

# Effects of Home-Based Breathing Exercises in Subjects With COPD

Yufan Lu, Peijun Li, Ning Li, Zhengrong Wang, Jian Li, Xiaodan Liu, and Weibing Wu

**BACKGROUND:** We sought to investigate the effects of home-based breathing exercises on pulmonary function, respiratory muscle strength, exercise capacity, dyspnea, and health-related quality of life in patients with COPD. **METHODS:** All randomized, controlled trials involving the use of home-based breathing exercises as an intervention in patients with COPD were searched on PubMed, Embase, Web of Science, EBSCO, CNKI, and Wangfang Data databases from January 1, 2008, to December 31, 2018. Two researchers independently extracted data and assessed the quality of the literature that met the inclusion criteria. **RESULTS:** A total of 13 studies were included, with a total of 998 subjects. The intervention methods consisted of diaphragmatic breathing, yoga breathing, breathing gymnastics, and singing. Meta-analysis showed that, compared with the control group, home-based breathing exercises had significant effects on the percent of predicted FEV<sub>1</sub> (mean difference = 3.26, 95% CI 0.52–5.99,  $P = .02$ ), FEV<sub>1</sub>/FVC (mean difference = 2.84, 95% CI 1.04–4.64,  $P = .002$ ), maximum inspiratory pressures (mean difference = 20.20, 95% CI 11.78–28.61,  $P < .001$ ), maximum expiratory pressures (mean difference = 26.35, 95% CI 12.64 to 40.06,  $P < .001$ ), 6-min walk distance (mean difference = 36.97, 95% CI 25.06–48.89,  $P < .001$ ), the modified Medical Research Council dyspnea scale (mean difference = –0.80, 95% CI –1.06 to –0.55,  $P < .001$ ), and the St George Respiratory Questionnaire (mean difference = –8.62, 95% CI –13.09 to –4.16,  $P < .001$ ). **CONCLUSIONS:** As an alternative method of home-based pulmonary rehabilitation program, breathing exercises can improve pulmonary function, respiratory muscle strength, exercise capacity, dyspnea, health-related quality of life in patients with COPD. *Key words:* chronic obstructive pulmonary disease; breathing exercises; pulmonary function; exercise capacity; quality of life. [Respir Care 2020;65(3):377–387. © 2020 Daedalus Enterprises]

## Introduction

COPD is a progressive inflammatory lung condition that seriously affects human health and is the third lead-

ing cause of death worldwide.<sup>1</sup> The global prevalence of COPD has reached 20.9%.<sup>2</sup> Its high mortality and prevalence have made COPD a serious public health problem, with a heavy social and economic burden.<sup>3</sup> COPD not only affects the lungs, causing dyspnea and reduced pulmonary function, but it is also accompanied by multiple and systemic comorbidities, which leads to respiratory muscle dysfunction that further impairs exercise capacity.<sup>4</sup> Pulmonary rehabilitation, as a comprehensive intervention program, can effectively enhance the phys-

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This work was funded by the General Administration of Sport of China (No. 2017B021), the “Qi Kang” young innovative talents project of School of Rehabilitation Medicine in Shanghai University of Traditional Chinese Medicine, the Science and Technology Commission of Shanghai Municipality (No. 18DZ1200600), and the Shanghai University of Sport “High-level International Talent Training Program”.

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DOI: 10.4187/respcare.07121

ical and psychological condition of patients with COPD.<sup>5</sup> As a kind of low-intensity aerobic exercise, breathing exercises reduce hyperinflation by improving the strength and endurance of respiratory muscles and correcting abnormal chest and abdomen movement patterns. Consequently, pulmonary function, dyspnea, and exercise capacity are improved, along with health-related quality of life (HRQOL) in patients with COPD.<sup>6</sup>

Breathing exercises are a direct training method for respiratory muscles, and they are highly targeted and less restricted by the environment. It is an effective home-based pulmonary rehabilitation method that can be practiced independently by patients with COPD. There are various types of breathing exercises, including diaphragmatic breathing, pursed-lips breathing, yoga breathing, breathing gymnastics, and singing.<sup>7</sup> Borge et al<sup>8</sup> compared breathing exercises with respiratory muscle training using threshold devices and reported that breathing exercises can manage and control breathing during exertion. However, respiratory muscle training requires a training program based on respiratory muscle strengthening to improve dyspnea. Another study found that pursed-lips breathing is not only conducive to increasing patients' confidence in their ability to use the technique for long-term management of dyspnea, but it can also be used effectively at night.<sup>9</sup> In addition, minute ventilation and breathing frequency during exercise could be effectively reduced through breathing exercises.<sup>10</sup> Research has shown that yoga breathing can effectively improve respiratory muscle strength in subjects with COPD.<sup>11</sup> Casey et al<sup>12</sup> reported that breathing exercises can effectively alleviate patient dyspnea due to its effectiveness in improving respiratory muscle strength. Some researchers have confirmed that breathing exercises can also improve exercise capacity and HRQOL in patients with COPD and can be recommended as an effective training modality in pulmonary rehabilitation.<sup>13</sup>

However, the effectiveness of breathing exercises varies depending on design and type. Researchers report that diaphragmatic breathing may have different effects compared with pursed-lips breathing, in that the former aims to reduce work of breathing in patients with COPD and the latter aims to improve gas exchange.<sup>14-16</sup> Moreover, breathing exercises using metronome-based acoustic feedback did not significantly improved exercise endurance or decrease the work of breathing for subjects with COPD compared with exercise training alone.<sup>17</sup> Therefore, it is necessary to integrate the results of individual studies to clarify the impact of breathing exercises on subjects with COPD. The aim of this meta-analysis was to determine the effects of breathing exercises on pulmonary function, respiratory muscle strength, exercise capacity, dyspnea, and HRQOL in subjects with COPD.

## Methods

### Search Strategy

This systematic review was registered (PROSPERO registration number: CRD42019129458) and is reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement.<sup>18</sup> To identify relevant manuscripts, the online databases of PubMed, Embase, Web of Science, Ebsco, China National Knowledge Infrastructure (CNKI), and WanFang Data were searched. The following search terms were used: (“chronic obstructive pulmonary disease” OR “COPD” OR “chronic air flow obstruction” OR “bronchitis chronic” OR “pulmonary emphysema”) AND (“breathing exercises” OR “exercise of breathing” OR “breathing control exercises” OR “diaphragmatic breathing” OR “pursed-lips breathing” OR “yoga” OR “breathing gymnastics” OR “singing”). Medical Subject Headings (MeSH) terms and free-text key words were used. The search strategies were written according to the retrieval requirements of each database. Search filters were applied to limit publication time (January 1, 2008, to December 31, 2018), article type (randomized controlled trials), species (humans), and language (English/Chinese) in all database output. In addition, the reference lists of potentially relevant studies were screened to make the review of the articles as complete as possible.

### Inclusion Criteria

We structured the criteria for study selection according to the principles of PICO (population, intervention, comparison, outcomes). Subjects had to be diagnosed with COPD confirmed by a pulmonologist or spirometry ( $FEV_1/FVC < 0.7$ )<sup>19</sup> with no history of COPD exacerbation within the previous 6 weeks. There were no gender and age restrictions. We required that at least one type of home-based breathing exercises was used for intervention (ie, diaphragmatic breathing, pursed-lips breathing, yoga breathing, breathing gymnastics, or singing). We required that the home-based breathing exercises intervention was compared against a usual treatment. With regard to outcomes, studies were included if they measured lung function parameter (percent of predicted  $FEV_1$  and  $FEV_1/FVC$ ), respiratory muscle strength (maximum inspiratory pressures [ $P_{I_{max}}$ ] and maximum expiratory pressures [ $P_{E_{max}}$ ]), exercise capacity (6-min walk distance [6MWD]), dyspnea (modified Medical Research Council [mMRC] dyspnea scale), and HRQOL (St George Respiratory Questionnaire). Finally, studies were included only if the study design was a randomized controlled trial.

Table 1. PEDro Criteria and Scores of the Included Randomized Controlled Trials

Study	Random Allocation	Concealed location	Baseline Similar	Blinding (Subject)	Blinding (Therapist)	Blinding (Assessor)	Measures for > 85%	Intention-to-Treat Analysis	Between-Group Difference Reported	Point Estimate and Variability Reported	Quality Score (0–10)
Bonilha et al <sup>31</sup>	Y	N	Y	N	N	N	Y	N	Y	Y	5
Gu et al <sup>30</sup>	Y	N	Y	N	N	N	Y	N	Y	Y	5
Hu et al <sup>24</sup>	Y	N	Y	N	N	Y	Y	Y	Y	Y	7
Kaminsky et al <sup>21</sup>	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	9
Li <sup>26</sup>	Y	N	Y	N	N	N	Y	Y	Y	Y	6
Lin et al <sup>27</sup>	N	N	Y	Y	Y	Y	Y	N	Y	Y	7
Lord et al <sup>29</sup>	Y	Y	Y	N	Y	Y	Y	N	Y	Y	8
Ranjita et al <sup>25</sup>	Y	Y	Y	N	Y	Y	Y	N	Y	Y	8
Tang et al <sup>23</sup>	Y	N	Y	N	N	N	Y	Y	Y	Y	6
Xu et al <sup>28</sup>	Y	N	Y	N	Y	N	Y	Y	Y	Y	7
Yamaguti et al <sup>15</sup>	Y	N	Y	N	N	Y	Y	Y	Y	Y	7
Zhang et al <sup>32</sup>	Y	N	Y	N	N	N	Y	N	Y	Y	5
Zhang et al <sup>22</sup>	Y	Y	Y	N	N	N	Y	Y	Y	Y	7

PEDro = Physiotherapy Evidence Database

## Exclusion Criteria

Trials were excluded if participants had other organic lesions or were in-patients; if other modes of exercise besides home-based breathing exercises were applied as the intervention; if the articles were case-control trials, cohort trials, crossover trials, cross-sectional studies, expert opinions, literature reviews, or letters; and if articles were not available in English or in Chinese.

## Study Collection and Data Collection

Two reviewers independently screened the title and abstract of each study from the search strategy to rule out irrelevant studies. According to the abstract review, full articles were requested for comprehensive review. When details were missing from the abstracts, full articles were retrieved and checked for eligibility. Discrepancies were resolved through discussions with the third investigator. Two reviewers independently extracted the characteristics of the subjects (ie, sample size and participants' demographic characteristics), home-based breathing exercises interventions (ie, method, frequency, and intensity), and effects using a standardized form.

## Quality Assessment

Each included study was scored to rate the methodological quality of study by the Physiotherapy Evidence Database (PEDro) scale.<sup>20</sup> The PEDro scale contains 11 evaluation items, scored from the aspect of external authenticity, internal authenticity, and statistical information, with a total score of 10 points (Table 1). The 11 criteria of the PEDro scale were rated as “yes” (criteria were met and scored 1) or rated as “no” (criteria were not met and

scored 0). Review quality was classified according to the PEDro scale score: 9–10 was considered high-quality literature, 6–8 was considered generally high-quality literature, 4–5 was considered medium-quality literature, and < 4 was considered low-quality literature. Two investigators conducted quality assessments independently, and disagreements were resolved by seeking third-party opinions.

## Statistical Analysis

Data were statistically analyzed using the Cochrane Collaboration software (RevMan 5.3). For each outcome, we tested the heterogeneity of results across studies using the chi-square test and the Higgins  $I^2$  test. A fixed-effects model was used when  $P \geq .10$  and  $I^2 < 50\%$ , which was considered low heterogeneity. Otherwise, a random-effects model was conducted in the meta-analysis and the results were carefully interpreted. Weighted mean differences and 95% CIs were used to pool data in continuous variables. For all results, a 2-sided  $P$  value of  $\leq .05$  was considered to indicate a statistically significant difference.

## Results

### Literature Search and Results

According to the search strategy, a total of 6,733 potentially relevant studies were identified by searching from each database. After the 1,858 duplicates were removed, the titles and abstracts of 4,875 articles were screened, and 4,811 studies were excluded based on the exclusion criteria, such as inappropriate interventions, other interventions, and other study designs. Of the remaining 64 studies, 51 were excluded after full-text review, mainly because of the training forms used in intervention. Finally, 13 studies met the inclusion

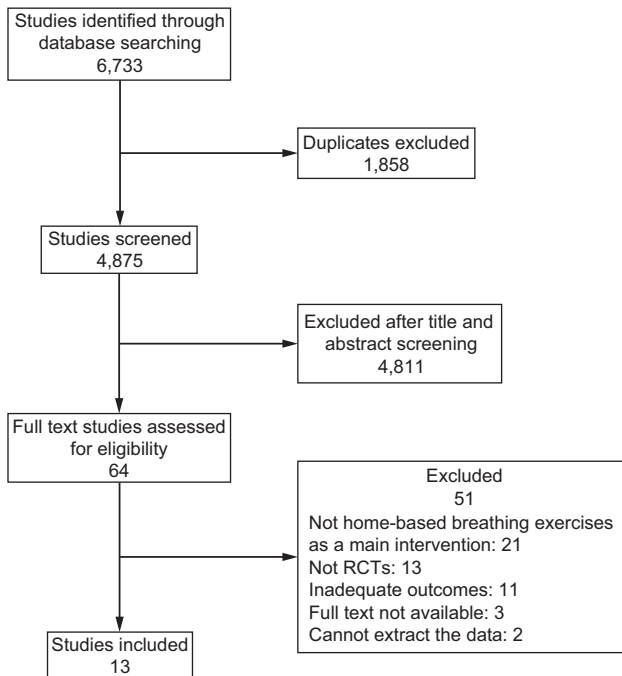


Fig. 1. Flow chart. RCT = randomized controlled trial.

criteria and were included in the meta-analysis. The process of inclusion is shown in Figure 1.

### Characteristics of the Selected Studies

A total of 998 subjects participated in the 13 randomized controlled trials included in our meta-analysis. Most of the included subjects had moderate or severe COPD. Considering all studies together, the subjects were predominantly male. The 13 studies involved 5 interventions: diaphragmatic breathing (1 study), pursed-lips breathing (1 study), yoga breathing (2 studies), breathing gymnastics (5 studies of traditional Chinese exercises combined with breathing and 2 of novel combined breathing exercises), and singing (2 studies). Session duration ranged from 10–60 min, with application frequency varying from once per day, 3 times per week to 3 times per day, 7 times per week. Program duration in the studies ranged from a minimum of 4 weeks to a maximum of 12 months. Characteristics of the 13 included studies are shown in Table 2.

### Quality of the Selected Literatures

The detailed results of the quality assessment for the selected studies are shown in Table 1. One trial<sup>21</sup> was evaluated as high-quality literature, 9 trials<sup>15,22–29</sup> were generally high-quality literature, and 3 trials<sup>30–32</sup> were of moderate quality. All studies reported that allocation was random. Six studies mentioned blinding the assessor collecting data. Eight studies

used random assignment without reporting on allocation concealment, and 4 studies used computer-generated random numbers, applied consistently. One study was randomly assigned by coin toss with no report whether the allocation was hidden. Several authors reported difficulty in blinding, considering the type of therapy, thus only 2 studies were double-blind, while 3 were single-blind. One study was performed for intention-to-treat analysis. Research protocols were available for all studies, and pre-declared outcomes were reported; there were no significant other biases.

### Outcomes

**Pulmonary Function.** Ten studies investigated the effects of home-based breathing exercises on pulmonary function in subjects with COPD. There were 2 main outcome indices, including the percent of predicted FEV<sub>1</sub> and FEV<sub>1</sub>/FVC. Seven studies evaluated the effect of respiratory training on percent of predicted FEV<sub>1</sub>, and a fixed-effects model was used for meta-analysis due to decreased heterogeneity ( $P = .48$ ,  $I^2 = 0\%$ ). The results showed that home-based breathing exercises effectively improved the percent of predicted FEV<sub>1</sub> in subjects with COPD (mean difference = 3.26, 95% CI 0.52–5.99,  $P = .02$ ) (Fig. 2). Seven studies evaluated the effect of respiratory training on FEV<sub>1</sub>/FVC, and a fixed-effects model was used for meta-analysis due to decreased heterogeneity ( $P = .65$ ,  $I^2 = 0\%$ ). The overall analysis showed significant improvement in FEV<sub>1</sub>/FVC after home-based breathing exercises (mean difference = 2.84, 95% CI 1.04–4.64,  $P = .002$ ) (Fig. 2).

**Expiratory Muscle Strength.** The P<sub>I<sub>max</sub></sub> and P<sub>E<sub>max</sub></sub> were measured in 3 studies (Fig. 3). With less heterogeneity ( $P = .96$ ,  $I^2 = 0\%$ ), a fixed-effects model was used for meta-analysis. The analysis indicated that there were effective increases in P<sub>I<sub>max</sub></sub> (mean difference = 20.20, 95% CI 11.78–28.61,  $P < .001$ ) and P<sub>E<sub>max</sub></sub> (mean difference = 26.35, 95% CI 12.64–40.06,  $P < .001$ ).

**Exercise Capacity.** Of the 13 trials, 9 studies assessed exercise capacity using the 6MWD. When pooled in the meta-analysis, results showed a small heterogeneity ( $P = .30$ ,  $I^2 = 16\%$ ) and that the home-based breathing exercises led to significant improvements in the 6MWD (mean difference = 36.97, 95% CI 25.06–48.89,  $P < .001$ ) (Fig. 4).

**Dyspnea.** The mMRC score was used to evaluate dyspnea. A pooled effect size from data of 5 studies with low heterogeneity ( $P = .22$ ,  $I^2 = 30\%$ ) indicated that home-based breathing exercises decreased mMRC scores of subjects with COPD (mean difference = –0.80, 95% CI –1.06 to –0.55,  $P < .001$ ) (Fig. 5).

## HOME-BASED BREATHING EXERCISES IN COPD

Table 2. Characteristics of Included Studies

Study	Group	Sample Size (% male)	Age, y	GOLD Stage	Intervention	Outcome
Bonilha et al <sup>31</sup>	EG	15 (80)	69.8 ± 7.4	II, III	Singing class (As a group: 60 min, 1/wk, 24 wk + At home: 30 min, 2/wk, 24 wk)	FEV <sub>1</sub> /FVC; P <sub>I</sub> max, P <sub>E</sub> max; SGRQ
	CG	15 (80)	73.6 ± 7.5	II, III	Handcraft work (As a group: 60 min, 1/wk, 24 wk + At home: 30 min, 2/wk, 24 wk)	
Gu et al <sup>30</sup>	EG	22 (95)	65.18 ± 6.25	II, III	Novel breathing training (15 min, 3/d, 8 wk)	FEV <sub>1</sub> (pred%); P <sub>I</sub> max, P <sub>E</sub> max; 6MWD; SGRQ, mMRC
	CG	20 (95)	67.55 ± 7.50	II, III	Drug therapy	
Hu et al <sup>24</sup>	EG	30		II, III	Traditional Chinese medicine respiratory guidance and rehabilitation technology (3/d, 5 d/wk, 12 wk)	FEV <sub>1</sub> (pred%)
	CG	30		II, III	Health education	
Kaminsky et al <sup>21</sup>	EG	21 (33)	68 ± 7	II–IV	Dirgha breath (60 min/d, 12 wk)	FEV <sub>1</sub> (pred%); 6MWD; SGRQ, mMRC
	CG	22 (45)	68 ± 9	II–IV	Usual care	
Li <sup>26</sup>	EG	36		III, IV	Respiratory function training (2/d, 4 wk)	FEV <sub>1</sub> /FVC; mMRC
	CG	36		III, IV	Drug therapy	
Lin et al <sup>27</sup>	EG	20 (75)	67.95 ± 12.36	II–IV	Respiratory training (30 min, 2/d, 12 wk)	FEV <sub>1</sub> (%), FEV <sub>1</sub> /FVC; 6MWD; SGRQ
	CG	20 (90)	69.45 ± 8.60	II–IV	Routine health education (30 min, 2/d, 12 wk)	
Lord et al <sup>29</sup>	EG	15	66.6 ± 9.3		Singing workshops (60 min, 2/wk, 6 wk)	SGRQ
	CG	13	68.1 ± 6.8		Usual care (30 min, 2/wk, 12 wk)	
Ranjita et al <sup>25</sup>	EG	36 (100)	53.69 ± 5.66	II, III	Integrated approach of yoga therapy (90 min, 6/wk, 12 wk)	6MWD
	CG	36 (100)	54.41 ± 5.40	II, III	Usual care	
Tang et al <sup>23</sup>	EG	20 (60)	72.5 ± 4.4	III, IV	Novel breathing training (15 min, 3/d, 8 wk)	FEV <sub>1</sub> /FVC; P <sub>I</sub> max, P <sub>E</sub> max; 6MWD; SGRQ, mMRC
	CG	20 (60)	72.1 ± 4.2	III, IV	Drug therapy	
Xu et al <sup>28</sup>	EG	20 (50)	56.83 ± 7.93	I, II	Integrative respiratory rehabilitation therapy (2/d, 48 wk)	6MWD
	CG	20 (55)	57.51 ± 7.23	I, II	Drug therapy	
Yamaguti et al <sup>15</sup>	EG	15 (73)	66.4	II–IV	Diaphragmatic breathing training program (45 min, 3/wk, 4 wk)	FEV <sub>1</sub> (pred%), FEV <sub>1</sub> /FVC; 6MWD; SGRQ, mMRC
	CG	15 (73)	66.5	II–IV	Usual care	
Zhang et al <sup>32</sup>	EG	20 (85)	68.85 ± 3.92	III, IV	Pulmonary rehabilitation with respiratory physiology (15 min, 3/d, 8 wk)	FEV <sub>1</sub> (pred%), FEV <sub>1</sub> /FVC; P <sub>I</sub> max, P <sub>E</sub> max, mMRC
	CG	20 (90)	69.90 ± 2.07	III, IV	No pulmonary rehabilitation	
Zhang et al <sup>22</sup>	EG	232 (66)	63.38 ± 9.70	II–IV	Pulmonary daoyin (10/wk, 12 wk)	6MWD
	CG	229 (64)	63.44 ± 11.00	II–IV	Drug therapy	

Data are presented as *n* (%) or mean ± SD.

GOLD = Global Initiative for Chronic Obstructive Lung Disease

EG = experimental group

CG = control group

P<sub>I</sub>max = maximum inspiratory pressure

P<sub>E</sub>max = maximum expiratory pressure

6MWD = 6-min walk distance

mMRC = modified Medical Research Council dyspnea scale

SGRQ = St. George's Respiratory Questionnaire

**HRQOL.** Seven studies estimated the effects of home-based breathing exercises on HRQOL measured with the St George Respiratory Questionnaire. Results indicated that home-based breathing exercises were associ-

ated with lower total scores on the St George Respiratory Questionnaire than usual treatment (mean difference = -8.62, 95% CI -13.09 to -4.16, *P* < .001) (Fig. 6).

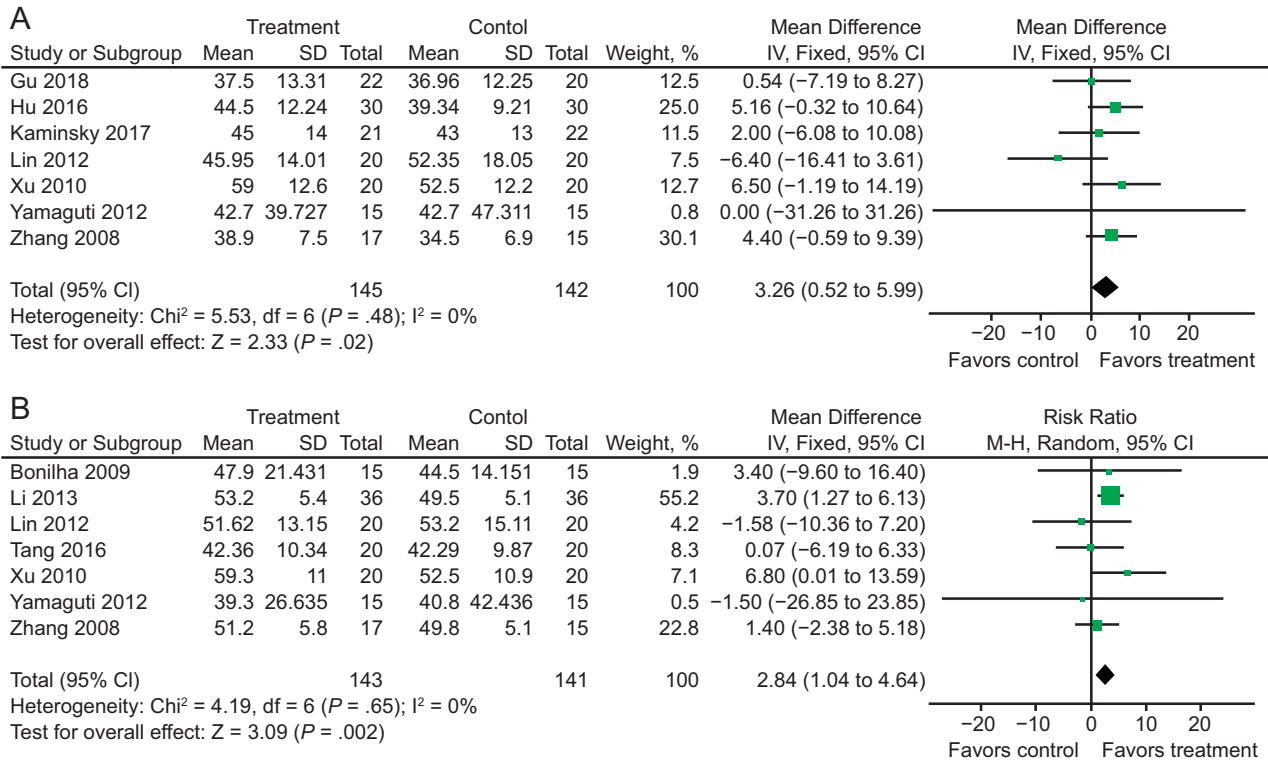


Fig. 2. Forest plot depicting the effects of home-based breathing exercises vs usual care on A: percent of predicted FEV<sub>1</sub> and B: FEV<sub>1</sub>/FVC.

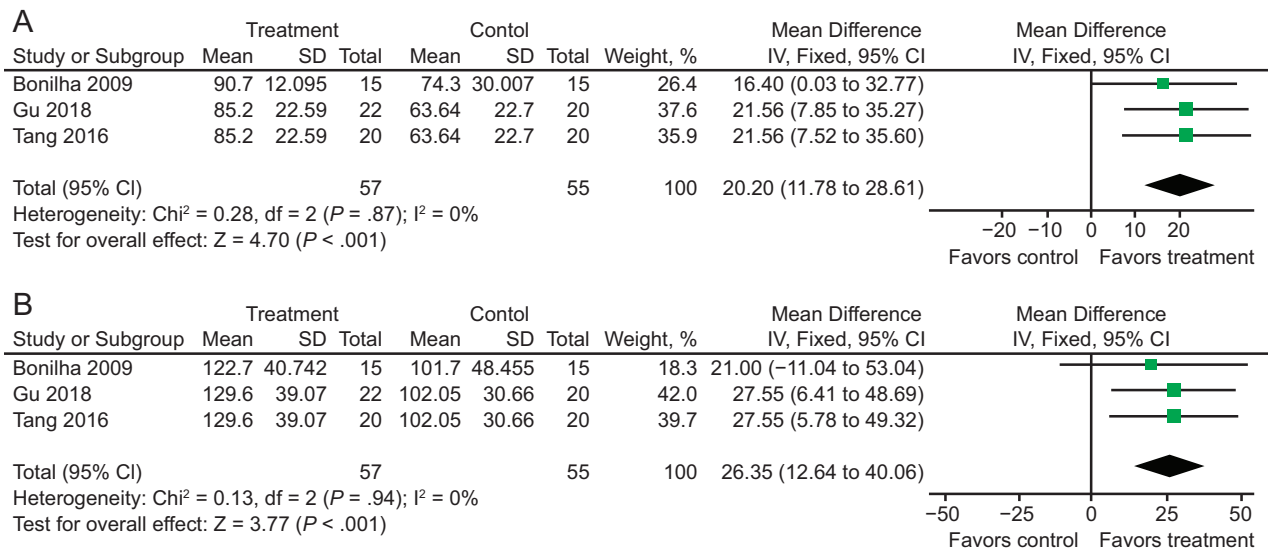


Fig. 3. Forest plot depicting the effects of home-based breathing exercises vs usual care on A: maximum inspiratory pressures and B: maximum expiratory pressures.

**Discussion**

Pulmonary rehabilitation is one of the most effective non-pharmacologic treatments for COPD<sup>33</sup> and breathing exercises are an important component,<sup>34</sup> providing an ef-

fective method to improve long-term self-efficacy of patients.<sup>35</sup> However, the methods and effects of breathing exercises are various and still controversial.<sup>30</sup> Therefore, we conducted a meta-analysis on 13 moderate-to-high quality studies and found significant improvements from home-

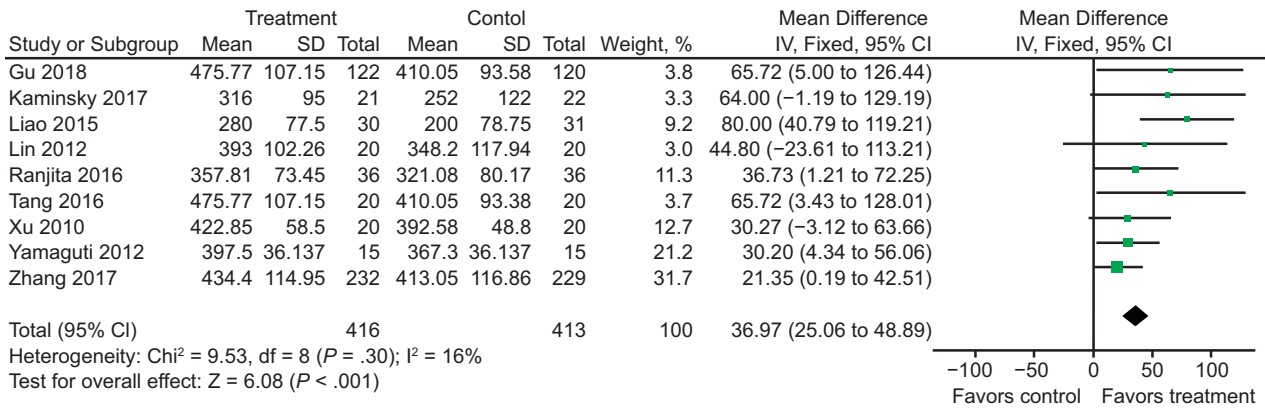


Fig. 4. Forest plot depicting the effects of home-based breathing exercises vs usual care on 6-min walk distance.

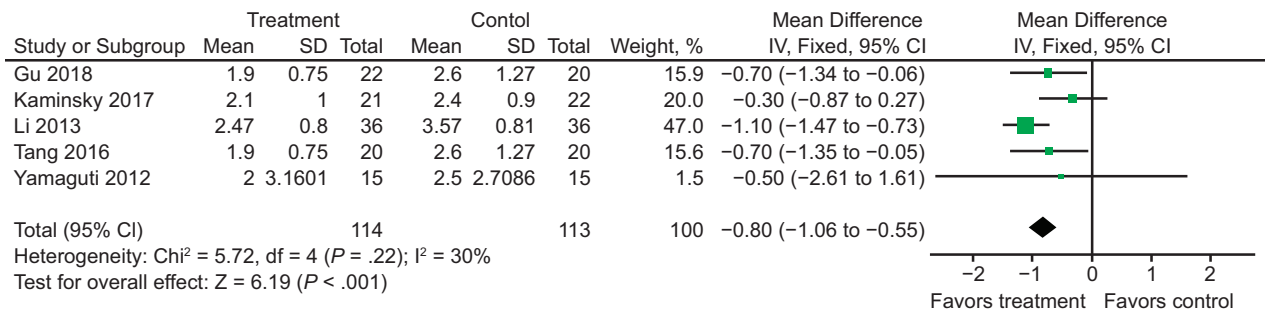


Fig. 5. Forest plot depicting the effects of home-based breathing exercises vs usual care on modified Medical Research Council dyspnea scale.

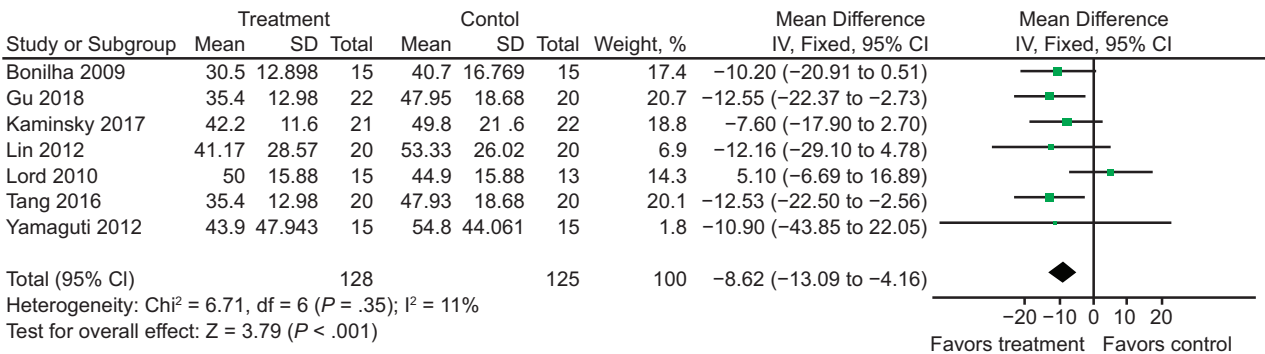


Fig. 6. Forest plot depicting the effects of home-based breathing exercises vs usual care on the St. George Respiratory Questionnaire.

based breathing exercises on pulmonary function, respiratory muscle strength, exercise capacity, dyspnea and HRQOL in patients with COPD.

**Effects of Home-Based Breathing Exercises on Pulmonary Function**

Pulmonary function (ie, percent of predicted FEV<sub>1</sub> and FEV<sub>1</sub>/FVC) can effectively reflect the ventilation of patients with COPD and assess the severity of air-flow obstruction.<sup>36</sup> Quantitative analysis showed a large effect size

of home-based breathing exercises on pulmonary function compared to controls. Breathing exercises are a type of aerobic exercise that integrate the mind, body, and spirit and are theoretically based on the dynamic response of the respiratory system. Breathing exercises may alleviate the adverse physiological effects of reduced lung function by enhancing the strength and endurance of the respiratory muscles, optimizing the mechanics of chest and abdominal-wall movement, reducing dynamic hyperinflation, and improving gas exchange.<sup>37</sup> Home-based breathing exercises can also improve patient adherence to training, which

ultimately leads to better pulmonary function. A previous study reported that yoga can improve pulmonary function in subjects with COPD by increasing the percent of predicted FEV<sub>1</sub>.<sup>38</sup> Another study noted improved FVC in subjects with COPD after 5 min of pursed-lips breathing, suggesting that pursed-lips breathing may improve pulmonary function by decreasing hyperventilation.<sup>39</sup> The Global Initiative for COPD (GOLD) recommends a follow-up of at least 12 months for the index of FEV<sub>1</sub> in patients with COPD.<sup>19</sup> However, the duration of studies included in our meta-analysis ranged from 4 to 24 weeks, which is far less than the follow-up time recommended by GOLD. Therefore, it is unclear whether a long-term improvement in pulmonary function can be obtained after home-based breathing exercises. Studies that extended the follow-up time to investigate the long-term effects of breathing exercises on pulmonary function in patients with COPD are recommended. In addition, a study showed that the inspiratory fraction (IF) better reflects lung hyperventilation and exercise capacity in subjects with COPD.<sup>40</sup> However, it is difficult to analyze the impact of home-based breathing exercises on IF due to the limited use of inspiratory capacity as a primary outcome to reflect IF in patients with COPD.

### **Effects of Respiratory Training on Respiratory Muscle Strength**

Compared with standard medical treatment, we found that breathing exercises can significantly improve the P<sub>I<sub>max</sub></sub> and P<sub>E<sub>max</sub></sub> of subjects with COPD. Most patients with COPD have weakened respiratory muscles and increased airway resistance, conditions that cause constant overload during breathing and lead to chronic respiratory failure.<sup>41</sup> Thus, it is vital to enhance the respiratory muscle strength of patients with COPD. Basso-Vanelli et al<sup>42</sup> reported that aerobic breathing training can effectively improve the respiratory muscle strength of patients with COPD. In this study, training with singing or a new combined breathing exercise was beneficial in improving respiratory muscle strength in subjects with COPD. The advantage of singing may be related to contraction of abdominal muscles and the diaphragm during training, which improves function. Previous research reported that singing training leads to immediate benefits in vital capacity and respiratory mechanics.<sup>43</sup> Combined breathing exercises emphasize the combination of inhalation and exhalation, which can effectively enhance the inspiratory-expiratory ratio and reduce breathing frequency.<sup>23</sup> These findings may be ascribed to structural remodeling of the lateral intercostal muscles after specific breathing training and the increased number of fiber type I and the area of fiber type II.<sup>44</sup>

### **The Effect of Home-Based Breathing Exercises on Exercise Capacity**

The 6-min walk test is a submaximal exercise test and one of the most widely used methods for assessing exercise capacity in patients with COPD.<sup>45</sup> The 6MWD may be a better reflection of the exercise capacity necessary to carry out daily physical activity, because most activities of daily living for patients with COPD are equivalent to moderate exercise levels. Consistent with the results of a study by Holland et al,<sup>7</sup> Camillo et al<sup>46</sup> reported that yoga, diaphragmatic breathing, and breathing gymnastics increased 6MWD by an average of 36.94 m (Fig. 4), which is greater than the minimum clinically important difference (ie, > 30 m). These results indicate that home-based breathing exercises produce clinically important improvements in the exercise capacity of patients with COPD. One possible explanation is that breathing training can improve ventilation and increase the patient's daily activities. One study demonstrated that yoga could improve cardiovascular efficiency and steady-state control of breathing, helping to increase walking speed and stride of subjects with COPD, thereby improving functional exercise capacity.<sup>11</sup>

### **Effects of Home-Based Breathing Exercises on Dyspnea**

Dyspnea is not the primary factor affecting the quality of life of patients with COPD, but it is one of the most clinically important indicators for evaluating the effects of pulmonary rehabilitation. Breathing training can improve effective perfusion of alveoli and reduce hyperinflation by correcting abnormal breathing patterns to further optimize the breathing efficiency and to alleviate dyspnea.<sup>47</sup> Although dyspnea was measured using the mMRC, studies have shown that the 5 grades of this assessment are too broad and insensitive to detect changes in patients with COPD.<sup>48</sup> Therefore, a variety of measurement methods are recommended for future clinical studies to comprehensively analyze the impact of home-based breathing training on dyspnea in patients with COPD.

### **Effects of Home-Based Breathing Exercises on HRQOL**

The purpose of COPD treatment is not only to alleviate symptoms, but to improve HRQOL.<sup>49</sup> Most previous studies have reported that the 3 categories of the St George Respiratory Questionnaire (ie, symptoms, activity, and impact) significantly correlate with HRQOL<sup>49,50</sup> and is considered the accepted standard of HRQOL assessment.<sup>51</sup> In this meta-analysis, the pooled effect sizes showed that singing, breathing gymnastics, yoga breathing, and diaphragmatic breathing are beneficial to improve the HRQOL



of COPD patients, and the improvement is greater than its minimum clinically important difference (ie, 4 points). One study found that pulmonary rehabilitation has different effects on HRQOL in subjects with varying disease severity.<sup>52</sup> However, because subjects included in this study were mostly categorized with moderate to very severe COPD, the effects of home-based breathing training on HRQOL across a broad spectrum of COPD severity could not be determined.

### Revelation of Home-Based Breathing Exercises

Pursed-lips breathing can increase expiratory time, decrease breathing frequency, reduce end-expiratory lung volume, increase exercise capacity, and effectively relieve dyspnea.<sup>53,54</sup> Abdominal breathing focuses on improving breathing pattern, increasing the involvement of the abdominal muscles in breathing, and reducing the activity of the accessory muscles, thereby improving ventilation efficiency and oxygen saturation.<sup>55</sup> Yoga breathing, as a slow-relaxation breathing training method, can also effectively improve breathing patterns, increase expiratory time, and alleviate static hyperinflation, which has a significant influence on the exercise capacity of patients with COPD. Moreover, studies have shown that yoga breathing can effectively enhance the respiratory muscle strength of subjects with COPD.<sup>11</sup> Breathing gymnastics improve exercise capacity and HRQOL by integrating and coordinating the patient's breathing, posture, and movement to alleviate the symptoms of dyspnea. The evidence for most physiological benefits is based on traditional Chinese exercise such as tai chi, ba duan jin, and qi gong. Singing training reduces the sensations of anxiety and fear associated with respiratory challenges with its focus on accurate control of breathing. In addition to its possible effects on breathing, singing as a positive experience has been associated with improvements of self-efficacy and HRQOL.<sup>56</sup> These home-based breathing exercises, although different in training content and specificity, have similar positive effects on alleviating dyspnea and improving exercise capacity in patients with COPD. Studies have reported that breathing exercises combined with exercise training can produce a more significant improvement in breathing frequency compared to breathing exercises alone, thereby more effectively improving lung function, exercise capacity, and dyspnea in patients with COPD.<sup>14,57</sup> However, future research is necessary due to insufficient information on program type, frequency and duration, and the effects on subjects with different grades of COPD severity.

### Limitations

This study has several limitations. First, this study only searched literature published in Chinese and English; such

a limitation on language increases the possibility of missing relevant literature and affects the comprehensiveness of the inclusion. Second, the lack of long-term follow up and large controlled clinical trials make it difficult to draw conclusions on the long-term efficacy of breathing exercises. Third, even though the 13 studies included in this systematic review were of high quality, most studies did not explicitly report allocation concealment, blinding, or intention-to-treat analysis, making assessment of the risk of bias difficult. In addition, one study accounted for nearly half of the overall sample size of our meta-analysis, and only exercise capacity and satisfaction were evaluated in this single study; this is a methodological limitation of our analysis. Fourth, static lung function indicators from subjects with COPD were analyzed in this study instead of comprehensive pulmonary function testing. Fifth, inspiratory muscle training is more effective for patients with COPD with inspiratory muscle weakness.<sup>58</sup> However, there insufficient data were available from the included studies to complete subgroup analyses to clarify the effects of home-based breathing exercises on subjects with COPD and respiratory muscle weakness. At the same time, this meta-analysis showed that inspiratory muscle training using a threshold device can effectively decrease dyspnea and increase inspiratory muscle strength, quality of life, and exercise capacity, but had no additional effect on dyspnea compared to pulmonary rehabilitation alone.<sup>59</sup> In this systematic review, we were only able to compare home-based breathing exercises to usual care and were unable to evaluate this training in relation to pulmonary rehabilitation.

### Conclusions

Home-based breathing exercises are beneficial to the pulmonary function, respiratory muscle strength, exercise capacity, dyspnea, and HRQOL of patients with COPD. The characteristics of these exercises, including their ease of execution and lack of constraints on site and time of performance, allow the possibility of their inclusion in a long-term pulmonary rehabilitation program. More attention should be paid to the application of the combined breathing exercise and exercise training program for further benefits.

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