OBJECTIVE: Respiratory muscle training has been considered one of the main strategies to alleviate sarcopenia in older adults. Therefore, the present study aimed to verify which respiratory muscle training protocols are most used in this population and their main benefits described in the literature. METHODS: A literature search was performed in the electronic databases PubMed, Latin American and Caribbean Health Sciences Literature (LILACS) and Scientific Electronic Library Online (SciELO). For this, we used the terms: respiratory muscle training, older adults, and muscle weakness. A total of 80 articles were studied, of which only 8 met the inclusion criteria of this study, whose methodology, variables studied, and outcome were analyzed. RESULTS: Among the 8 articles analyzed, we can observe an important diversity of the studied protocols; and all articles showed the most varied gains possible with respiratory muscle training. CONCLUSION: The protocols used in the various studies depend directly on the objective to be achieved with respiratory muscle training; and the main outcomes were improvements in strength, lung function, physical fitness level, quality of life, inflammatory markers and glucose intake. KEYWORDS: breathing exercises; aged; muscle weakness.
INTRODUCTION

Sarcopenia is known to be one of the main consequences of advancing age and is related to a functional decline, increased risk of falls and morbidity and mortality, leading to reduced performance of activities of daily living and entailing high costs for the health system.\(^1,3\) Gradual and progressive loss of muscle mass and strength occurs concurrently with that of the skeletal and respiratory muscles.\(^4\) The decline in respiratory muscle strength is a factor directly related to decreased lung function, resulting in reduced thoracic mobility and consequent reduction in lung volume and capacity.\(^2\)

Reduction in respiratory muscle strength can be mitigated by the regular practice of physical exercise.\(^7\) Whole-body physical training and the simple practice of activities of daily living aim at maintaining peripheral and respiratory muscle strength, besides having positive outcomes in the cardio-pulmonary and musculoskeletal systems and in the mental health of older adults.\(^6,7\) However, in individuals who have some physical limitation, the practice of certain activities may be limited; and the use of specific training for respiratory muscles may be an effective alternative method, able to decrease the sensation of dyspnea, increase the ability to perform daily activities, and improve quality of life.\(^6,8\)

Respiratory muscle training (RMT) can be performed with some types of spring resistance devices such as Threshold and PowerBreathe, with loads imposed by volume and flow incentive spirometry or breathing techniques.\(^2,6,7,9-11\) Regardless of the technique used, breathing exercises aim to improve pulmonary function, respiratory muscle strength and thoracoabdominal mobility in geriatric patients, and are considered efficient and safe in physical therapy.\(^5\) However, there is still no consensus on the technique to be performed nor the time and load of each device. Therefore, the aim of this study was to verify which RMT protocols are most used in older adults and their main benefits described in the literature.

METHODS

The literature research was performed in the following electronic databases: PubMed, Latin American and Caribbean Health Sciences Literature (LILACS), and Scientific Electronic Library Online (SciELO). For this purpose, the terms used were: respiratory muscle training, older adults, and muscle weakness. The searches were performed restricting the date for articles published between 2008 and 2018, in English and Portuguese, including studies that addressed cases in which the intervention in older adults was exclusively by RMT. Thus, of the 80 articles studied, only eight were analyzed, as they met the inclusion criteria of this study. We excluded \((n = 72)\) articles that met any of the following criteria: repeated articles, articles without abstract or full text, literature review articles, articles involving other non-geriatric populations submitted to RMT; articles that did not directly respect the searched descriptors, dissertations, theses and monographs.

RESULTS AND DISCUSSION

Among the 80 articles studied, only eight were controlled clinical trials using devices to perform RMT in older adults. The articles compared breathing training with placebo \((n = 2)\),\(^12,13\) with a group without any intervention \((n = 3)\),\(^8,14\) or with different devices among themselves \((n = 3)\).\(^2,4,15\) The outcomes evaluated were: lung strength and function, quality of life, ability to perform daily activities, functional autonomy, as well as hematological and hemodynamic markers.

Table 1 presents data from the studies selected for this review: author, group, methodology used, variables analyzed, and conclusion of each study.

Regarding the time used for the intervention, the studies ranged from 1 to 8 weeks of training. One study trained the muscles of older women with and without metabolic syndrome for 7 days,\(^13\) another used 12 days to perform the intervention;\(^2\) 2 studies lasted 6 weeks,\(^8,14\) 3 studies lasted 8 weeks,\(^8,12,13\) and a 10-week training was conducted in one of the studies.\(^4\) The frequency of RMT during the week also varied, with 1 study performing 3 workouts per week\(^4\) and 2 studies\(^8,14\) with training 5 times a week. The study by Watsford & Murphy\(^9\) conducted 6 days of training during the week, but with 2 workouts per day; and the other 4 studies,\(^2,12,13,15\) trained every day.

As for the size of the load used and the number of repetitions for each series of exercises, there was a great variation among all articles and it was observed that they were inversely proportional and depended on the objective of each author. For strength training, shorter series with higher load were prioritized, while for endurance training, smaller loads were used with a higher number of repetitions. Most studies (75%) used initial load between 30 and 50% of maximal
<table>
<thead>
<tr>
<th>Author</th>
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<th>Methodology</th>
<th>Variable</th>
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</tr>
</thead>
</table>
| Pascotini et al.  | n1 = 23, n2 = 25 | n1 = daily training for 12 days, 3 sets of 8 in the first 3 days, 3 sets of 10 from the 4th to 6th day, 3 sets of 12 from the 7th to 9th day and 3 sets of 14 repetitions from the 10th to the 12th day. Volume Incentive Spirometry (Voldyne).  
|                   |       | n2 = same protocol as n1, but with flow incentive spirometry (Respiron).     | - MIP  
|                   |       |                                                                            | - MEP  
|                   |       |                                                                            | - FVC  
|                   |       |                                                                            | - FEV1 
|                   |       |                                                                            | - TV   
|                   |       |                                                                            | - MV   
|                   |       |                                                                            | - Thoracoabdominal expandability                                   | \( n1/n2 \) ↑/↑ |
| Fonseca et al.    | n1 = 14, n2 = 14, n3 = 14 | n1 = Threshold, starting at 50% of MIP, increasing 10% per week until week 4. From the 5th week, 9% was added until the 8th week. 20-minute sessions, 7 strengthening sessions (2 minutes each) and 1 minute interval between sets, 10 weeks, 3 times a week. In addition to active-resistance arm and trunk exercises.  
|                   |       | n2 = Voldyne, 20-minute sessions totaling 40 repetitions for 10 weeks, 3 times a week. In addition to the same series of exercises in group n1.  
|                   |       | n3 = Only the exercises in groups n1 and n2.                                | - W10m (walk 10 meters);  
|                   |       |                                                                            | - GSP (getting up from a sitting position);  
|                   |       |                                                                            | - GPP (getting up from the prone position);  
|                   |       |                                                                            | - GCMH (getting up from a chair and movement around the house);  
|                   |       |                                                                            | - PTS (putting on and taking off shirt)                               | \( n1/n2/n3 \) ↑/↑/- |
| Huang et al.      | n1 = 24, n2 = 12, n3 = 24 | n1 = IMT in patients without COPD. IMT with Threshold 5 times a week (3 with supervision and 2 without), for 6 weeks (75% da MIP). Each workout consisted of 4 sets of 6 repetitions.  
|                   |       | n2 = IMT in patients with COPD. Same protocol as n1.                        | - MIP  
|                   |       | n3 = control group. No training.                                            | - Dyspnea |
|                   |       |                                                                            | - Quality of life |
|                   |       |                                                                            | - Physical Component |
|                   |       |                                                                            | - Mental Component |
|                   |       |                                                                            | - 6MWT  | \( n1/n2/n3 \) ↑/↑/↑ |
| Watsford & Murphy | n1 = 13, n2 = 13 | n1 = inspiratory and expiratory muscle training with a Powerlung device at home, 12 workouts per week (8 workouts with 3 sets of 10 repetitions and 1 minute rest between sets; 2 workouts with 40 repetitions and 2 workouts with 5 sets of 5 repetitions) for 8 weeks.  
|                   |       | n2 = did not perform any kind of training.                                 | - MIP  
|                   |       |                                                                            | - MEP  
|                   |       |                                                                            | - MVV  
|                   |       |                                                                            | - Submaximal incremental test |
|                   |       |                                                                            | - %MVV used |
|                   |       |                                                                            | - HR   |
|                   |       |                                                                            | - Borg in LL |
|                   |       |                                                                            | - Borg in breathing | \( n1/n2 \) ↑/- |
| Mills et al.      | n1 = 17, n2 = 17 | n1 = IMT with POWERbreathe Classic, initial load of 50% da MIP, 30 reps, twice a day, every day, for 8 weeks.  
|                   |       | n2 = placebo, with the same device, but with a load < 5 cmH2O, same repetition protocol, being oriented to breath normally by the device.  | - MIP  
|                   |       |                                                                            | - MEP  
|                   |       |                                                                            | - Diaphragm Thickness;  
|                   |       |                                                                            | - PIF  
|                   |       |                                                                            | - Spirometry  
|                   |       |                                                                            | - Inflammatory cytokines;  
|                   |       |                                                                            | - DNA damage in peripheral mononuclear cells;  
|                   |       |                                                                            | - Dynamic inspiratory muscle function;  
|                   |       |                                                                            | - Respiratory Endurance;  
|                   |       |                                                                            | - Exercise Performance;  
|                   |       |                                                                            | - Level of Physical Activity;  
|                   |       |                                                                            | - Quality of life  | \( n1/n2 \) ↑/-/|

Table 1 Physiotherapeutic approaches: group, methodology, studied variables and conclusion.
inspiratory pressure (MIP), and 2 of them increased the load during training. The study by Pascotini et al.2 used volume and flow incentive spirometry and increased the number of repetitions every 4 days, starting with 3 sets of 8 repetitions; and at the end of 12 days, participants performed 3 sets of 12 repetitions.

Predominant variables in the studies were: respiratory muscle function and strength, functional autonomy level, and quality of life in older adults; which generally had significant improvement with the regularly performed RMT. The results by Iranzo et al.14 were different from most studies, since the Threshold was not able to improve respiratory strength and endurance parameters in older adults. The justification for these differences may be the type of population evaluated, considering that the mean age of the sample was 85 years, against 65–70 years in the other studies. Another important factor was the previous physical limitations of the population, when these individuals had inability to walk and functional limitations.

Mills et al.12 observed positive results, similar to the others, regarding strength and respiratory function parameters. In addition, they sought to analyze the effects of RMT on blood inflammatory markers in the hypothesis that increased respiratory work was directly related to systemic inflammation, with a reduction in the evoked plasma interleukin-6 response. However, after 8 weeks of training, no significant changes in inflammatory cytokines or DNA damage in peripheral mononuclear cells were observed. The size of the load applied and the number of repetitions performed during muscle training were questioned and possibly justify the treatment failure for these variables.

Inspiratory muscle metaboreflex is a sympathetic nervous system–mediated response in which there is vasoconstriction in skeletal muscles during an exercise, limiting physical performance by reducing blood flow to active muscles.26 Studies have associated RMT with metaboreflex attenuation in different populations, increasing oxygen supply to peripheral muscles during exercise, improving performance and tolerance.17,18 This mechanism would explain the improvement in submaximal incremental test performance in Watsford & Murphy’s research,9 although Borg’s reports on the lower limbs did not change during the exercise; as well

### Table 1 Continuation.

<table>
<thead>
<tr>
<th>Author</th>
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<th>Variable</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Silva et al.13</td>
<td>n1 = 18</td>
<td>n1 = IMT with <strong>Threshold</strong>, 40% of MIP, 30-minute sessions every day, for 8 weeks.</td>
<td>- MIP</td>
<td>↑/↑</td>
</tr>
<tr>
<td></td>
<td>n2 = 20</td>
<td>n2 = control group, <strong>Threshold</strong> training with minimum load</td>
<td>- MEP</td>
<td>↑/↑</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Maximum sustained pressure</td>
<td>↑/↑</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Blood glucose</td>
<td>↓/-</td>
</tr>
<tr>
<td>Iranzo et al.14</td>
<td>n1 = 27</td>
<td>n1 = IMT with <strong>Threshold</strong>, 5 times per week (7 cycles of 2 minutes and 1 minute of rest between cycles), with a load of 30 to 50% of the MIP, with reevaluation of the inspiratory force and the load used after the first 3 weeks, total time of 6 weeks.</td>
<td>- MIP</td>
<td>-/-</td>
</tr>
<tr>
<td></td>
<td>n2 = 27</td>
<td>n2 = control group. Without training, but with inspiratory strength evaluation in the same period of group n1.</td>
<td>- MEP</td>
<td>-/-</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- MVV</td>
<td>-/-</td>
</tr>
<tr>
<td>Feriani et al.15</td>
<td>n1 = 16</td>
<td>n1 = Older women with metabolic syndrome. IMT with <strong>Threshold</strong>, 3 sessions of 15 minutes and 15–20 repetitions per minute, with 3-minute interval between sessions, load of 30% of MIP, in a total of 7 sessions.</td>
<td>- MIP</td>
<td>↑/↑</td>
</tr>
<tr>
<td></td>
<td>n2 = 12</td>
<td>n2 = Older women without metabolic syndrome. Same IMT protocol as n1.</td>
<td>- MEP</td>
<td>-/-</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- FEV1/FVC</td>
<td>-/-</td>
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<td>- Triglycerides</td>
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<td>- Blood glucose</td>
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<td>- Systolic pressure</td>
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<td></td>
<td></td>
<td></td>
<td>- Autonomic cardiac modulation</td>
<td>↑/↑</td>
</tr>
</tbody>
</table>

MIP: maximal inspiratory pressure; MEP: maximal expiratory pressure; FVC: forced vital capacity; FEV1: forced expiratory volume in 1 second; TV: tidal volume; MV: minute volume; PIF: peak inspiratory flow; MVV: maximum voluntary ventilation; HR: heart rate; LL: lower limbs; COPD: chronic obstructive pulmonary disease; FEV1: forced expiratory volume in 1 second; 6MWT: 6-minute walk test; IMT: inspiratory muscle training; ↑: increase; ↓: decrease; (−): there were no changes.
as the improvement in most functional domains evaluated by Fonseca et al.4 and in the 6-minute walk test (6MWT), evaluated by Huang et al.8 in the group without chronic obstructive pulmonary disease (COPD).

The results presented by Mills et al.12 showed no increase in the distance covered in the 6MWT after RMT, which means that there was no performance improvement during the exercise, which is due to the profile of the evaluated patients. While Huang et al.8 trained older adults with a baseline walking test score of 90% of the predicted for their age, Mills et al.12 performed training on older adults with 102 to 103% of the predicted distance for this population. This fact may be best explained by a 2012 meta-analysis,19 which suggests that participants with a lower baseline fitness level had an increased ability to exercise after RMT, compared with those who already performed better.

Another benefit of RMT is the regulation of blood glucose levels, an important function, especially in patients with type II diabetes mellitus. This may be explained by decreased insulin resistance after exercise, where regular training can increase insulin transporter 4 (GLUT-4) mobilization and, consequently, increase blood glucose uptake.13,20,21 The results of Silva et al.13 corroborate most previous studies, when an 8-week Threshold protocol was sufficient to decrease blood glucose levels, proving to be an alternative strategy for those patients who have contraindications to perform other exercise modalities. In contrast, the 7-day RMT protocol used by Feriani et al.15 was not sufficient to achieve significant changes in blood glucose in older women with metabolic syndrome, requiring more training days for such changes.

CONCLUSION

Due to the numerous protocols used for RMT, it is clear that the number of repetitions, the size of the load, and the number of days used depend directly on the objective to be achieved. RMT in older adults has proved to improve muscle strength and lung function, and showed evidence of increased physical fitness, improved quality of life and inflammatory markers, as well as increased glucose intake. We can also observe that there was no device that was considered superior to another in relation to RMT in older people.

REFERENCES


