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REVIEW

Effectiveness of Respiratory Muscle Training on Respiratory Muscle Strength, Pulmonary Function, and Respiratory Complications in Stroke Survivors: A Systematic Review of Randomized Controlled Trials

Sisay Deme[1], Dheeraj Lamba[1], Abayneh Alamer[2], Haimanot Melese[2], Sileshi Ayhualem[3], Dechassa Imeru[4], Tsegereda Abebe[5]

[1]Department of Physiotherapy, Faculty of Medical Science, Institute of Health, Jimma University, Jimma, Ethiopia; [2]Department of Physiotherapy, School of Medicine, College of Health Sciences, Tibebe Ghion Comprehensive Specialized Hospital, Bahir Dar University, Bahir Dar, Ethiopia; [3]Department of Anatomy, College of Medicine and Health Sciences, University of Gondar, Gondar, Ethiopia; [4]Department of Physiotherapy, College of Medicine and Health Sciences, University of Gondar, Gondar, Ethiopia; [5]Department of Human Nutrition, Institute of Public Health, University of Gondar, Gondar, Ethiopia

Correspondence: Sisay Deme, Tel +251923272360, Email sisaydeme21@gmail.com

Background: Stroke is the most common leading cause of mortality and related morbidities worldwide. After stroke, the motor function of extremities and spinal muscles is significantly impairment, but not only this, it also has attributable factors leading to respiratory dysfunction. Nevertheless, to the extent of the authors' knowledge, there is a dearth of conclusive studies which examined the effectiveness of RMT on muscle strength, pulmonary function, and respiratory complications of individuals after stroke.

Objective: The purpose of this systematic review was to evaluate the effectiveness of respiratory muscle training on respiratory muscle strength, pulmonary function, and respiratory complications in patients after stroke.

Methods: An electronic database search of HINARI, PEDro, PubMed, Cochrane Library and Google scholar was used to identify randomized controlled trials that evaluated the effectiveness of respiratory muscle training in patients with stroke. Articles published from 2010 to 2019 were included. The quality of the articles was assessed using PEDro scale. Articles with abstract only, PEDro scores less than 5, published in non-English language, not freely available articles, and quasi experimental studies were excluded from this study.

Results: The literature search yielded a total of 7 articles (6 randomized controlled trials with 1 pilot randomized controlled trial) which met inclusion criteria despite their heterogeneity. The methodological quality of all studies ranged from 6 to 8 in Pedro score. Most of the articles reported a significant increase in respiratory muscle strength, respiratory muscle function, and reduced risk of complications with a p value <0.05.

Conclusion: Respiratory muscle training could potentially improve muscle strength and pulmonary functions of subjects after stroke. Thus, it may reduce stroke-related respiratory complications in subjects after stroke. However, further study is warranted with high quality RCTs and pooled synthesis of results.

Keywords: stroke, respiratory muscle training, systematic review, randomized or quasi-randomized trials and respiratory muscle training

Introduction

A stroke could occur either due to blocking by clot or bursts/rupture of blood vessels that carries oxygen and nutrients to the brain.[1]

Stroke is the most common leading cause of mortality and related morbidities worldwide.[2] After stroke, the motor function of extremities and spinal muscles is significantly impaired, but not only this, it also has attributable factors

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leading to respiratory dysfunction.[3] Respiratory function is related to the breathing process, in which the lungs perform its ventilation and perfusion to oxygenate all body tissues. Thus, this function depends on strength and endurance of respiratory muscles, lung volumes and capacity.[4] However, post-stroke individuals have respiratory muscle force production deficit, abnormal breathing pattern, and decreased lung volumes that may lead to restrictive respiratory disease.[5]

A prior study reported mean values of maximal inspiratory pressure ranging from 17 to 57 cmH_2O in people after stroke, compared with approximately 100 cmH_2O, and mean values of maximal expiratory pressure ranging from 25 to 68 cmH_2O, compared with approximately 120 cmH_2O in healthy adults.[6] This decreased respiratory function is also associated with deconditioning respiratory complication and activity limitations. This will lead to non-vascular death after stroke.[7] Hence, physiotherapy intervention like respiratory muscle training (RMT) can improve the strength or force productions, and endurance of respiratory muscles, thereby reducing respiratory complications in individuals after stroke.[4,6,8] RMT is performed based on the argument that respiratory muscles respond to training stimuli by undergoing adaptations to their structure in the same manner as any other skeletal muscles.[9]

Nevertheless, to the extent of the authors' knowledge, there is a dearth of conclusive studies which evaluated the effectiveness of RMT on muscle strength, pulmonary function, and respiratory complications in individuals after stroke. Therefore, the purpose of this systematic review was to establish its effects on respiratory functions of individuals post-stroke.

Methods

Design

This review was done and reported in accordance with Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guideline.[10]

Search Strategy

An electronic database search of HINARI, Pedro, PubMed, science direct and Google scholar was used to identify randomized controlled trials that evaluated the effectiveness of respiratory muscle training in patients with stroke. Search strategy was done on 2010–2019 published articles by using the following search terms: "Stroke" AND "systematic review" AND "respiratory muscle training" AND "randomized controlled trials" OR "inspiratory muscle training" OR "expiratory muscle training" OR "breathing exercises".

Eligibility Criteria

Each study's eligibility was evaluated using the PICO (Population/problem(s), intervention(s), comparison(s), outcome-(s)) framework. The PICO process (or framework) is a mnemonic used in evidence-based practice (and specifically evidence-based medicine) to frame and answer a clinical or health care-related question. This method enables the clinician in articulating the therapeutic issues that are most relevant to the patient and supports the discovery process by defining the middle concepts for the appropriate seek strategy.[11,12]

Inclusion Criteria

If the studies found met the following criteria, they were deemed qualified: 1) Target population: patients with all types of stroke. 2) Intervention: respiratory muscle training (inspiratory muscle training, expiratory muscle training, breathing exercises). 3) Comparisons: conventional stroke rehabilitation, a sham intervention, standard swallow therapy. 4) Outcomes: respiratory muscle strength, function and incidence of respiratory complication. Full text articles published in English language in a peer-reviewed journal were considered. This review included adults with acute and chronic stroke. Randomized controlled trials and pilot randomized controlled trials studying the effectiveness of respiratory muscle training in patients with stroke were included (Table 1).

Table 1 Summary of Included Studies

Author/ Year	Characteristics of Participants	Outcome Measures	Interventions	Results	Conclusions
Sutbeyaz. ST et al 2010[15]	45 total participants: BRTG (n=15), IMTG (n=15), CG (n=15) -Mean age (years): BRTG;60.8 (6.8), IMTG;62.8 (7.2), CG;61.9 (6.15) Gender (Female/male): BRTG;7/8, IMTG;7/8, CG;7/8 Duration (days): BRTG;156 (49.7), IMTG;155.1 (46.9), CG;163.2 (36.5) Type of lesion (ischemic/hemorrhagic): BRTG;10/5, IMTG;12/3, CG;11/4	-FAC -BI -FVC -VC -FEV_1 -FEV_1/FVC	-EG: diaphragmatic breathing combined with pursed-lip breathing were given for 15 minutes, five days a week, 6 weeks durations. -CG: conventional stroke rehabilitation was given for five days a week for six-week period.	- Pulmonary function measures had no significant difference (FVC (P=0.41), VC (P=0.94), FEV1 (P=0.96), FEF 25–75% (P=0.28) and MVV (P=0.23)) in the BRT group compared with baseline and the control group. - PEF values were improved by the BRT intervention with a p value (p=0.01). Statistically significant improvement was observed in the IMT group regarding FVC (p=0.01), VC (p=0.01), FEV1 (p=0.01) and MVV (p<0.001) values compared with baseline and the control group.	-Risk of stroke and various forms of cardiovascular disease and stroke mortality might be reduced by respiratory muscle training.
Yoo H-J, Pyun S-B 2018[16]	40 total participants: EG (n=20), CG (n=20) Mean age (years): EG (n=57), CG (n=65) Female/male: IG;6/14, CG;8/12 Duration (days): IG;24 (11–95), CG;24.5 (11–95) Types of stroke: (ischemic/ hemorrhagic) IG;11/9, CG;12/8	-FVC -FEV_1 -BBS -Fugl-Meyer - pneumonia incidence	-EG: bedside respiratory muscle training and conventional stroke rehabilitation program was given for 30 minutes, twice a day 5 days a week, for 3 weeks. CG: conventional stroke rehabilitation program was given for 30 minutes twice a day 5 days a week, for 3 weeks.	-The effect of respiratory muscle training on FEV1 (P= 0.027) and peak flow (P=0.004) were statistically significant. The improvement in FVC and also FEV1/FVC, % was not statistically significant between the two groups. (P=0.066), (P=0.607) respectively. -There were no significant differences between the two groups in pulmonary function and stroke-related complications.	- Significant short-term effects of bedside respiratory muscle training in patients with stroke were observed. Much improvement in pulmonary function was reported, but the prophylactic effect of reducing pneumonia was not shown.
de Menezes KKP et al, 2019[17]	-38 total participants: EG (n=19), CG (n=19) -Mean age (years): EG (n=60), CG (n=67) Female/male: EG;11/8, CG;11/8 -Duration (months); EG;24±2), CG;16±12 Types of stroke:(ischemic/ hemorrhagic/unknown) EG;12/3/4, CG;15/3/1	-MIP -MEP -6m walk test -Endurance inspiratory muscle (no of breaths)	-EG: received high intensity home based respiratory muscle training for 40 min/day, 7 times a week over 8 weeks. -CG: received sham home based respiratory muscle training for 40 min/day, 7 times a week over 8 weeks.	The result showed that significant changes were observed in MIP (P<0.001), MEP (P<. 001) and inspiratory endurance (P<0.001). Significant between-group differences were also found for dyspnea at post-intervention (P<0.01) and follow-up (P<0.05) measures. No significant differences were found in walking capacity P<0.29) and respiratory complications (P=99)	High-intensity home-based respiratory muscle training was effective in increasing strength and endurance of the respiratory muscles and reducing dyspnea for people with stroke.

(*Continued*)

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Table 1 (Continued).

Author/ Year	Characteristics of Participants	Outcome Measures	Interventions	Results	Conclusions
Guillén-Solà, et al, 2017[18]	-62 total participants: SST (n=21), IEMT (n=20), NMES (n=21) -Mean age (years): SST (n=68.9), IEMT (n=67.9), NMES (n=70.3) Female/male: SST;9/12 IEMT;4/16, NMES;11/10 -Duration (days): SST; 9.3± 5.1) IEMT; 10.8± 8.7, NMES; 11.0 ±5.5 -Types of stroke: subacute dysphagic stroke	-Penetration-aspiration scale, -MIP -MEP -Respiratory complication -Dysphagia Outcome Severity Scale -Barthel Index -Modified Rankin scale	-Group I: received SST (3 hours per day, 5 days a week, for 3 weeks) -Group II: received SST & respiratory muscle training, 5 sets of 10 respirations twice a day, 5 days per week for 3 weeks. -Group III: received SST & sham respiratory muscle training for 3 weeks and 80 Hz of transcutaneous electrical stimulus on suprahyoid muscles for 40-minute daily sessions, 5 days per week for 3 weeks.	- inspiratory and expiratory muscle training showed significant improvement in PImax (p=0.015) and PEmax (P=0.044) at 3 week intervention and no significant change was observed at 3 months post-intervention and efficacy signs improved for inspiratory and expiratory muscle training (p=0.037) at 3 months post-intervention.	- Adding IEMT to SST was an effective, feasible, and safe approach that improved respiratory muscle strength. Both IEMT and NMES were associated with improvement in pharyngeal swallowing security signs at the end of the intervention but the effect did not persist at 3-month follow-up and there were no differences in respiratory completions b/n groups.
Messaggi-Sartor, M et al 2015[19]	-Total 109 participants: IEMT (n = 56) and sham (n = 53) -Mean age (Years): IEMT (65.6), sham (67.6) Female/male: IEMT;21/35, sham;25/28 -Duration (months): IEMT 9.5±7.8 Sham 8.8 ± 5.1 -Types of stroke: ischemic stroke	-PI max -PE max -Respiratory complication	- EG: received CPT and IEMT of 5 sets of 10 repetitions, twice a day, 5 days per week for 3 weeks duration -CG: received standard multidisciplinary inpatient rehabilitation program 3 hours per day, 5 days a week, for 3 weeks).	-IEMT induced a greater change on PImax (p=0.002) and PEmax (p=0.02) in comparison to the sham group. Respiratory complications were frequently observed in the control group	-IEMT appears to be a useful tool to improve respiratory muscle strength. Fewer respiratory complications at 6 months in the intervention group suggest that IEMT could be considered for inclusion in stroke rehabilitation programs
Britto, R.R et al 2011[20]	-Total 18 participants: EG:9, CG:9 -Mean age (years): EG (56.66), CG (51.44) Female/male: EG;4/5, CG;5/4 -Duration (months): not mentioned -Types of stroke: chronic stroke	-MIP - IME -NHP -FVC -FEV1	EG: received home-based training, with resistance adjusted biweekly to 30% of MIP 30 minutes a day 5 times a week for 8 weeks. CG: received home training 30 minutes a day, 5 times a week for 8 Weeks.	-There were significant between-group differences for the MIP and IME measures. Significant changes were observed for only the experimental group for MIP (67.8/14.6) at baseline to 102./26.0cmH2O (at post training) and IME (31.819.3 to 421.1cmH2O). No statistically significant differences were observed in functional performance and QOL.	-IMT training resulted in benefits regarding respiratory muscular performance, determined by increases in respiratory strength and endurance.
Kulnik, S.T et al 2015[21]	-Total of 78 participants: (EG1;27), (EG2;26), (CG;25) -Mean age (years): ET (65.7) IT (62.5), Sham:(65.1) Female/male: ET;13/14, IT;9/17, Sham;9/16 -Duration (months): not mentioned -Types of stroke: (ischemic/hemorrhagic); ET22/5, IT;23/3, Sham;24/1	-PECF -PEmax -PImax	-RMT consisted of 5 sets of 10 breaths each with 1-minute rests between sets. Resistance was set at 50% of maximal inspiratory (PImax) or expiratory (PEmax) mouth pressure for inspiratory or expiratory training, respectively.	There were significant improvements in the mean maximal inspiratory (14 cmH_2O; P<0.0001) and expiratory (15 cmH_2O; P<0.0001) between baseline and 28 days in all groups. There were no between-group differences regarding respiratory muscle training and incidence of pneumonia.	-Respiratory muscle function and cough flow improved with time after acute stroke. Additional inspiratory or expiratory respiratory muscle training does not augment or expedite this improvement.

Abbreviations: BBS, Berg Balance Scale; BI, Barthel Index; BRT, breathing retraining; CG, control group; EG, experimental group; ET, expiratory training; FAC, Functional Ambulation Categories; FEF 25–75%, forced expiratory flow rate 25–75%; FEV1, forced expiratory volume in 1 second; FVC, forced vital capacity; IG, intervention group; IEMT, inspiratory and expiratory muscle training; IME, inspiratory muscular endurance; IMT, inspiratory muscle training; IT, inspiratory training; MEP, maximum expiratory pressure; MIP, maximum inspiratory pressure; MVV, maximum voluntary ventilation; NHP, Nottingham Health Profile; NMES, neuromuscular electrical stimulation; PECF, peak expiratory cough flow; PEF, peak expiratory flow rate; PEmax, maximal expiratory pressure; PImax, maximal inspiratory pressure; QOL, quality of life; RMTG, respiratory muscle training group; VC, vital capacity; SST, standard swallow therapy.

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Exclusion Criteria

Articles with abstract only, PEDro score less than 5, published in non-English language, not freely available articles, and quasi experimental studies were excluded from this study.

Study Selection

Two reviewers (S.D and A.A.) extracted journal articles based on predetermined eligibility criteria. The studies were collected and retrieved in depth through methodological quality and data extraction tools. The third reviewer (H.M) was on hand to solve any discrepancy between the two reviewers.

Risk of Bias in Individual Studies

Three authors assessed the accuracy of retrieved trials using the PEDro (Physiotherapy Evidence Database) Scale, which consists of 11 items, with the first item being article external validity.[13,14] The PEDro scale was used to assess the methodological quality of trials based on key parameters such as; concealed assignment, intention-to-treat analysis, and appropriate follow-up. These features make the PEDro scale a useful tool for assessing the methodological quality of RCTs. This review considered trials with a score of 6 to 7 as moderate quality, and a rating of ≥8 as a high-quality study (Table 2).

Data Extraction

The data were extracted using a pre-designed data retrieval framework. The data were extracted independently by two reviewers (S.D and A.A.) and reviewed by the third author. Disagreements with the third author were resolved through discussion. Each RCT yielded the following data: author name and publication year, stroke (severity, kind, and duration), number of participants, types of treatment in both experimental and control groups, mean follow-up period, participants' mean age, and treatment results (baseline, follow-up and post-treatment). The effect of interventions on each result, mean and standard deviations of outcome measures at baseline, after treatment, and during follow-up, were extracted and synthesized.

Table 2 PEdro Scores of Each RCT

No	PEDro Scale Item	Subtbeyaz. ST et al 2010[15]	Yoo H-J, Pyun S-B 2018[16]	de Menezes KKP et al 2019[17]	Guillén-Solà, A et al 2017[18]	Messaggi-Sartor, M et al 2015[19]	Britto, R.R et al 2011[20]	Kulnik, S. T et al 2015[21]
1.	Eligibility	YES	YES	YES	YES	YES	YES	YES
2.	Random allocation	YES	YES	YES	YES	YES	YES	YES
3.	Concealed allocation	YES	NO	YES	NO	YES	YES	YES
4.	Baseline comparability	YES	YES	YES	YES	YES	YES	YES
5.	Blind participant	NO	NO	YES	NO	YES	NO	YES
6.	Blind therapist	NO	NO	NO	NO	NO	NO	NO
7.	Blind assessor	YES	NO	NO	YES	YES	YES	YES
8.	Adequate follow up	YES	YES	YES	NO	NO	YES	NO
9.	Intention-to- treat	NO	YES	YES	YES	YES	NO	YES
10.	Between-group comparison	YES	YES	YES	YES	YES	YES	YES
11.	Point estimate and variability	YES	YES	YES	YES	YES	YES	YES
	Total score	7/10	6/10	8/10	6/10	8/10	7/10	8/10

Results

Study Selection

The search approach found 890 items in total. After deleting duplicates, there were 517 left. After title and abstract screening, 487 studies were discarded. This review included 7 RCTs after a thorough full content screening review of 30 trials (Figure 1).

Study Characteristics

A detailed summary of the trials' features as well as the results of the outcomes was reported in Table 1. A total of 7 trials with 427 participants were synthesized. All seven trials examined the effectiveness of respiratory muscle training on respiratory muscle strength, function and respiratory complication in stroke survivors.[15–21] The features of the included trials, as well as an explanation of the outcomes based on the PICO standard, are provided in the following section.

Participants

The mean age of the participants ranged from 51.4 to 70.3 years.[18,20] The mean duration after stroke diagnosis ranged from 9.3 ± 5.1 to 163.2 ± 36.5 days.[15,18] The majority of the studies enrolled more people who had had an ischemic stroke.

Interventions

The studies compared the effectiveness of respiratory muscle training with the compassion of multidisciplinary stroke rehabilitation, a sham intervention, standard swallow therapy and respiratory muscle training combined with trunk stabilization exercise. The treatment duration ranged 30–40 minutes, 5–7 times a week for 3–8 week period.[16,17]

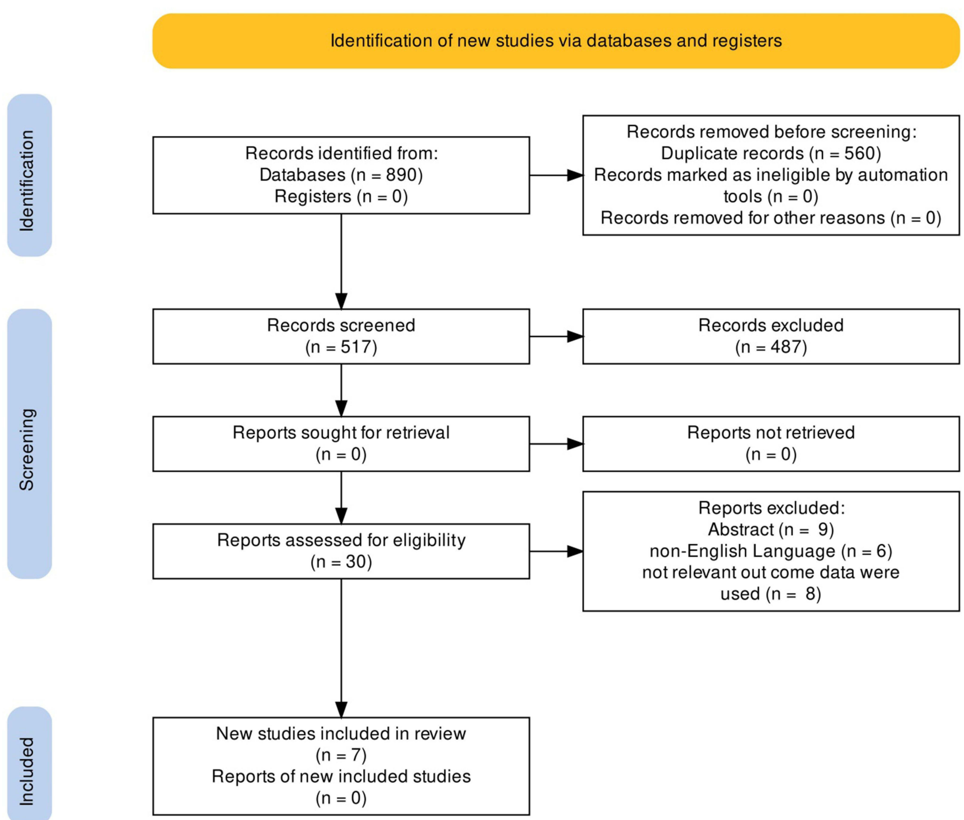

Figure 1 PRISMA diagram of effectiveness of respiratory muscle training in patients with stroke.

Outcome Measures

The following outcome measures were used: FVC, VC, FEV1, FEV1/FVC, FEF (25–75%), MVV PImax, PEmax, PEF, PECF, and incidence of respiratory complication (Table 1).

Risk of Bias Within Studies

The possibility of predisposition within each study and conclusions of all items for the enlisted studies appear in Table 2. The PEDro rating for the included trials ranged from 6 to 8, with a mean score of 7. All participants in the study were assigned at random, and all trials were reviewed for baseline comparability, between-group comparison, and acceptable outcomes. Five trials, in fact, employed disguised allocation.[15,17,19–21] Two of the included trials did not blind the assessor[16,17] and only five trials assessed intention-to-treat analysis.[16–19,21] None of the trials blinded the therapist and only three of the trials blinded the participants.[17,19,21]

Effect of Respiratory Muscle Training on Respiratory Muscle Strength

Detailed description of respiratory muscle strength has been summarized and presented in Table 1. Five trials involving individuals reported on the effect of respiratory muscle strength from the included articles.[17–21] Four studies (n = 227 participants) demonstrated that respiratory muscle strength in stroke survivors was significantly enhanced by respiratory muscle training (inspiratory/expiratory) in the case group compared to the control group.[17–20] Conversely, one study (n = 82 subjects) found that while respiratory muscle training (RMT) was safe for people with acute stroke, it did not significantly affect respiratory muscle strength.[21]

Effect of Respiratory Muscle Training on Cardiopulmonary Function

Three independent investigations with documented treatment effects on respiratory function were conducted.[15,16,21] Two trials with a total of n=85 subjects reported that cardiopulmonary function of stroke patients significantly improved in respiratory muscle training groups compared to control groups in the following outcome measures; forced vital capacity (FVC), forced expiratory volume in one second, FEV1, ratio forced expiratory volume at 1 second and forced vital capacity (FEV1/FVC), vital capacity (VC), forced expiratory flow rate 25–75% (FEF 25–75%).[15,16] On the other hand, one study with a total of (n=82) reported that there were no significant differences between the groups for voluntary cough PECF, involuntary cough PECF, PEmax and PImax.[21]

Effect of Respiratory Muscle Training on Respiratory Complications

Four different investigations with treatment effects on respiratory complications were done.[17–19,21] A total sample of n=47 participants reported that respiratory muscle training significantly reduced respiratory complications.[17,19] Two trials with a total of n=144 participants showed that respiratory muscle training reduced respiratory complications but there was no statistically significant change between case and control groups.[18,21]

Discussion

This systematic review aimed to assess the effectiveness of respiratory muscle training on respiratory muscle strength, cardiopulmonary function, and reduction of respiratory complications. To the extent of the authors' knowledge, there has been no systematic review that has examined effectiveness of respiratory muscle training on respiratory muscle strength, cardiopulmonary function and reduction of respiratory complications in stroke patients. The majority of the included articles had moderate to high methodological quality. Out of 5 studies, four of them confirmed that respiratory muscle training had significant improvement in muscle strength in stroke survivors of experimental groups compared to the control groups. Similarly, two studies had reported that respiratory muscle training improved the cardiopulmonary function of stroke patients significantly in the experimental groups compared to the control groups.

A study done in Ankara, Turkey showed IMT groups had significantly improved in FVC, VC, FEV1 and MVV compared to baseline and the control group after 6 weeks of respiratory muscle training. Not only this but also, Pimax and PEmax in BRT group and PImax in IMT group had increased significantly in the experimental groups. All respiratory complications except dyspnea had reduced after respiratory muscle training in the experimental groups.[15] A similar study was done in Seoul, South Korea to evaluate the effectiveness of bedside respiratory muscle training and also reported a similar finding. The result showed that respiratory muscle training showed a significant increase in FEV1 and PEF after 3 weeks of intervention time compared to the control group.[16] This might be because of similarities in their inclusion and exclusion criteria, clinical setup, severity of the disease, and rehabilitation protocol.

A study done in Brazil showed significant improvement in respiratory muscle function after eight weeks of respiratory muscle training intervention. Significant changes were observed in PImax, PEmax and Inspiratory muscle endurance, and reduced dyspnea in the case group.[17] This study is supported by a study done in Spain Barcelona in 2017 which demonstrated that inspiratory and expiratory muscle training had significant improvement in PImax and PEmax after 3 week respiratory muscle training intervention. Likewise, a similar study done in Spain, Madrid supported the findings of the aforementioned two studies, which reported that the improvement in PImax and PEmax were significant in inspiratory expiratory muscle training group after 3 weeks of intervention.[19] This similarity might be because of similarity in eligibility criteria, clinical setup, professional skill and rehabilitation session and protocol, and a very similar sample size. However, another pilot randomized controlled trial done in London, United Kingdom in 2015 reported that there was no significant change reported in respiratory muscle strength, inspiratory or expiratory mouth pressures, PImax and PEmax at any time-point during the intervention.[21] This difference might be because of variation in follow-up time, the difference in the quality of the study, eligibility criteria, rehabilitation setup, number of sessions, and sample size (this study had a total number of 78 participants compared to studies done in Spain which had 39 study participants) and differences in professional skill.

Different respiratory complications were assessed by some of the articles included in these literature reviews. A study done in Turkey, Ankara reported that respiratory muscle training had a significant impact on decreasing dyspnea of stroke survivours in the experimental group after eight week duration. This was supported by a study done in Brazil which reported that significant differences were found for dyspnea at post-intervention. This similarity might be because of similarity in eligibility criteria, rehabilitation protocol and session, clinical setup, and professional skill.[15,17] Furthermore, a similar study done in Madrid, Spain reported that respiratory complications were mostly observed in the control group compared to experimental group. This study is supported by a study done in Barcelona, Spain. This similarity might be because of similarity in study setup (both were done in Spain), similarity in follow-up period, similarity in intervention, and eligibility criteria.[19]

This systematic review had similar findings to a prior study done in Sydney, Australia in 2016 which reported that respiratory muscle training significantly increases respiratory muscle strength and decreases the risk of respiratory complications (eg, pneumonia and lung infections). Thus, 30 minutes of respiratory muscle training, five times per week, for 5 weeks can be expected to increase respiratory muscle strength in individuals after stroke. Similarly, another systematic review done in Brazil is comparable with this systematic review. They reported that respiratory muscle training is effective in improving respiratory function and decreases respiratory complications after stroke.[4,6]

Given all the included studies, respiratory muscle training had clinical benefits for respiratory muscle strength and pulmonary functions of individuals after stroke.

Conclusion

Respiratory muscle training could potentially improve muscle strength and pulmonary functions of subjects after stroke. Thus, it may reduce stroke-related respiratory complications in subjects after stroke. However, this study had some limitations such as; articles published in non-English language were excluded, small number of RCTs, and heterogeneity of outcome measures. Hence, further study is warranted with high quality RCTs and pooled synthesis of results.

Clinical Implication

Respiratory muscle training is a technique which can be performed by a trained physical therapist so as to improve cardiopulmonary functions of stroke patients. This technique does not need sophisticated or expensive material, soit is cost effective and easily applicable to any setup. Therefore, considering its cost-effectiveness and safety, respiratory muscle training is recommended to be incorporated into daily stroke rehabilitation setting during hospitalization and home stay.

Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

Disclosure

The authors report no conflicts of interest for this work.

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