Efficacy and safety of oropharyngeal muscle strength training on poststroke oropharyngeal dysphagia: a systematic review and meta-analysis

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ABSTRACT

Objectives To investigate how oropharyngeal muscle strength training affected the safety and performance of swallowing in patients with poststroke oropharyngeal dysphagia.

Design Systematic review and meta-analysis.

Data sources Cochrane Central Register of Controlled Trials, Web of Science, PubMed, Embase databases and ClinicalTrials.gov were systematically searched, for publications in English, from database inception to December 2022.

Eligibility criteria Studies comparing the effect of oropharyngeal muscle strength training with conventional dysphagia therapy in patients with poststroke. Penetration-Aspiration Scale (PAS) and Functional Oral Intake Scale (FOIS) were assessed as the main outcomes.

Data extraction and synthesis Two researchers independently screened the literature, extracted data and evaluated the quality of the included studies, with disagreements resolved by another researcher. The Cochrane risk-of-bias tool was used to assess the risk of bias. Review Manager V.5.3 was employed for the meta-analysis. Random effect models were used for meta-analysis.

Results Seven studies with 259 participants were included in this meta-analysis. The results showed that oropharyngeal muscle strength training could reduce PAS score compared with conventional dysphagia therapy (mean difference=−0.98, 95% CI −1.34 to −0.62, p<0.0001, I²=28%). The results also showed that oropharyngeal muscle strength training could increase FOIS score (mean difference=1.04, 95% CI 0.55 to 1.54, p<0.0001, I²=0%) and the vertical displacement of the hyoid bone (mean difference=0.20, 95% CI 0.01 to 0.38, p=0.04, I²=0%) compared with conventional dysphagia therapy.

Conclusion In patients with poststroke oropharyngeal dysphagia, oropharyngeal muscle strength training can improve swallowing safety and performance.

INTRODUCTION

Approximately 13.7 million people worldwide suffer from stroke annually,1 and nearly half experience functional impairments to varying degrees, which seriously affects individuals’ quality of life.2 3 Oropharyngeal dysphagia is a common poststroke functional impairment with an incidence of up to 80%.4 Patients with oropharyngeal dysphagia exhibit symptoms such as aspiration and pharyngeal residue.5 Most patients will recover swallowing function spontaneously. However, in many Asian countries, patients with chronic and severe dysphagia are commonly provided with a long-term nasogastric tube (NGT).6 This both increases medical expenses and leads to complications, such as malnutrition, dehydration and aspiration pneumonia.7 Therefore, proper swallowing training is especially important for safe swallowing. Training for oropharyngeal dysphagia may include surgery, drugs, compensatory dysphagia strategies, oropharyngeal muscle strength training, sensory and neurophysiologic simulation and many others. Currently, oropharyngeal dysphagia trainings are often used for dysphagia caused by stroke, traumatic brain injury, spinal cord injury, head and neck tumours and Parkinson’s disease.
Compensatory dysphagia strategies often include swallowing manoeuvres, improving oral sensory awareness, postural changes and dietary modifications, among others. The goal of compensatory dysphagia strategies is to improve the symptoms of dysphagia to ensure a safe and adequate intake of nutrients and fluids. However, the effect is temporary. Therefore, additional scientific and novel training programmes are required as a supplement. Nowadays, oropharyngeal muscle strength training is one of popular programmes.

Oropharyngeal muscle strength training usually includes Shaker exercise (or chin tuck against resistance exercise), and tongue strengthening exercise. Suprhyoid muscles are the most basic structures responsible for hyoid and larynx elevation. Insufficient elevation of the hyoid and larynx results in increasing the amount of pharyngeal residue and the risk of aspiration. Fujiki et al. found that Shaker exercise aimed to improve swallowing biomechanical effects by increasing the excursion or duration of hyolaryngeal movement. During swallowing, superior hyolaryngeal excursion is thought to help protect the airway and prevent aspiration.

The number of studies investigating the effect of oropharyngeal muscle strength training on changes in swallowing physiology in healthy individuals and treatment effectiveness in patients with dysphagia has increased. Nonetheless, most studies have concentrated on healthy or elderly people, as well as dysphagia caused by Parkinson’s disease or head and neck cancer. Some studies examined the effect of oropharyngeal muscle strength training on patients with poststroke oropharyngeal dysphagia. However, systematic reviews and meta-analyses are scarce.

Therefore, we conducted this meta-analysis to determine whether oropharyngeal muscle strength training can improve the safety and performance of swallowing in patients with poststroke oropharyngeal dysphagia, as well as whether differences in training type, time and intensity can affect the safety and treatment effect of swallowing.

METHODS
This meta-analysis was conducted under the guidance of the Cochrane Handbook for Systematic Reviews of Interventions and reported according to the update Preferred Reporting Items for Systematic Reviews and Meta-Analyses as well as the research protocol we developed. The protocol for this study is available online.

Literature search and search strategy
We systematically searched the Cochrane Central Register of Controlled Trials, Web of Science, Medline, Embase databases and ClinicalTrials.gov (www.clinicaltrials.gov). The retrieval method was a combination of medical subject headings terms and free terms. Key terms included ‘deglutition disorders’, ‘dysphagia’, ‘Shaker exercise’, ‘head lift exercise’, ‘chin tuck against resistance’, ‘Iowa oral performance instrument’, ‘isometric lingual exercise’, ‘tongue to palate resistance training’ and ‘tongue strengthening exercises’. The references of the included studies and systematic reviews of related topics were manually retrieved to execute a comprehensive search. The retrieval time limit was from the establishment of the database to 11 December 2022. The primary search strategy is outlined in online supplemental additional file 1.

Inclusion and exclusion criteria
Inclusion criteria
This systematic review and meta-analysis included randomised controlled trials (RCTs) published in English. Participants were stroke patients who were diagnosed with oropharyngeal dysphagia via the videofluoroscopic swallowing study, flexible endoscopic evaluation of swallowing or clinical assessment. Regardless of whether other training methods are combined, the intervention must contain at least one of the following methods: Shaker exercise (or chin tuck against resistance exercise or head lift exercise), device facilitated lingual exercise (Iowa Oral Performance Instrument, IOPI MEDICAL LLC, Redmond, Washington, USA) or low technology (tongue to palate or tongue to tongue depressor) exercises. Lingual range of motion exercises are not considered as experimental group. Comparison involved conventional dysphagia therapy or placebo training (the same equipment was used as in the intervention group, but without resistance). Primary outcomes included safety (Penetration-Aspiration Scale, PAS) and performance outcomes (Functional Oral Intake Scale, FOIS) of swallowing. Secondary outcomes included the severity of dysphagia (such as Functional Dysphagia Scale and Videofluoroscopic Dysphagia Scale) and indicators of swallowing physiology (such as hyoid movement and tongue pressure).

Exclusion criteria
Participants were under 18 years old; recurrent stroke; a history of head and neck surgery before stroke onset, such as thyroidectomy and symptoms of dysphagia caused by oropharyngeal cancer, Parkinson’s disease or drugs before onset.

Study selection
Two researchers (HW and JS) independently screened the literature titles and abstracts according to the research protocol. Eliminated literature that did not meet the selection criteria and independently reviewed the full texts of the remaining literature before finally confirming inclusion. Any disagreement should be resolved in consultation with a third reviewer (FZ).

Data extraction
Two researchers (YW and XW) documented and independently extracted data from eligible articles using
Excel spreadsheets. The specific format is as follows: (1) general characteristics: country, publication year, the first author’s name, sample size and patient characteristics. (2) intervention and comparison: training type, intensity, duration and frequency. (3) outcome: PAS, FOIS, Functional Dysphagia Scale, Videofluoroscopic Dysphagia Scale, hyoid bone movement and tongue pressure. The lead author was contacted by email if incomplete data were provided for analysis. Any disagreements between the two researchers during the abovementioned process were resolved by discussion or consultation with a third researcher (FZ).

Risk of bias assessment

Two researchers (LX and XY) independently assessed the risk of bias of included studies using the Cochrane risk-of-bias tool. The Cochrane risk-of-bias tool was recommended by Cochrane handbook including random sequence generation (selection bias), allocation concealment (selection bias), blinding of participants and personnel (performance bias), blinding of outcome assessment (detection bias), incomplete outcome data (attrition bias), selective reporting (reporting bias) and other bias (bias due to problems not covered elsewhere). In the Cochrane risk-of-bias tool, the risk of bias was classified as ‘low risk’, ‘unclear’ and ‘high risk’. The risk of bias graph was performed using the Cochrane Review Manager software (V.5.3; Cochrane, London, UK). Any disagreements between the two researchers during the abovementioned process were resolved by discussion or consultation with a third researcher (FZ).

Quality of evidence

The quality of the evidence was assessed in terms of the risk of bias, inconsistency, indirectness, imprecision and publication bias according to the Grading of Recommendations Assessment, Development and Evaluation (GRADE) system. The quality of the evidence for the primary and secondary outcomes was assessed and rated as very low, low, moderate or high.

Data analysis

This meta-analysis was performed using the Cochrane Review Manager software (V.5.3; Cochrane, London, UK). Based on the Cochrane Handbook for Systematic Reviews of Interventions (V.6.3, 2022), we calculated mean and SD in each group. If included study had more than one experimental group, we will combine the sample data according to the following formula. A random-effects model was used to quantitatively pool data to assess the treatment effects. Continuous data were presented using mean differences and 95% CI. The I² statistic was used to assess heterogeneity among included studies; results were classified as low (I²<25%), moderate (I² between 25% and 50%) and high (I²>50%). Considering certain differences in intervention methods across studies, we performed subgroup analyses for training type, intensity and duration to explain the sources of heterogeneity.

Patient and public involvement

Patients or the general public will not be directly involved in the study. All data collected in this study will be derived from published data in databases or clinical trial registries.

RESULTS

Trial selection

We retrieved a total of 925 records from the Medline (n=276), Embase (n=346), Cochrane Central Register of Controlled of Trials (n=86) and Web of Science (n=217) databases. After deleting duplicated records (n=449), the titles and abstracts of the remaining 476 records were screened, and 49 records that appeared to meet the selection criteria were identified. After reading the full text, seven studies were finally included. The screening process is outlined in figure 1.

Study characteristics

The seven studies included 259 participants; sample sizes ranged from 25 to 90 participants. The average disease course ranged from 19.2 to 37.2 weeks. The number of participants lost to follow-up varied between 0 and 11 (25%); the main reasons included hospital discharge and neck muscle fatigue. In the seven included studies, PAS was used to assess the safety of swallowing. FOIS was used in three studies to assess swallowing...
performance. Characteristics of the included studies and interventions are shown in table 1.

Risk of bias assessment
Results for the risk of bias assessment are shown in online supplemental figure 1. While all studies used randomisation, there was a lack of detailed explanations and descriptions for allocation concealment. Five studies37 38 41–43 used a blinded design, and in three studies,37 41 43 the rate of loss to follow-up exceeded 20%, resulting in incomplete outcome data.

Safety of swallowing-PAS
All seven included studies (n=259) used PAS to assess the safety of swallowing. The results indicated that oropharyngeal muscle strength training when compared with conventional dysphagia therapy group (Figure 2).

Subgroup analysis of PAS was performed to explain the sources of heterogeneity of the findings. Supine and upright position groups were generated according to the training type. The results suggested that compared with conventional dysphagia therapy group, PAS score decreased in the supine position group (MD=−1.13, 95% CI −1.55 to −0.71, I²=0%, p<0.0001), and decreased in the upright position group (MD=−0.82, 95% CI −1.46 to −0.18, I²=57%, p=0.01). Also, 60s and <60s groups were generated according to training intensity. The results revealed that compared with conventional dysphagia therapy group, PAS score decreased in both the 60s group (MD=−1.14, 95% CI −1.53 to −0.75, I²=0%, p<0.0001), and the <60s group (MD=−0.71, 95% CI −1.54 to −0.11, I²=70%, p=0.09); but no statistically significant differences were identified in the <60s group. Four and 6weeks groups were generated according to the training time; the results revealed that compared with conventional dysphagia therapy group, PAS score decreased in 4weeks group (MD=−0.78, 95% CI −1.17 to −0.39, I²=10%, p<0.0001), and decreased in 6weeks group (MD=−1.40, 95% CI −1.89 to −0.91, I²=0%, p<0.0001).

Performance of swallowing
Functional Oral Intake Scale
Three studies37 40 41 (n=85) used FOIS to assess the performance of swallowing. The results indicated that oropharyngeal muscle strength training increased (MD=1.04, 95% CI 0.55 to 1.54, I²=0%, p<0.0001) when compared with conventional dysphagia therapy (Figure 3).

Hyoid movement
Two studies41 43 (n=56) evaluated the hyoid movement, and a meta-analysis demonstrated that oropharyngeal muscle strength training was associated with an increase of 0.09 in horizontal displacement of the hyoid when compared with conventional dysphagia therapy; no significant difference was observed (MD=0.09, 95% CI −0.05 to 0.23, I²=0%, p=0.21), but the vertical displacement of the hyoid increased (MD=0.20, 95% CI 0.01 to 0.38, I²=0%, p=0.04) (Figure 4).

GRADE certainty of evidence
The GRADE evidence for the primary and secondary outcome measures is summarised in online supplemental additional file 2; the quality of evidence for the PAS, FOIS and hyoid bone movement was moderate.

DISCUSSION
Our meta-analysis comprehensively and systematically reviewed the current literature, comparing oropharyngeal muscle strength training and conventional dysphagia therapy for the treatment of patients with poststroke oropharyngeal dysphagia. We found that oropharyngeal muscle strength training can reduce PAS score, improve FOIS score and increase the vertical displacement of the hyoid in patients with poststroke oropharyngeal dysphagia.

PAS is an 8-point scale used to describe the depth and response to airway invasion during videofluoroscopy,44 which is a standard method used by researchers and clinicians to assess the safety of swallowing. PAS is used to describe the depth of material into laryngeal vestibule or airway and whether it can be expelled.45 Higher scores indicate more severe aspiration and less safe swallowing. This meta-analysis revealed that oropharyngeal muscle strength training can effectively reduce PAS score in patients with poststroke oropharyngeal dysphagia.

Shaker exercise is also known as the head lift exercise. Studies have shown that Shaker exercise can effectively activate the suprahyoid muscles (geniohyoid, mylohyoid, digastric anterior/posterior belly and stylohyoid), increase the forward and upward displacement of the hyoid, achieve epiglottis inversion and laryngeal vestibular closure, and reduce residues in the epiglottic valleculae and pyriform recess, thereby reducing the risk of aspiration. However, Shaker exercise is performed against gravity in the supine position and requires strenuous physical effort, often causing neck muscle fatigue and temporary pain. Shaker exercise is difficult to accomplish in patients with neurological disorders, explaining the relatively high rate of loss to follow-up in the studies included in this meta-analysis. Chin tuck against resistance exercise is a modification of Shaker exercise,47 which induces activation of the suprahoid muscles by forcefully pressing the mandible against an elastic rubber ball in the sitting position. Park et al48 found that chin tuck against resistance exercise helped to activate the suprahoid muscle group in healthy adults. Additionally, it activated the sternocleidomastoid muscle less than Shaker exercise. Training in the supine and sitting positions can effectively activate the suprahoid muscles; however, the rate of loss to follow-up for training in the sitting position is relatively low. Therefore, it may better serve patients with neurological disorders.
<table>
<thead>
<tr>
<th>Author, year</th>
<th>Sample size (E/C)</th>
<th>Age (E/C) mean±SD</th>
<th>Duration of stroke (E/C) mean±SD</th>
<th>Interventions</th>
<th>Controls</th>
<th>Treatment course</th>
<th>Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kim et al, 2017</td>
<td>18 (11M/7F)/17 (8M/9F)</td>
<td>62.2±11.0/59.3±10.2</td>
<td>4.9±5.5/5.3±5.6 months</td>
<td>TPR+CDT</td>
<td>CDT</td>
<td>5 sessions/w 4 weeks</td>
<td>PAS</td>
</tr>
<tr>
<td>Choi et al, 2017</td>
<td>16 (10M/6F)/15 (9M/6F)</td>
<td>60.8±10.9/60.4±10.5</td>
<td>3.4±1.2/4.1±1.0 months</td>
<td>Shaker exercise+CDT</td>
<td>CDT</td>
<td>5 sessions/w 4 weeks</td>
<td>PAS</td>
</tr>
<tr>
<td>Gao et al, 2017</td>
<td>Shaker30 (15M/15F) CTAR30 (13M/17F)/30 (14M/16F)</td>
<td>Shaker 71.1±7.1 CTAR 70.9±6.6/71.1±6.4</td>
<td>NA/NA</td>
<td>Shaker exercise+CTAR</td>
<td>CDT</td>
<td>7 sessions/w 6 weeks</td>
<td>SDS</td>
</tr>
<tr>
<td>Park et al, 2017</td>
<td>13 (9M/4F) / 14 (8M/6F)</td>
<td>59.3±11.9/61.6±13.6</td>
<td>21.3±8.9/19.2±5.7 weeks</td>
<td>Shaker exercise+CDT</td>
<td>CDT</td>
<td>5 sessions/w 4 weeks</td>
<td>PAS</td>
</tr>
<tr>
<td>Park et al, 2018</td>
<td>11 (6M/5F) / 11 (4M/7F)</td>
<td>62.2±17.3/58.4±12.5</td>
<td>37.2±8.5/32.1±14.4 weeks</td>
<td>CTAR+CDT</td>
<td>CDT</td>
<td>5 sessions/w 4 weeks</td>
<td>PAS</td>
</tr>
<tr>
<td>Kim et al, 2019</td>
<td>12 (6M/6F) / 13 (6M/7F)</td>
<td>63.5±5.5/65.2±6.2</td>
<td>NA/NA</td>
<td>mCTAR+CDT</td>
<td>CDT</td>
<td>5 sessions/w 6 weeks</td>
<td>PAS</td>
</tr>
</tbody>
</table>

Continued
The amount of effort or force exerted during a single repetition of an exercise is reflected in intensity, and the length of hold can be used to define intensity in isometric exercises. The results of this study reveal that maintaining a training intensity of 60s can significantly reduce the risk of aspiration, while a training intensity <60s has no statistical difference. The duration represents the total length of the training plan. A previous study has shown that at least 4 weeks of training are required for significant increases in muscle volume and strength. Kraaijenga et al found that 6 weeks of chin tuck against resistance exercise increased the muscle volume of suprahyoid muscles in healthy adults. While Choi et al discovered that 6 weeks of Shaker exercise could increase the thickness of digastric and mylohyoid muscles in patients with poststroke dysphagia. Therefore, all studies included in this meta-analysis performed at least 4 weeks of training. However, our results demonstrated that 6 weeks of training may be more effective than 4 weeks. Nevertheless, there was no statistical difference.

FOIS is a 7-point scale developed to assess the level of functional oral intake of food and liquids in stroke patients. FOIS describes distinct levels of oral intake, with levels 1–3 relating to varying degrees of tube feeding and levels 4–7 relating to varying degrees of oral feeding without feeding tube supplements. Patients with levels 1–3 sometimes had partial oral intake capacity, but they were still dependent on a feeding tube. This may be due to the clinician’s cautious about aspiration during the initial oral intake, or it may be due to prevent malnutrition and dehydration. This meta-analysis suggests that oropharyngeal muscle strength training can improve FOIS score in patients with poststroke oropharyngeal dysphagia. This may be that oropharyngeal muscle strength training could increase the strength of the suprahyoid muscles with reducing the risk of aspiration, and promote the production of swallowing with allowing the patient to intake more food and liquids in a shorter time, thus reducing the risk of malnutrition and dehydration.

For all we know, Park et al summarised the applications of CTAR exercise, including healthy participants and stroke patients. They found that compared with control group, CTAR group showed a more significant improvement in PAS, but no statistically significant difference in FOIS. This may be that CTAR could induce a greater mean and peak values of suprahyoid muscle activation. But this systematic review did not compare healthy participants and stroke patients in PAS and FOIS. Speyer et al found that Shaker exercise, CTAR and expiratory muscle strength training had significant effects for reducing PAS scores compared with CDT in stroke patients. Because of the heterogeneity between studies, this systematic review did not conduct subgroup analysis on the training dose and duration. Antunes and Lunet found that head lift exercise showed better effects regarding postswallow aspiration than traditional therapy in upper oesophageal sphincter dysfunction. The main results of these studies are consistent with ours. For clinical, standardised...
Figure 2  Forest plot for Penetration-Aspiration Scale.
treatment protocol is good for the comparison of therapeutic effects. But training dose and duration are always influenced by age, primary dysphagia aetiology, physical fitness level and so on. Future research should continue to explore the relationship on training dose and duration with training efficacy in order to establish standard parameters for oropharyngeal muscle strength training to maximise patient benefits.

Although this meta-analysis was reported following the PRISMA (PRISMA, preferred reporting items for systematic reviews and meta-analysis) guidelines to reduce bias, it still has some limitations. First, the number of available studies limited current analyses, and although more published data on oropharyngeal muscle strength training, the literature remains sparse and always concerned about healthy or Parkinson’s disease. The participants in this meta-analysis were only concerned with stroke, so there was less amount of literature included. Second, unpublished literature was not included. This may have resulted in an over-representation of positive treatment effects in this review. Third, Egger’s publication bias test is known to have limited efficiency for meta-analysis that involving less than 10 studies, we did not conduct the test. Fourth, some included studies had a high risk of bias in terms of randomisation and allocation, which may limit the quality of the evidence. Fifth, the score of PAS may vary depending on different bolus volumes, consistencies, postural manoeuvres and barium concentration. When the same task is repeated several times, penetration-aspiration events are unlikely to occur consistently within a person.

CONCLUSION

In conclusion, this meta-analysis has found that oropharyngeal muscle strength training can improve the safety and performance of swallowing in patients with poststroke.
oropharyngeal dysphagia. The evidence is still insufficient to support clinical use. To fully investigate the clinical efficacy, large-scale, multicentre RCTs are required.

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Contributors MG, YW, LX and FZ designed the study and interventions. HW, JS and XY designed search strategies and perform the study search. MG, YW, XX and FZ perform data collection, analysis and synthesis. MG wrote the manuscript and all coauthors critically reviewed and approved the final manuscript. FZ is the guarantor for the protocol and the final review.

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REFERENCES

12 Kagaya H, Inamoto Y. Possible rehabilitation procedures to treat sarcopenic dysphagia. Nutrients 2022;14:778.