



# The effect of breathing exercises on patients with GERD: a meta-analysis

Kaijie Qiu, Jie Wang, Baiwen Chen, Haibiao Wang, Chenyang Ma

Department of General Surgery, Ningbo Medical Center, Lihuili Hospital, Ningbo 315000, China

*Contributions:* (I) Conception and design: C Ma; (II) Administrative support: H Wang; (III) Provision of study materials or patients: K Qiu, J Wang, B Chen; (IV) Collection and assembly of data: K Qiu, J Wang, B Chen; (V) Data analysis and interpretation: K Qiu, J Wang; (VI) Manuscript writing: All authors; (VII) Final approval of manuscript: All authors.

*Correspondence to:* Chenyang Ma. #57 Xingning Road, Yinzhou District, Department of General Surgery, Ningbo Medical Center, Lihuili Hospital, Ningbo 315000, China. Email: mcy3300862@163.com.

**Background:** Breathing exercises can improve the symptoms of patients with gastroesophageal reflux disease (GERD), but their specific effect and function are disputed. To evaluate and conduct a meta-analysis on the effect of breathing exercises on patients with GERD.

**Methods:** A literature search for randomized controlled trials (RCTs) and prospective studies on the effects of employing breathing exercises on patients with GERD was conducted of all major online English databases (PubMed, Embase, the Cochrane library, CENTRAL, Web of Science, AMED, and CINAHL). After the systematic review of all the studies according to inclusion and exclusion criteria, we analyzed the extracted data through meta-analysis by using RevMan 5.3 software.

**Results:** This thesis analyzes 7 studies (including three RCTs), which together involved 194 patients and 16 healthy volunteers. The primary outcomes of these studies included GERD symptoms, esophageal manometry, esophageal pH monitoring, laryngoscopic findings, and acid suppression usage. The results of meta-analysis indicate that breathing exercises can improve pressure generated by the lower oesophageal sphincter (LES), and a statistically significant difference was observed. The possible mechanism behind this is the enhancement of the anti-regurgitation barrier [especially crural diaphragm (CD) tension].

**Conclusions:** To some extent, breathing exercises can relieve the symptoms of patients with GERD.

**Keywords:** Breathing exercises; gastroesophageal reflux disease (GERD); randomized controlled trial (RCT); meta-analysis

Submitted Jan 13, 2020. Accepted for publication Feb 22, 2020.

doi: 10.21037/apm.2020.02.35

View this article at: <http://dx.doi.org/10.21037/apm.2020.02.35>

## Introduction

Gastroesophageal reflux disease (GERD) is a frequently-occurring digestive system disorder, and its incidence has been increasing year by year (1). GERD is caused by disorder in the movement of the upper digestive tract and gastric acid reflux in the esophagus, which leads to various injuries and discomfort. There are two main reasons for gastric acid entering the esophagus: firstly, an increase in stomach abdominal cavity pressure cause by,

for example, satiety, obesity, or gastric emptying disorder; and, secondly, a weakened anti-reflux mechanism (2). Normally, the gastroesophageal junction (GEJ) valve mechanism can be found between the esophagus and the stomach, consisting of the lower oesophageal sphincter (LES), the crural diaphragm (CD), the angle of His, and the phrenoesophageal membrane, which together form a barrier against gastroesophageal reflux (3).

Proton pump inhibitors (PPIs) are the first choice and

classic drug for treating patients with GERD (4). However, symptoms may recur after withdrawal, and there is no significant benefit for patients with refractory GERD (5). Long-term use of PPI drugs holds potential risks for the respiratory, circulatory, and digestive systems (6), particularly in elderly people (7). Therefore, it is necessary to explore other safe and effective treatments.

Recent studies have shown that breathing exercises can enhance the crural diaphragm tension (CDT), strengthen the diaphragm barrier mechanism, reduce acid reflux and subsequent damage, and improve the efficacy of drug therapy (8). The purpose of this article is to explore the efficacy and effect of breathing exercises on GERD through a systematic review and meta-analysis of relevant literature, and to provide reference evidences of breathing exercises as a treatment for GERD patients.

## Methods

### *Literature search*

An online search was conducted to identify relevant randomized controlled trials (RCTs) and prospective studies published online on all major English language databases (PubMed, Embase, the Cochrane library, CENTRAL, Web of Science, AMED, and CINAHL).

Generally, the literature retrieval process was carried out as follows: (I) retrieval of relevant systematic reviews and meta-analysis from the Cochrane Library, (II) retrieval and reading of the relevant original literature from the domestic and foreign databases, and analysis and summary of the relevant literature subject words, keywords. The search terms used were: “Gastric Acid Reflux”, “Acid Reflux, Gastric”, “Reflux, Gastric Acid”, “Gastric Acid Reflux Disease”, “Gastro-Esophageal Reflux”, “Gastro Esophageal Reflux”, “Reflux Gastro-Esophageal”, “Gastroesophageal Reflux Disease”, “GERD”, “Reflux Gastroesophageal”, “Esophageal Reflux”, “Gastro-oesophageal Reflux”, “Gastro oesophageal Reflux”, “Reflux Gastro-oesophageal” and “Respiratory Muscle Training”, “Exercise Breathing”, “Muscle Training, Respiratory”, “Training, Respiratory Muscle”, (III) we took into account literature published from the time of database construction to October 1, 2019, and applied the inclusion and exclusion criteria set out below, (IV) we also searched the references and related research of the returned literature to identify any further

studies relevant to our meta-analysis.

### *Inclusion and exclusion criteria*

#### **Inclusion criteria**

The following inclusion criteria was applied to our literature search:

- (I) Research type: a prospective or RCT of breathing exercises in patients with GERD that was officially published in English before October 1, 2019;
- (II) Research design: the purpose and method of each study were the same or similar, and the RCT study was divided into a respiratory exercise treatment group and a control group. The intervention was to treat the patients with respiratory exercises, while the control group was treated only with conventional drugs or with sham breathing exercises. There was no limit to the frequency and cycle of breathing exercise interventions;
- (III) Subjects: aged  $\geq 18$  years, meeting the diagnostic criteria of GERD (9): (i) the patients have symptoms such as typical heartburn, regurgitation and acid regurgitation, which can be combined with atypical symptoms such as chest pain, belching or extra-esophageal symptoms such as cough and asthma, should have been experienced for at least 6 months; (ii) the diagnosis was confirmed by endoscopy or a 24 h esophageal pH-value test; (iii) the patients treated by PPI or acid suppressant effectively, and symptoms recur after withdrawal. The patients with secondary GERD (other factors can cause or aggravate esophagitis, such as surgery, pregnancy, drugs, etc.) should be excluded. Patients have no serious chronic disease or organic disease such as, for example, hypertension, diabetes, upper gastrointestinal ulcer, or hiatus dysfunction;
- (IV) Primary outcomes: reflux symptoms, GERD-health-related quality of life, (GERD-HRQL), acid suppressant consumption, and esophageal pressure measurement;
- (V) Research ethics: informed consent was obtained from all participants and the study was approved by the relevant ethics committee.

#### **Exclusion criteria**

Studies that met the following criteria were excluded from

our met-analysis:

- (I) Redundant or duplicate publication;
- (II) The original document cannot be obtained through various methods;
- (III) A small sample size ( $N < 10$ );
- (IV) Incomplete or contradictory data;
- (V) Inappropriate statistical methods;
- (VI) The experimental design and the intervention were vague or combined with other interventions;
- (VII) Review, letter, case report, or other non-primary literature.

### *Screening literature and extracting data*

The retrieved studies were imported into EndNote X7 to remove duplication. Two researchers independently screened the literature according to the inclusion criteria and exclusion criteria, and a third researcher participated in the decision-making to settle differences when they occurred.

The text of the selected literature was read in full, and the following data were extracted: basic information (e.g., author and publication year), research objects (e.g., sample size, age, and gender), experimental design (e.g., grouping method, intervention measures, frequency, and intensity.), and outcome indicators.

### *Evaluating the quality of the literature*

The Cochrane 5.1.0 systematic review manual (10) was used to evaluate the studies, including generation of random sequences, allocation concealment, blinding method (for researcher/patients), integrity of the data, selective reporting, and other biases. Each item in the literature was evaluated and classified into “low risk”, “high risk”, or “unclear”, according to the probability of bias. Guided by these standards, the studies were divided into A, B, and C levels, which meant “full compliance”, “partial compliance”, and “complete non-compliance”. C-level studies had high risk for performance bias, we excluded those.

The whole evaluation process was conducted independently by two researchers, with a third researcher to assist with decision-making when differences occurred in the evaluation results.

### *Statistical methods*

The RevMan 5.3 statistical software provided by “www.

cochrane.org” was used for the meta-analysis. The chi-square test was used to verify the heterogeneity among the studies, and sensitivity analysis was used to identify the source of heterogeneity as far as possible and eliminate it. A random effects model was used if there was heterogeneity ( $P \leq 0.1$ ,  $I^2 \geq 50\%$ ). If heterogeneity did not exist ( $P > 0.1$ ,  $I^2 < 50\%$ ), the fixed effects model was used for analysis. Subgroup analysis or descriptive analysis was used for results with significant heterogeneity or different study methods. We use the weighted mean difference (WMD) to analyze statistical data effectiveness for numerical or continuous data, and calculated the 95% confidence interval (95% CI). The difference was statistically significant when  $P < 0.05$ .

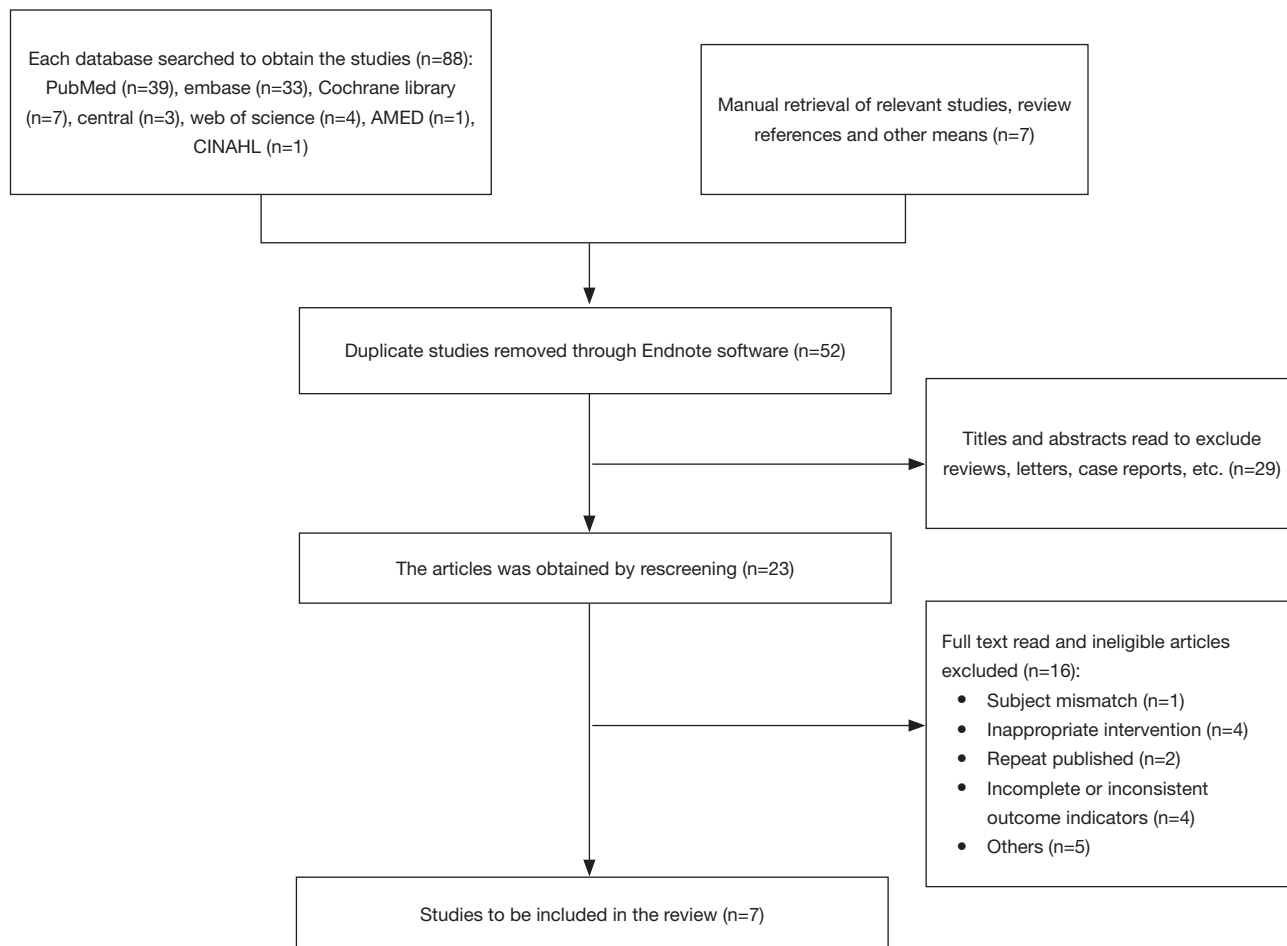
## **Results**

### *Literature search results*

A total of 88 studies were returned via the database search, and 7 were manually identified by other means. After eliminating duplicates, 52 studies remained. The abstract and then the full texts of these studies were carefully read, and 29 and 16 studies were excluded at each stage, respectively. Seven eligible studies were included in our meta-analysis. The Flow chart of literatures screening is shown in *Figure 1*.

### *Features of the selected literature*

The seven eligible studies were all prospective in nature (11-17) and explored the actual efficacy and possible mechanism of breathing exercises in patients with GERD. These studies were performed in China, Singapore, Australia, Italy, and Brazil, involving 194 GERD patients and 16 healthy volunteers. All of the studies had clear inclusion and exclusion criteria, and patients were diagnosed with GERD according to clear diagnostic criteria through endoscopic examination and symptom assessment. Mainstream diagnostic criteria were used in each region and country, and secondary patients were excluded prior to the research commencing. Generally, the breathing exercise methods in the seven studies were the same or similar, and they all focused on strengthening diaphragm tension and improving GERD symptoms (11-17). All of the studies evaluated the effect of short-term intervention from four to eight weeks (11-17), and 3 of them evaluated the long-term effect of four to nine months (12,13,16). Four studies



**Figure 1** Flow chart of literature screening.

recorded the symptoms of gastroesophageal reflux in patients (11-14), four recorded the change in esophageal pressure (13-15,17), two measured esophageal pH-value (14-16), one showed the results of laryngeal endoscopy (11), and one recorded the usage of acid suppression (13).

Three of the RCTs were designed in parallel (13,15,16). Both the experimental and control groups received PPI or acid suppressant before starting the experiment to ensure the initial disease severity of the subjects was roughly similar, and refractory GERD patients were excluded. In the study of Sun *et al.*, five patients were lost during long-term follow-up (13). The characteristics of the selected studies are shown in *Table 1*.

#### *Methodological quality of the selected studies*

The blinding method was described in detail in two studies,

but not in the rest. According to the Cochrane 5.1.0 systematic review manual, six RCT studies were grade B and two were grade A. In these RCT studies, there was no statistically significant difference between the experimental and control groups in terms of age, gender, body weight, body mass index. The methodological quality of the selected studies is shown in *Table 2*.

#### *Meta-analysis results of breathing exercises on anti-reflux barrier in patients with GERD*

Three RCTs reported the effects of breathing exercises on LES pressure in patients with GERD (13,15,16). There was no significant heterogeneity between the studies ( $P=0.62$ ,  $I^2=0\%$ ), and the fixed effects model was adopted. The results showed that breathing exercises had an effect on LES stress in GERD patients, with a statistically significant difference

**Table 1** The characteristics of the selected studies

Authors/ year	Region	Study design	Number of participants	Therapy		Exercise time	Parameters	Results
				Training	Control			
Nobre e Souza <i>et al.</i> (14) (2013)	Brazil	Prospective study	20 patients, 7 controls (healthy volunteers)	Inspiratory muscle training (IMT)	-	4 weeks	Esophago-gastric junction (EGJ) pressure measurements; assessment of tLESR; esophageal pH monitoring; and autonomic function: heart rate variability	Improved EGJ pressure and reduced GERD symptoms
da Silva <i>et al.</i> (15) (2013)	Brazil	Prospective randomized controlled study	38 patients (randomized, 22 in osteopathy group, and 16 in placebo group)	Breathing exercise (diaphragm stretching technique)	Breathing exercise (Sham technique)	4 weeks	Esophageal manometry: average respiratory pressure (ARP); and maximum expiratory pressure (MEP)	Increased ARP and no statistical difference in MEP
Eherer <i>et al.</i> (16) (2012)	Austria	Prospective randomized controlled study	19 patients (randomized, 10 in exercise group, and 9 in control group)	Abdominal breathing exercise + acid-suppressant drugs	Acid-suppressant drugs	4 weeks/9 months	Quality of life (QoL); esophageal pH monitoring; and proton pump inhibitor (PPI) usage	Decrease in time with a pH <4.0; improved QoL scores (4 weeks); and decreased QoL scores and PPI usage (9 months)
Carvalho de Miranda Chaves <i>et al.</i> (17) (2012)	Brazil	Prospective study	20 consecutive patients and 9 control group	Inspiratory muscle training (IMT)	-	8 weeks	Esophageal manometry, mid-respiratory pressure (MRP), and end expiratory pressure (EEP) before/after training	Increased LES by MRP (75% patients) and EEP (60% patients)
Ong <i>et al.</i> (12) (2018)	Singapore	Prospective study	36 patients (15 in exercise group and 21 in control group)	Diaphragmatic breathing exercise	-	4 weeks/4 months	Belching visual analogue scale (VAS); GERD symptoms (evaluated using the reflux disease questionnaire); and QoL scores	Decreased belching VAS score; reduced symptoms of GERD; and increased QoL scores and EuroQoL-VAS scores
Sun <i>et al.</i> (13) (2016)	China	Prospective randomized controlled study	40 patients (randomized, 20 in exercise group and 20 in control group)	Diaphragm biofeedback training (DBT) + rabeprazole	Rabeprazole alone	8 weeks/6 months	Amount of acid suppression used; reflux symptoms; GERD- health-related quality of life, (GERD-HRQL); and esophageal manometry	Decreased acid suppression usage; improved reflux symptoms; reduced GERD-HRQL; and increased crural diaphragm tension (CDT) and gastroesophageal junction (GEJ) pressure
Moffa <i>et al.</i> (11) (2020)	Italy	Prospective study	21	Diaphragmatic respiratory training (n-IMT)	-	4 weeks	GERD oesophageal symptomatology (GERDQ); extraesophageal GERD symptomatology (RSI); GERD-HRQL; and laryngeal endoscopy	Reduced GERDQ and GERD-HRQL; and improved laryngeal endoscopy score

**Table 2** Methodological quality of the selected studies

Authors/year	Generation of random sequences	Allocation concealment	Blinding method		Integrity of the data	Selective reporting	Other bias	Levels of methodological value
			For researcher	For patients				
Nobre e Souza <i>et al.</i> (14) (2013)	Low level	High level	High level	Low level	Low level	Low level	Low level	B
da Silva <i>et al.</i> (15) (2013)	Low level	Low level	High level	Low level	Low level	Low level	Low level	B
Eherer <i>et al.</i> (16) (2012)	Low level	Low level	Low level	Low level	Low level	Low level	Low level	A
Carvalho de Miranda Chaves <i>et al.</i> (17) (2012)	Low level	High level	High level	Low level	Low level	Low level	Low level	B
Ong <i>et al.</i> (12) (2018)	Low level	High level	High level	Low level	Low level	Low level	Low level	B
Sun <i>et al.</i> (13) (2016)	Low level	Low level	Low level	Low level	Low level	Low level	Low level	A
Moffa <i>et al.</i> (11) (2020)	High level	High level	High level	Low level	Low level	Low level	Low level	B

[WMD =1.36, 95% CI: (0.82, 1.91),  $P < 0.01$ ], as shown in *Figure 2*. The data used in the meta-analysis were calculated and converted from the original data.

Sun *et al.* (13) showed that GERD symptoms improved in the experimental group after breathing exercises. Further investigation revealed that CDT and GEJ pressure in the experimental group were enhanced, which may be the mechanism of breathing exercises in the treatment of GERD.

## Discussion

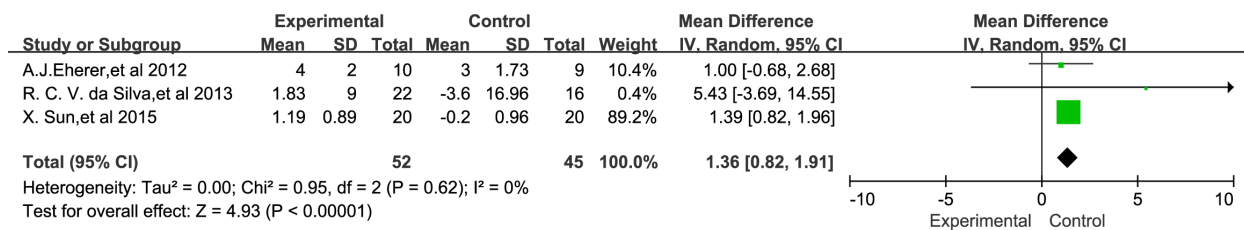
### *Methodological quality of the selected studies*

All of the studies included in this meta-analysis performed prospective efficacy studies on breathing exercises as an auxiliary treatment method. We evaluated the literature focusing on seven areas: generation of random sequences, allocation concealment, integrity of the data, blinding method, selective reporting, and other bias. Out of the three RCTs included (13,15,16), da Silva *et al.* (15) did not describe the blinding method for the researcher, but the other two RCTs had complete records, and their methodological quality level was A (13,16).

### *The effects of breathing exercises on reflux symptoms in patients with GERD*

The evaluation criteria of GERD symptoms and the quality of life use the universal and simple objective evaluation and self-scoring system in these literatures (18). Minor modifications were made to for each study according to the specific conditions for the smaller heterogeneity. According to the analysis results, the short-term effect of breathing exercises on reflux symptoms and quality of life in patients was found to be similar to the findings of some selected studies (11-14), but their long-term efficacy is controversial (16). There are two reasons for this: firstly, the sample size was small and the rate of losing to follow-up was high in the long term, which fails to give an accurate reflection the real situation; and secondly, Some patients have difficulty maintaining long-term high-quality breathing exercise, and cannot guarantee the quality of exercise.

Yang *et al.* (19) showed a positive correlation between anxiety and depression in GERD patients and disease severity. The symptoms of anxiety and depression and diseases in patients often interact with each other, and may affect patients' life and work due to repeated long-term symptoms such as acid regurgitation, belching, and



**Figure 2** The effects of breathing exercises on LES pressure in GERD patients. LES, lower oesophageal sphincter; GERD, gastroesophageal reflux disease.

heartburn, causing anxiety and depression, while long-term anxiety and depression may also cause over-sensitivity and aggravate symptoms. Self-assessment of anxiety and depression is subjective and uncertain to some extent, and short-term breathing exercises may not work, resulting in differences in outcomes.

#### *The effects of breathing exercises on acid suppressant consumption in patients with GERD*

PPIs can be used to diagnose GERD and to treat and relieve symptoms (20). It is easy to calculate the consumption of antacids or the proportion of people who stop taking them as objective indicators of disease severity. In the included studies, the patients used PPIs (such as: Rabeprazole) to control their symptoms, and before the experiment, all patients received routine PPI drugs treatment to ensure each had similar disease severity and to eliminate refractory GERD patients (21). Long-term breathing exercises had a greater effect than short-term observations (13,16).

#### *The effects of breathing exercises on the anti-reflux barrier in patients with GERD*

The function of anti-reflux barrier at the lower end of the esophagus is weakened in GERD patients, so gastric acid may enter the esophagus and cause damage to the esophageal mucosa (22). The CD is a skeletal muscle, which can be strengthened through physical exercise like other striated muscles. Although this is a variety of different exercises, their goal is always to strengthen these muscles and to enhance their anti-reflux mechanisms. Different studies have measured strength in different ways and breathing exercises have been shown to improve CD

tension, although the effect of strengthen LES and EGJ is still controversial (13,16).

In addition to improving the function of the anti-reflux barrier, breathing exercises may also have other mechanisms, such as reducing the frequency of one-time esophageal relaxation and increasing the rate of gastric emptying (14). At present, many research conclusions are still controversial, so larger sample sizes and more refined clinical trials are needed to explore the efficacy and specific mechanisms of breathing exercises in the treatment of GERD.

#### *Limitations*

This study has a number of limitations. Firstly, the included literature included RCTs and general prospective studies, which showed differences in the methods of breathing exercises, and so their results may be uncertain to some extent. Secondly, there was a lack of effective monitoring of the patients in the studies, and the quality of the exercises they were carrying out cannot be guaranteed. Thirdly, only seven studies were included, and the total sample size of these studies was also small. Furthermore, every study was published in English, and there is therefore a possibility that literature in other languages was omitted. Finally, these studies came from different countries and regions, with differences in race and levels of physical fitness, and this may have affected the final results.

#### **Conclusions**

This study showed that breathing exercises can help GERD patients reduce the symptoms of gastroesophageal reflux, improve their quality of life, and decrease acid

suppression usage, and that their specific mechanism may be to strengthen the anti-reflux barrier function. Therefore, GERD patients may experience better therapeutic effects through treatment with general drug therapy in conjunction with professional breathing exercises.

### Acknowledgments

*Funding:* This study was supported financially by Medicine and Health Science and Technology Plan Projects in Zhejiang Province (NO: 2020RC108).

### Footnote

*Conflicts of Interest:* The authors have no conflicts of interest to declare.

*Ethical Statement:* The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

*Open Access Statement:* This is an Open Access article distributed in accordance with the Creative Commons Attribution-NonCommercial-NoDerivs 4.0 International License (CC BY-NC-ND 4.0), which permits the non-commercial replication and distribution of the article with the strict proviso that no changes or edits are made and the original work is properly cited (including links to both the formal publication through the relevant DOI and the license). See: <https://creativecommons.org/licenses/by-nc-nd/4.0/>.

### References

- Richter JE, Rubenstein JH. Presentation and epidemiology of gastroesophageal reflux disease. *Gastroenterology* 2018;154: 267-76.
- Ness-Jensen E, Hveem K, El-Serag H, et al. Lifestyle Intervention in Gastroesophageal Reflux Disease. *Clin Gastroenterol Hepatol* 2016;14:175-82.e1-3.
- Newberry C, Lynch K. The role of diet in the development and management of gastroesophageal reflux disease: why we feel the burn. *J Thorac Dis* 2019;11:S1594-601.
- Brunner S, Fass R, Gerson LB. Value of the Proton Pump Inhibitor (PPI) Test for Patients with GERD, NCCP, and Extra-Esophageal GERD: A Meta-Analysis: 433. *Am J Gastroenterol* 2016;111:S194.
- Scarpellini E, Ang D, Pauwels A, et al. Management of refractory typical GERD symptoms. *Nat Rev Gastroenterol Hepatol* 2016;13:281-94.
- Laine L, Nagar A. Long-term PPI use: balancing potential harms and documented benefits. *Am J Gastroenterol* 2016;111:913-5.
- Devitt J, Lyon C, Swanson SB, et al. What are the risks of long-term PPI use for GERD symptoms in patients > 65 years? *J Fam Pract* 2019;68:E18-9.
- Casale M, Sabatino L, Moffa A, et al. Breathing training on lower esophageal sphincter as a complementary treatment of gastroesophageal reflux disease (GERD): a systematic review. *Eur Rev Med Pharmacol Sci* 2016;20:4547-52.
- Gyawali CP, Kahrilas PJ, Savarino E, et al. Modern diagnosis of GERD: the Lyon Consensus. *Gut* 2018;67:1351-62.
- Shuster JJ. Review: Cochrane handbook for systematic reviews for interventions, Version 5.1.0, published 3/2011. Higgins JP, Green S, editors. *Research Synthesis Methods* 2011;2:126-30.
- Moffa A, Oliveto G, Matteo FD, et al. Modified inspiratory muscle training (m-IMT) as promising treatment for gastro-oesophageal reflux disease (GERD). *Acta Otorrinolaringol Esp* 2020;71:65-9.
- Ong AM, Chua LT, Khor CJ, et al. Diaphragmatic Breathing Reduces Belching and Proton Pump Inhibitor Refractory Gastroesophageal Reflux Symptoms. *Clin Gastroenterol Hepatol* 2018;16:407-16.e2.
- Sun X, Shang W, Wang Z, et al. Short-term and long-term effect of diaphragm biofeedback training in gastroesophageal reflux disease: an open-label, pilot, randomized trial. *Dis Esophagus* 2016;29:829-36.
- Nobre e Souza MÂ, Lima MJ, Martins GB, et al. Inspiratory muscle training improves antireflux barrier in GERD patients. *Am J Physiol Gastrointest Liver Physiol* 2013;305:G862-7.
- da Silva RC, de Sá CC, Pascual-Vaca ÁO, et al. Increase of lower esophageal sphincter pressure after osteopathic intervention on the diaphragm in patients with gastroesophageal reflux. *Dis Esophagus* 2013;26:451-6.
- Eherer AJ, Netolitzky F, Hogenauer C, et al. Positive effect of abdominal breathing exercise on gastroesophageal reflux disease: a randomized, controlled study. *Am J*



- Gastroenterol 2012;107:372-8.
17. Carvalho de Miranda Chaves R, Suesada M, et al. Respiratory physiotherapy can increase lower esophageal sphincter pressure in GERD patients. *Respir Med* 2012;106:1794-9.
  18. Velanovich V. The development of the GERD-HRQL symptom severity instrument. *Dis Esophagus* 2007;20:130-4.
  19. Yang XJ, Jiang HM, Hou XH, et al. Anxiety and depression in patients with gastroesophageal reflux disease and their effect on quality of life. *World J Gastroenterol* 2015;21:4302-9.
  20. Gasiorowska A, Fass R. The proton pump inhibitor (PPI) test in GERD: does it still have a role? *J Clin Gastroenterol* 2008;42:867-74.
  21. Fass R, Gasiorowska A. Refractory GERD: what is it? *Curr Gastroenterol Rep* 2008;10:252-7.
  22. Pandolfino JE, Kim H, Ghosh SK, et al. High-resolution manometry of the EGJ: an analysis of crural diaphragm function in GERD. *Am J Gastroenterol* 2007;102:1056-63.

**Cite this article as:** Qiu K, Wang J, Chen B, Wang H, Ma C. The effect of breathing exercises on patients with GERD: a meta-analysis. *Ann Palliat Med* 2020;9(2):405-413. doi: 10.21037/apm.2020.02.35