Literature Review

Effects of respiratory muscle training in patients after cerebral vascular accident: a systematic review

Efeitos do treinamento muscular respiratório em pacientes após acidente vascular cerebral: uma revisão sistemática

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ABSTRACT | INTRODUCTION: Stroke is the result of the interruption of blood supply to the brain and can cause cellular damage and changes in neurological functions. These changes are relevant to the inefficiency of the oropharyngeal mechanisms of swallowing, breathing, phonation and protective reflexes of the lower airways culminating in a high incidence of aspiration pneumonia. Respiratory Muscle Training has the function of restoring muscle function that is compromised, training both strength and muscle endurance, better effectiveness in clearing the airways, conditioning and adapting to exercise and preventing respiratory muscle fatigue. **OBJECTIVE:** The aim of this study is to verify the effect of respiratory muscle training on individuals who have suffered a stroke. **MATERIALS AND METHODS:** This systematic review was carried out by searching the VHL databases (Scielo, Lilacs, IBECS, Medline), PubMed and analyzing the references. **RESULTS:** A total of 4834 studies were screened and analyzed, where 17 studies published between 2010 and 2019 were part of this review. **CONCLUSION:** Studies have shown that the use of TMR in post-stroke patients has positive effects on lung volumes and capacities, despite have a small sample size. The search for creating new studies that can assist in the prescription and standardization of the training of these individuals in different environments should be a way to think.

KEYWORDS: Exercise for respiratory muscles. Stroke. Breathing exercises.

RESUMO | INTRODUÇÃO: O Acidente Vascular Cerebral (AVC) é o resultado da interrupção aguda do suprimento sanguíneo ao cérebro por meio de entupimento ou rompimento dos vasos podendo provocar lesões celulares e alterações nas funções neurológicas. Essas alterações são relevantes para a ineficiência dos mecanismos orofaríngeos da deglutição, respiração, fonação e reflexos protetores das vias aéreas inferiores culminando em alta incidência de pneumonia por aspiração. O Treinamento Muscular Respiratório tem como função restabelecer a função muscular que esteja comprometida, treinar tanta a força quanto à *endurance* muscular, melhorar a eficácia na desobstrução das vias aéreas, condicionar e adaptar ao exercício e prevenir a fadiga muscular respiratória. **OBJETIVO:** O objetivo desse estudo é sistematizar o efeito do treinamento muscular respiratório sobre os volumes e capacidades pulmonares em indivíduos que sofreram acidente vascular cerebral. **MATERIAIS E MÉTODOS:** Esta revisão sistemática foi realizada pela busca nas bases de dados BVS (Scielo, Lilacs, IBECS, Medline), PubMed e análise das referências. **RESULTADOS:** Um total de 4834 estudos foram rastreados e analisados, onde fizeram parte desta revisão 17 estudos publicados entre 2010 e 2019. **CONCLUSÃO:** Estudos comprovaram que o uso de TMR em pacientes pós-AVC gera efeitos positivos nos volumes e capacidades pulmonares, apesar de terem um tamanho amostral pequeno. A busca por criar novos estudos que possam auxiliar na prescrição e padronização dos treinamentos desses indivíduos em diversos ambientes deve ser um caminho a se pensar.

PALAVRAS-CHAVE: Exercício para os músculos respiratórios. Acidente vascular cerebral. Exercícios respiratórios.

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Introduction

Stroke is the result of acute disruption of blood supply to the brain through clogging or rupture of vessels[1]which can cause cellular damage and changes in neurological functions. According to the Ministry of Health[2] in 2017, Brazilian statistics indicate that stroke is the most frequent cause of death in the adult population (about 10% of deaths) and consists of the diagnosis of 10% of public hospital admissions. Worldwide, stroke is ranked as the second leading cause of death, with about 5.5 million people each year, where 50% of survivors have chronic disabilities[3].

The stroke causes impairment in the production of motor stimuli, resulting in the loss of peripheral muscle function, reducing the strength of the respiratory muscles and cough flow by 50%[4]. Changes in the components after the stroke are relevant to the inefficiency of the oropharyngeal mechanisms of swallowing, breathing, phonation and protective reflexes of the lower airways culminating in high incidence of aspiration pneumonia[5]. In this profile of individuals, the thoracic and pulmonary complacency is decreased which causes a decrease in the total lung capacity and vital capacity[6].

Respiratory Muscle Training (RMT)* is a set of exercises capable of improving the functionality of the respiratory muscles. Used by physiotherapists in clinical practice, RMT involves breathing patterns that can be combined with movements of the upper limbs and trunk, as well as maneuvers in the rib cage, with or without the resistance of an apparatus[7]. It aims to improve breathing pattern, increase lung expansion, functional residual capacity and inspiratory reserve volume, train both respiratory muscle strength and endurance, re-establish muscle function whether it is compromised or has a strong risk of declining, improve airway clearance effectiveness through more efficient coughing, and, through exercise conditioning and adaptation, prevent respiratory muscle fatigue[8-10].

Little has been studied about the effect of respiratory muscle training on respiratory comorbidities in post-stroke patients. Therefore, the objective of this study is to systematize the effect of respiratory muscle training on lung volumes and capacities in individuals who have suffered stroke.

Materials and methods

This systematic review was carried out according to the PRISMA11 criteria, by four researchers (PROSPERO - CRD42020193421).

Eligibility criteria

Articles that met the following criteria were included in the study: randomized controlled trials, participants over 18 years of age and post-stroke, as well as studies using some method of respiratory muscle training. Repeated articles, review articles, studies that were not related to the objective of this study were excluded, as well as studies with other isolated therapies, which were not associated with respiratory muscle training.

Sources of information

The articles were searched in the BVS (Scielo, Lilacs, IBECS, Medline) and PubMed databases between January 2019 and June 2020, without limitation in the language or period in which the studies were published. Descriptors in Health Science Descriptors (DeCS) and Medical Subject Headings (MeSH) in Portuguese, English and Spanish were used in combination with the Bolean operators AND and OR, in addition to the keyword Respiratory muscle training/ respiratory muscle input. After the selection in the databases, their references were analyzed and if there were studies with potential to be part of this study, they were also selected.

Search

The descriptors used for searching in the BVS were: ("Cerebral Vascular Accident" OR "Cerebral Stroke" OR "Cerebral Ictus" OR Stroke OR Apoplexy OR "Cerebrovascular Accident" OR "Cerebrovascular Apoplexy" OR "Cerebral Icto" OR "Encephalic Vascular Accident" OR EVA OR "Brain Vascular Accident" OR "Cerebral Vascular Accident" OR "Vascular Brain

*McConnell A. Breathe strong, perform better. Champaign: Human Kinetics Books; 2011 apud (7).

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Accidents" OR "Cerebrovascular Accidents" OR "Cerebral Vascular Accidents") AND ("Breathing Exercises" OR "Exercises for the Respiratory Muscles" OR "Breathing Exercise").

When searched by PubMed the studies in English were selected by Mesh Stroke or its correlates (Strokes, Cerebrovascular Accident, Cerebrovascular Accidents, CVA (Cerebrovascular Accident), CVAs (Cerebrovascular Accident), Cerebrovascular Apoplexy, Apoplexy, Cerebrovascular, Vascular Accident, Brain, Brain Vascular Accident, Brain Vascular Accidents, Vascular Accidents, Brain, Cerebrovascular Stroke, Cerebrovascular Strokes, Stroke, Cerebrovascular, Strokes, Cerebrovascular, Apoplexy Cerebral Stroke, Cerebral Strokes, Stroke, Cerebral, Strokes, Cerebral, Stroke, Acute, Acute Stroke, Acute Strokes, Strokes, Acute, Cerebrovascular Accident, Acute, Acute Cerebrovascular Accident, Acute Cerebrovascular Accidents, Cerebrovascular Accidents, Acute), together with Breathing Exercises or its correlatives (Exercise, Breathing, Respiratory Muscle Training, Muscle Training, Respiratory, Training, Respiratory Muscle). For studies in Spanish the studies were selected through Mesh Accidente Cerebrovascular and Ejercicios Respiratorios.

Study selection

The studies were traced in the above-mentioned databases. Initially, the selection of studies was made by checking the titles of the studies, as well as by analyzing the available summaries. If the study was selected all its content was read in full and formed the table of results of this review.

Data Collection Process

The selected studies were analyzed according to the methodology used and the results demonstration. After defining the search strategy and standardizing the authors' collection, the first investigator searched the databases and selected the studies that would be part of the review. From then on, the two authors alone analyzed the studies and defined those that would continue in the study. If there was divergence in the definition of a study, a third investigator did the independent analysis and decided to maintain or exclude it in the review.

List of data

After searching the articles, they were catalogued in Microsoft Excel 2010 spreadsheets, containing author, year, magazine and title. As the study was analyzed their data were organized in a table in Microsoft Word 2010, containing the variables: author and year of publication, sample size, groups, selected outcomes, intervention of groups and results.

Risk of Bias in Each Study

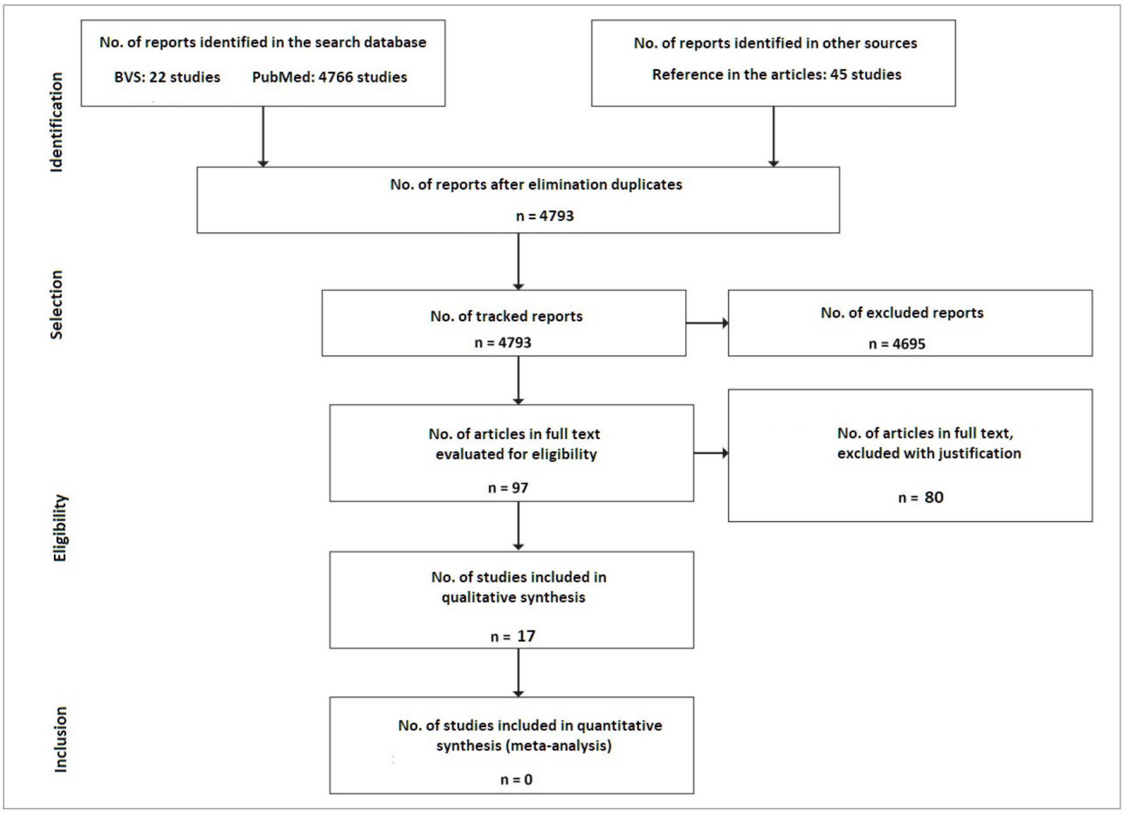
The studies were evaluated according to the Cochrane Handbook for Development of Systematic Revisions of Intervention, version 5.1.012. This manual is a tool that uses domains to promote a critical assessment of different aspects of biased risks. It was developed between 2005 and 2007 by a group of editors and authors of systematic review.

It is composed of two parts, contemplated in seven domains: generation of the random sequence, concealment of the allocation, blinding of participants and professionals, blinding of outcome evaluators, incomplete endpoints, reporting of selective endpoints and other sources of biases. The first part refers to the description of what was reported in the study being evaluated. The second part is the judgment as to the risk of bias for each of the domains. After analysis, the domains can be classified into three categories: low risk of bias, high risk of bias or uncertain risk of bias[13].

Results

A total of 4834 studies were screened and analyzed after database search and references of analyzed studies. After analysis of eligibility through inclusion and exclusion criteria 17 studies were part of this review (Figure 1).

Figure 1. Selection of studies for analysis



The range of years of study publications varied between 2010 and 2019. The sample size of the population varied from 12 to 82 participants where only two groups, an experimental group and a control group, were used for the most part. Exceptions occurred in three studies, one included a third sham group[16], and the other two included another group performing another therapeutic method[14,18].

The main respiratory characteristic endpoints on which the studies focused their results were mainly volumes, capacities and flow. All 17 studies focused on lung volumes, 15 on lung capacities, and 11 other studies focused on expiratory flow (Table 1).

Table 1. Data from selected studies

AUTHOR	YEAR	SAMPLE	GROUPS	SELECTED OUTCOMES	INTERVENTION	RESULTS
Kim et al[14]	2015	37	IT = 13 RMT = 15 CG = 12	FVC and FEV1.	R-STROKEx RMT x AM	(+) FVC e FEV1.
Joo, Shin, Song[15]	2015	38	EG = 19 CG = 19	FVC, FEV1, FEV1/FVC e MVV.	Game x R-STROKR	(+) FVC, FEV1 e MVV.
Kulnik et al[16]	2015	82	IMT= 27 EMT = 26 Sham = 25	PEF.	EMT X IMTx Sham	(+) PEF
Kim, Park, Yim[17]	2014	20	EG = 10 CG = 10	FVC, FEV1, FEV1/FVC, PEF,	RMT x R-STROKE	(+) FVC, VFE1, PEF.
Lima et al[18]	2014	40	EG = 20 CG = 20	FVC, FEV1, VC.	RMT	(+) VC
Sutbeyaz et al[19]	2010	45	IMT= 15 ER = 15 CG = 15	PFT.	R-STROKEx RMT	(+) FEV1, FVC, VC, FEF 25-75%, MVV, PEF,
Jung, Bang[20]	2017	12	EG = 6 CG = 6	FVC, FEV1.	IMTx R-STROKE	(+) FVC, FEV1.
Jung et al[21]	2014	18	EG = 9 CG = 9	FVC, FEV1, PEF, FEF25-75%.	IMTx abdominal stimulation	(+) PEF e FEV1
Chen et al[22]	2016	21	EG = 11 CG = 10	PFT.	R-STROKEx TMI	(-)
Jo, Kim[23]	2017	25	EG = 12 CG = 13	FVC e PEF.	R-STROKEx RMT	(+) FVC e PEF.
Yoo, Pyun[24]	2018	40	EG = 20 CG = 20	FVC, FEV1, PEF.	R-STROKEx RMT	(+) FVC, PEF.
Jo, Kim[25]	2016	42	EG = 21 CG = 21	FVC e PEF.	R-STROKEx RMT	(+) FVC, PEF.
Lee, Park, Lee[26]	2019	25	EG = 13 CG = 12	PEF, FEV1, PIF, FVC.	R-STROKEx RMT	(+) PEM, PEF, PIF.
Jung, Kim[27]	2013	29	EG = 15 CG = 14	FEV1, PEF e FEV1/FVC.	R-STROKEx TMI	(-)
Kim, Lee[28]	2018	24	EG = 12 CG = 12	FVC e FEV1.	R-STROKEx RMT	(+) FVC e FEV1.
Kim, Lee, Yun[29]	2012	18	EG = 10 CG = 8	FVC, FEV1, FEV1/FVC, PEF.	R-STROKEx RMT	(+) FEV1, FVC, PEF.
Jo, Kim, Jung[30]	2014	34	EG = 17 CG = 17	FVC e PEF.	R-STROKEx RMT	(+) FVC e PEF.

Key: EG = Experimental group; CG: Control group; IT = Integrated training; FVC = Forced vital capacity; FEV1 = Final expiratory volume 1 second; PFE = Peak expiratory flow; PIF = Peak inspiratory flow; MVV = Maximum ventilatory volume; CV = Vital capacity; FEF = Forced expiratory flow; CV = Current volume; PFT = Pulmonary function test; TMI = Inspiratory muscle training; TME = Expiratory muscle training; TMR = Respiratory muscle training; R-STROKE: Rehabilitation for Stroke; AM = Abdominal maneuver.

In all, 16 studies used devices for respiratory muscle training, which could be of the inspiratory, expiratory or incentive spirometry type. Two studies used abdominal breathing exercises in one group and one used game-based exercises as a training method. Conventional physiotherapy, or kinesiotherapy, in stroke was the most used method of treatment in the control group, not being used in only three of the studies.

When it came to the standardization of the training used, ten studies graduated the session per minutes executed between 15 and 30 minutes, while another seven were for repetitions executed, varying between three and 30 repetitions. About the series division of the session, eight studies did the approach in only one series, two studies divided in two series, three studies divided in three series, three divided in five series and only one divided in six series. While three studies did not limit the number of sessions during the week, the other 14 studies ranged from three to seven times a week. The total number of training weeks varied from three to ten weeks, but only one study did the approach on a single day, (Table 2).

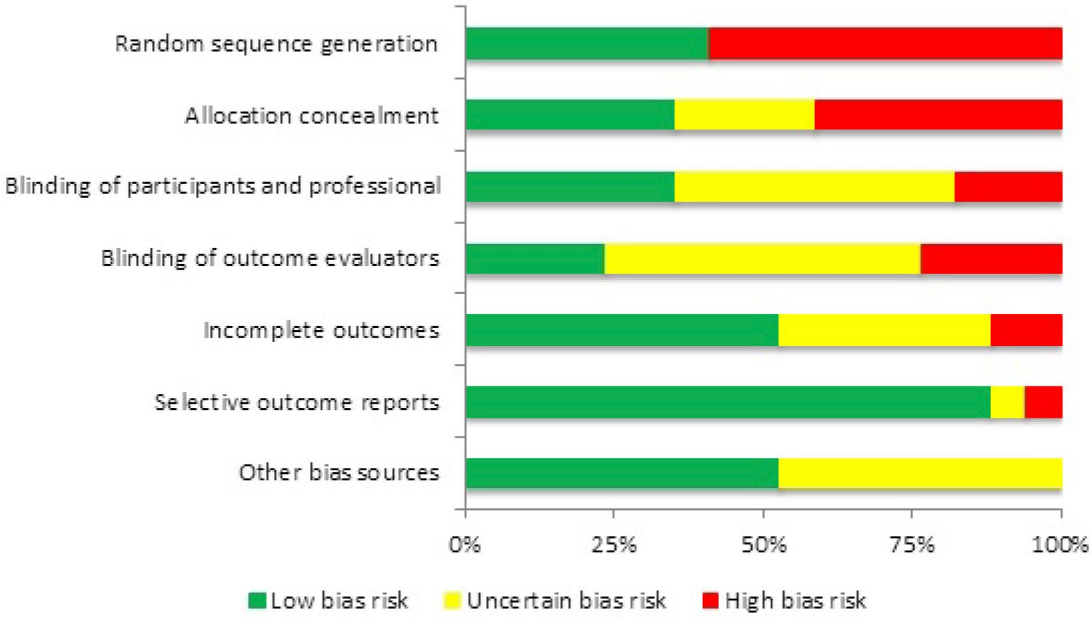
Table 2. Use of RMT by the studies analysed

AUTHOR	REPETITION	SERIES	TIME	LOAD (f, p)	TOTAL INTERVENTION TIME
Kim et al[14]	10	5	5x/weeks	-	6weeks
Joo, Shin, Song[15]	25min	-	3x/weeks	f	5weeks
Kulnik et al[16]	10	5	x	p 50% maxip ou maxep	4weeks
Kim, Park, Yim[17]	20min	-	3x/weeks	p	4weeks
Lima et al[18]	10	3	x	80% maxip	1 dia
Sutbeyaz et al[19]	15min	2	6x/weeks	p 40% maxip	6weeks
Jung, Bang[20]	5min	6	5x/weeks	f 30% maxip	4weeks
Jung et al[21]	20min	-	3x/weeks	f 30%maxip	4weeks
Chen et al[22]	30	-	5x/weeks	p 30% maxip	10weeks
Jo, Kim[23]	20-30min	-	3x/weeks	p maxip or maxep	8weeks
Yoo, Pyun[24]	30min	2	7x/weeks	-	3weeks
Jo, Kim[25]	3	3	x	p maxip or maxep	8weeks
Lee, Park, Lee[26]	10-15	5	3x/weeks	p 30% maxip	6weeks
Jung, Kim[27]	20min	-	3x/weeks	-	6weeks
Kim, Lee[28]	20min	-	5x/min	p	4weeks
Kim, Lee, Yun[29]	30min	-	3x/weeks	p	6weeks
Jo, Kim, Jung[30]	3	3	3x/weeks	P maxip or maxep	4weeks

KEY: RMT= Respiratory muscle training (inspiratory; expiratory or mixed); p = progressive; f = fixed; Maxep = maximum expiratory pressure; Maxip = maximum inspiratory pressure; Min = minutes; Weeks = Weeks.

Of the studies analyzed regarding the risk of bias, only two did not present high or uncertain risk. There were 11 studies that left in doubt the analysis of points in the rating scale, which made them receive as an assessment the risk of uncertain bias. On the important characteristics of a clinical trial that minimize interference with the results found, 13 studies did not fully comply with them, receiving a high risk of bias score, (Graph 1).

Graph 1. Bias risk analysis



Discussion

It is already known that in this profile of individuals there is a decrease in the value of the Forced Vital Capacity (FVC) compared to the reference value6, who can generate severe ventilatory disturbances in the long run[31]. Thus, 10 studies concluded that after the use of RMT in post-Stroke individuals there is a significant improvement in FVC. This volume of exhaled air is obtained when maximum effort is printed from a maximum inspiration[31]. RMT can be used in these patients to improve volumes, which are usually reduced due to the muscular imbalance that provides the entry of this air into the lungs[32].

The Forced Expiratory Volume in the First Second (FEV1) represents the amount of air leaving the first second of the FVC. Its value stands out if there is an obstruction of the air exit, making it remain in the lung for longer, having an important impact on the oxygenation and consequently on the aerobic activities[33]. Seven (07) studies of this review concluded that RMT as a technique for the treatment of ventilatory disorders has proven effective in improving FEV1. With this, it is possible to have a basis for the use of RMT when post-Stroke patients present obstructive disorders, benefiting from another option for improvement of daily activities.

Even with a considerable number of studies showing improvement in FEV1 and FVC, 5 studies found no improvement in any of these markers: 4 found no significant improvement in FVC, and 3 in FEV1. A study[18] performed an incentive spirometry technique with three series of ten repetitions in just one day, where the objective was to verify the acute effect of the technique in post-Stroke patients. This time may have influenced the result, and your control group was formed by healthy individuals, which also obtains improvement in ventilatory capacity after training[34]. In addition, the human body tends to make compensations in other variables to keep the values closer to normal, in this case modifying the respiratory rate and the minute volume to compensate in gas exchanges[6].

In the case of Maximum Ventilation Volume (MVV) it was possible to verify the improvement in this marker through the analysis of two studies. MVV is a volume obtained through the repetitive and dynamic technique of respiratory muscle contractions, with rapid and sudden chest expansion and retraction. As it is a technique that needs integrated muscle strength, its low values reflect clinically significant restrictive diseases[31]. Post stroke individuals, who present muscle imbalance, increased stiffness of the rib cage and low tolerance to prolonged aerobic activities[6], benefit from RMT by promoting greater tolerance and quality in low- and moderate-intensity activities.

Thinking of Current Volume (CV), only one study used this marker as the object of analysis and can see its improvement at the end of the RMT application. Since CV is the amount of air entering and leaving the lungs in basal ventilation, it is important for the maintenance of changes in rest periods[31]. Due to the changes in the rib cage and muscles in the post-stroke already mentioned, working the muscles so that they need to generate less effort to maintain the basal exchanges becomes important for this population, generating less energy expenditure at rest.

Of the verified studies, 11 tried to analyze the Peak Expiratory Flow (PEF), having as answer the confirmation of RMT as a technique to improve this marker. The PEF is obtained from a rapid exhalation of air after a maximum inspiration[31]. Physiologically we do this during the cough reflex, which is why it is so important to determine a better cough capacity[35]. The function of the cough reflex is to remove the secretion and/or foreign body from the airways, generating an important expiratory flow in the defense of the pathways[5]. By training the respiratory muscles of these individuals the risk of comorbidities and mortality is reduced, since aspiration pneumonia may be a death factor for this population.

Conclusion

This study concluded that there are several positive effects on respiratory volumes and capacities of post-stroke individuals submitted to the use of RMT. There are several studies proving the effects of this training on FVC, FEV1, MVV and PEF. Although many studies have a small sample size, the confirmation of the improvement promoted by RMM through these studies helps us to have an understanding of the use of this method in our clinical practice, aiming to avoid the deleterious effects caused by the stroke on the pulmonary function.

The use of RMT in post-stroke patients seems to have caught the attention of scholars more recently in the literature, but over time more studies are being done in this population. The production of new studies with a larger number of participants and with distinct protocols that can help in prescribing and standardizing the training of these individuals in several environments is suggested.

Author contributions

Nascimento JS participated in the study design, search and statistical analysis of the research data, interpretation of results and writing of the scientific article. Neto FF participated in the conception, study design and review of the final draft. Ribeiro NMS participated in the study design and final analysis of the data. Barauna LH participated in the conception, design and writing. Jesus ACC participated in the conception, design and interpretation of results.

Competing interests

No financial, legal or political conflicts involving third parties (government, companies and private foundations, etc.) have been declared for any aspect of the submitted work (including, but not limited to grants and funding, participation in advisory board, study design, preparation of manuscript, statistical analysis, etc.).

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