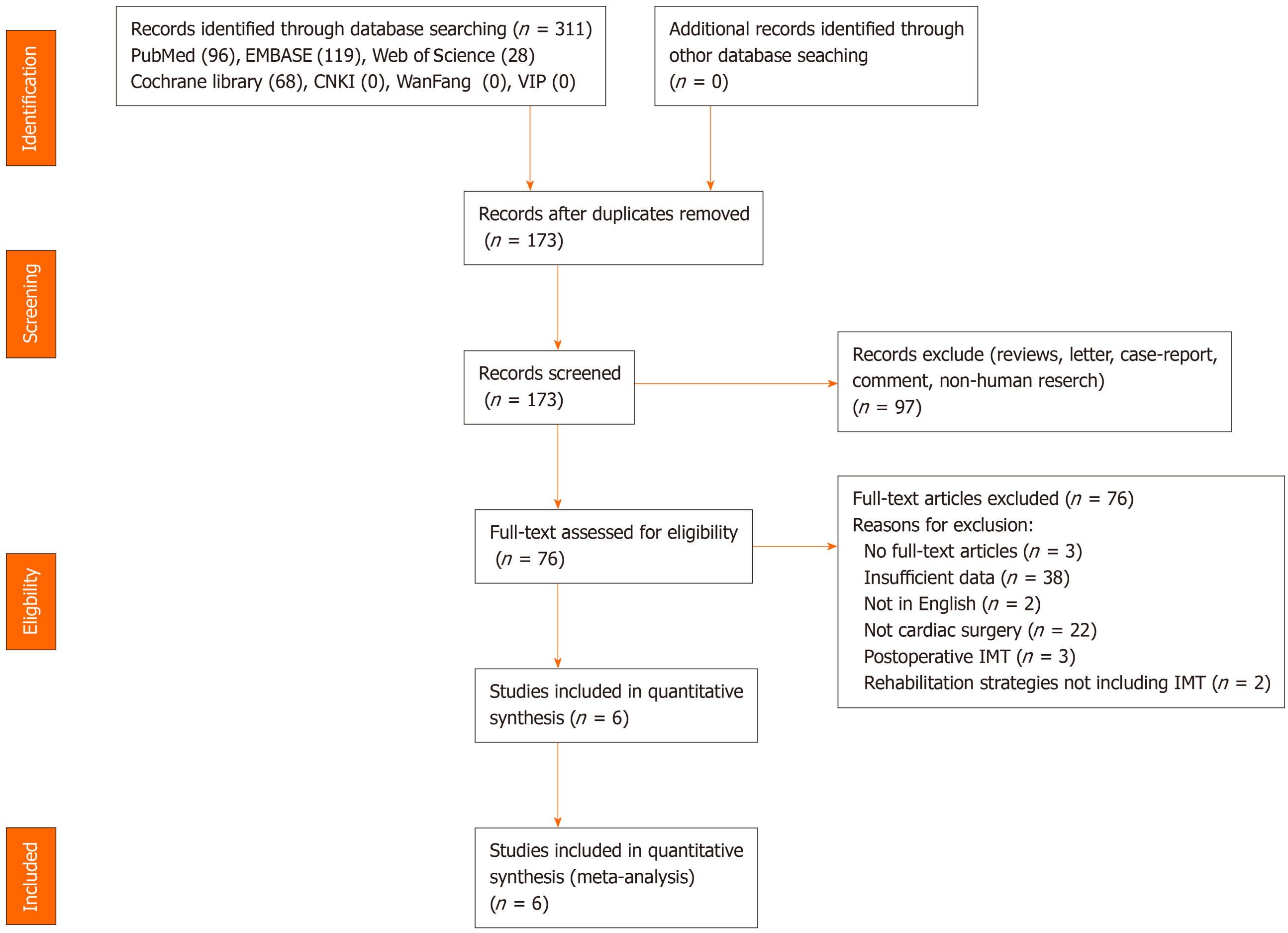

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Figure 1 Flowchart of literature search. After the initial search, 311 articles were selected. After a review of abstracts and full-text articles, only six trials met the inclusion criteria. CNKI: Chinese National Knowledge Infrastructure; IMT: Inspiratory muscle training.

reduce hospitalization expenses for patients. It has been hypothesized that preoperative IMT would increase the muscle strength of the patients and lead to less PPCs. Several studies (summarized in the Introduction section) have confirmed this hypothesis. We hypothesized that less postoperative complications and decreased hospitalization would in turn decrease hospitalization expenses. With the shorter postoperative stay in the hospital, patients may pay less for medicines, nursing, room and board, *etc*. Further cost analysis studies should be conducted to confirm our hypothesis.

With the popularity of the use of diagnosis-related groups, medical costs have caught the increasing attention of doctors and patients. In a health economic analysis of a randomized trial implemented by Boden *et al*[23] in Australia, participants were randomly divided into two groups (intervention group and control group). The intervention involved respiratory education and breathing exercise training with a physiotherapist. The control group received the information booklet only. They found that the mean estimate of net savings provided a return on investment of approximately 800% ($8 saved by the hospital for every $1 spent on physiotherapy to provide education and breathing exercise training to patients before surgery). This means that from the hospital's perspective, preoperative physiotherapy was cost-effective. A meta-analysis by Takura *et al*[24] found that cardiac rehabilitation (CR) significantly improved cost/quality-adjusted life-years in the CR arm compared with the usual care arm [standardized mean difference: -0.31, 95%CI: -0.53-(-0.09)], which means that CR is cheaper and more effective than usual care. Preoperative IMT is one method of CR, and we can speculate that it could also decrease hospital expenses.

Limitations

The most important limitation of our study was that few studies met our inclusion criteria. This led to a small sample size, which may influence the precision and accuracy of our study. At the same time, we did not obtain the patient level data from the studies. The second limitation was the heterogeneity. There were some differences among the interventions in these included studies. The length, frequency, duration, intensity, and supervision of IMT were different in each study. The details of each intervention are shown in Table 2. These differences could lead to heterogeneity of our results, and we

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Figure 2 Risk of bias summary for each included study.

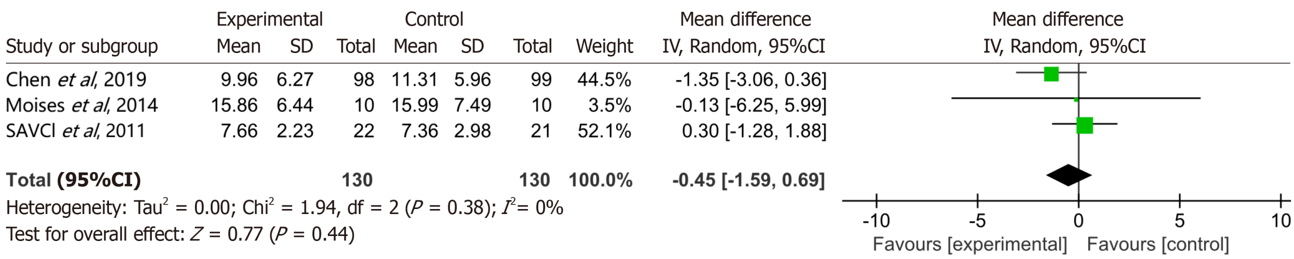

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Figure 3 Effect of preoperative inspiratory muscle training on mechanical ventilation time. The pooled mean difference of -0.45 h (95%CI: -1.59 to 0.69) and low heterogeneity (I^2 = 0) showed no statistically significant effect on mechanical ventilation time in patients with preoperative inspiratory muscle training after cardiac surgery. SD: Standard deviation.

cannot determine which training method is the best. In addition, the standards for extubating and hospital discharge are different in each country, hospital, and even doctor. These factors would lead to heterogeneity. The third limitation was that the type of operation in the included studies was mostly CABG, which did not include other cardiac surgeries (*e.g.*, valve replacement and aortic dissection). Thus, we cannot claim the positive effect of preoperative IMT on the above outcomes in patients with all types of cardiac surgery.

The fourth limitation is the data obtained. Data about mechanical ventilation time were expressed as ranges or interquartile ranges in the studies by Hulzebos *et al*[12], Sobrinho *et al*[18], and Chen *et al*[19]. Data on the length of ICU stay were expressed as ranges or interquartile ranges in the studies of Sobrinho *et al*[18] and Chen *et al*[19]. Data on the duration of hospitalization were also expressed as ranges or interquartile ranges in the studies by Hulzebos *et al*[12] and Sobrinho *et al*[18]. We used the tool on the website (http://www.math.hkbu.edu.hk/~tongt/papers/median2mean.html) to estimate the sample mean and standard deviation from the sample size, median, range, and/or interquartile range for the above studies. This conversion decreases the precision and accuracy of data and can lead to statistical error. More high-quality studies are needed to explore the effect of preoperative IMT on mechanical ventilation time, length of ICU stay, and duration of postoperative hospitalization after cardiac surgery.

Study or subgroup	Experimental Mean	SD	Total	Control Mean	SD	Total	Weight	Mean difference IV, Random, 95%CI
Chen *et al*, 2019	42.63	3.6	98	42.31	3.83	99	95.6%	0.32 [-0.72, 1.36]
Moises *et al*, 2014	42.86	4.2	10	37.81	10.37	10	2.1%	5.05 [-1.88, 11.98]
SAVCI *et al*, 2011	32.52	12.33	22	30.13	11.86	21	2.0%	2.39 [-4.84, 9.62]
Weber *et al*, 2021	74.4	40.8	58	81.84	52.8	50	0.3%	-7.44 [-25.45, 10.57]
Total (95%CI)			**188**			**180**	**100.0%**	**0.44 [-0.58, 1.45]**

Heterogeneity: Tau^2 = 0.00; Chi^2 = 2.76, df = 3 (P = 0.43); I^2= 0%
Test for overall effect: Z = 0.84 (P = 0.40)

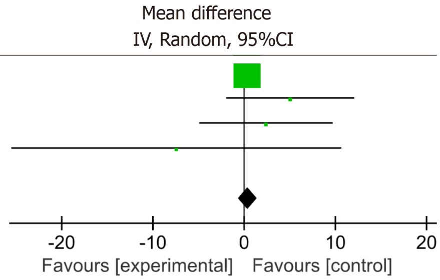

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Figure 4 Effect of preoperative inspiratory muscle training on length of intensive care unit stay. The result indicated a nonsignificant effect on the length of intensive care unit stay with a pooled mean difference of 0.44 h (95%CI: -0.58 to 1.45) and low heterogeneity (I^2 = 0) in cardiac surgery patients (including transcatheter aortic valve replacement) receiving preoperative inspiratory muscle training. Weight refers to the contribution of each study to the meta-analytic estimate of effect. SD: Standard deviation.

Study or subgroup	Experimental Mean	SD	Total	Control Mean	SD	Total	Weight	Mean difference IV, Random, 95%CI
Chen *et al*, 2019	42.63	3.6	98	42.31	3.83	99	94.7%	0.32 [-0.72, 1.36]
Moises *et al*, 2014	42.86	4.2	10	37.81	10.37	10	2.8%	5.05 [-1.88, 11.98]
SAVCI *et al*, 2011	32.52	12.33	22	30.13	11.86	21	2.6%	2.39 [-4.84, 9.62]
Total (95%CI)			**130**			**130**	**100.0%**	**0.50 [-0.66, 1.66]**

Heterogeneity: Tau^2 = 0.09; Chi^2 = 2.03, df = 2 (P = 0.36); I^2= 1%
Test for overall effect: Z = 0.85 (P = 0.39)

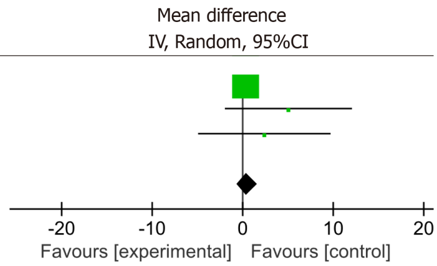

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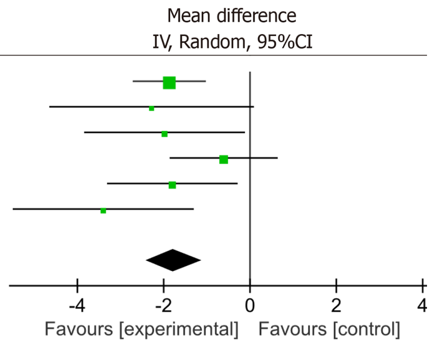
Figure 5 Effect of preoperative inspiratory muscle training on length of intensive care unit stay. The result indicated a nonsignificant effect on the length of intensive care unit stay with a pooled mean difference of 0.50 h (95%CI: -0.66 to 1.66) and low heterogeneity (I^2 = 1) in cardiac surgery patients (excluding transcatheter aortic valve replacement) receiving preoperative inspiratory muscle training. SD: Standard deviation.

Study or subgroup	Experimental Mean	SD	Total	Control Mean	SD	Total	Weight	Mean difference IV, Random, 95%CI
Chen *et al*, 2019	7.51	2.83	98	9.38	3.1	99	36.9%	-1.87 [-2.70, -1.04]
Hulzebos *et al*, 2006	8.44	6.89	139	10.72	12.27	137	6.9%	-2.28 [-4.63, 0.07]
Moises *et al*, 2014	5.86	0.75	10	7.84	2.88	10	10.8%	-1.98 [-3.82, -0.14]
SAVCI *et al*, 2011	5.77	1.74	22	6.38	2.33	21	21.2%	-0.61 [-1.84, 0.62]
Valkenet *et al*, 2016	8.2	2.6	119	10	7.8	116	15.5%	-1.80 [-3.29, -0.31]
Weber *et al*, 2021	10.1	4.7	58	13.5	6.1	50	8.7%	-3.40 [-5.48, -1.32]
Total (95%CI)			**446**			**433**	**100.0%**	**-1.77 [-2.41, -1.12]**

Heterogeneity: Tau^2 = 0.11; Chi^2 = 6.04, df = 5 (P = 0.30); I^2= 17%
Test for overall effect: Z = 5.37 (P < 0.00001)



DOI: 10.12998/wjcc.v11.i13.2981 **Copyright** ©The Author(s) 2023.

Figure 6 Impact of preoperative inspiratory muscle training on the duration of postoperative hospitalization. The result indicated a significant positive effect on the duration of postoperative hospitalization with a pooled mean difference of -1.77 d [95%CI: -2.41-(-1.12)] in cardiac surgery patients (including transcatheter aortic valve replacement) receiving preoperative inspiratory muscle training. SD: Standard deviation.

Clinical application

As we have found, preoperative IMT may decrease the length of postoperative hospitalization and potentially lessen expenses in the hospital to save money for patients. Thus, we recommend that preoperative IMT be implemented in hospitals or at home for patients who are waiting for cardiac surgery. However, we cannot determine the best length, frequency, duration, intensity, and supervision of IMT for patients. More studies are needed to find the best way to carry out IMT in hospitals or at home.

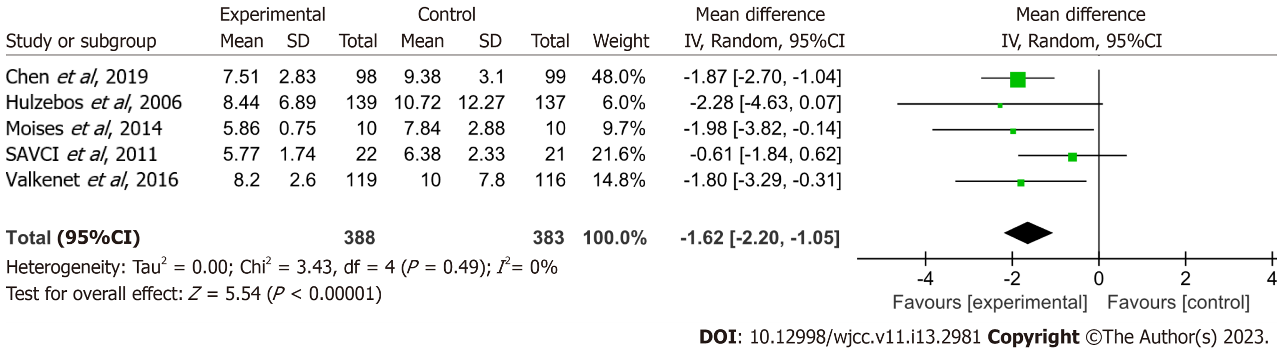


Figure 7 Impact of preoperative inspiratory muscle training on the duration of postoperative hospitalization excluding patients who received transcatheter aortic valve replacement. The result indicated a significant positive effect on the duration of postoperative hospitalization with a pooled mean difference of -1.62 d [95%CI: -2.20-(-1.05)] in cardiac surgery patients (excluding transcatheter aortic valve replacement) receiving preoperative inspiratory muscle training. SD: Standard deviation.

CONCLUSION

Preoperative IMT, as an important part of physical therapy, may decrease the duration of postoperative hospitalization and may decrease hospital costs for patients undergoing cardiac surgery. Meanwhile, IMT does not appear to lessen the time to extubate from mechanical ventilation or the duration of ICU stay.

ARTICLE HIGHLIGHTS

Research background

The effect of preoperative inspiratory muscle training (IMT) on mechanical ventilation time, length of intensive care unit stay, and duration of postoperative hospitalization after cardiac surgery are unknown.

Research motivation

Decreasing pulmonary complications can lead to shorter hospital stays. This in turn could decrease costs for the patient and the hospital.

Research objectives

To evaluate whether preoperative IMT is effective in improving postoperative outcomes such as the mechanical ventilation time, length of intensive care unit stay, and duration of postoperative hospitalization in patients receiving cardiac surgery.

Research methods

Several databases were searched to obtain eligible randomized controlled trials. Outcomes were mechanical ventilation time, length of intensive care unit stay, and duration of postoperative hospitalization.

Research results

The pooled mean difference of -0.45 h [(95%CI): -1.59-0.69] showed no statistically significant effect on mechanical ventilation time. The pooled mean difference 0.44 h (95%CI: -0.58-1.45) showed no statistically significant effect on length of intensive care unit stay. The pooled mean difference showed -1.77 d [95%CI: -2.41-(-1.12)] for postoperative hospitalization.

Research conclusions

Preoperative IMT may decrease the duration of postoperative hospitalization for patients undergoing cardiac surgery.

Research perspectives

More high-quality studies are needed to confirm our conclusion.

FOOTNOTES

Author contributions: Wang J and Yu PM designed the study; Wang J and Wang YQ searched the literature and extracted the data; Shi J contributed to data verification; Wang J, Yu PM, and Wang YQ analyzed the data; Wang J, Wang YQ, Shi J, Yu PM, and Guo YQ interpreted the data; Wang J drafted the manuscript; Wang YQ, Shi J, Yu PM, and Guo YQ critically reviewed the manuscript; Guo YQ had full access to all the data and carries responsibility for the decision to submit it for publication; all authors read and approved the final manuscript.

Conflict-of-interest statement: The authors declare that they have no conflicts of interest to report.

PRISMA 2009 Checklist statement: We performed this systematic review and meta-analysis according to the preferred reporting items for systematic reviews and meta-analysis (PRISMA) guidelines. Meanwhile, it has been registered with PROSPERO (ID: CRD42022333441).

Country/Territory of origin: China

ORCID number: Peng-Ming Yu 0000-0001-9908-2349; Ying-Qiang Guo 0000-0003-4894-2614.

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