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The Effect Of Inspiratory Muscle Training On Exercise Capacity After Stroke: A Systematic Review Of Randomized Clinical Trials

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Abstract:
Background*: Stroke is a severe neurological condition leading to significant functional impairments. Inspiratory muscle training (IMT) is a promising intervention for improving exercise capacity in post-stroke patients. This study aimed to systematically review randomized controlled trials (RCTs) assessing the effects of IMT on exercise capacity in post-stroke patients.*
Materials and Methods*: A systematic review was conducted across PUBMED, LILACS, MEDLINE, Portal BVS, SciELO, and PEDro databases. Included were RCTs evaluating IMT in post-stroke patients with outcomes such as functional capacity, respiratory muscle strength, balance, dyspnea, and cardiopulmonary capacity. Methodological quality was assessed using the PEDro scale. The study was registered with PROSPERO (CRD42022338504).*
Results*: Out of 140 identified studies, 11 met the inclusion criteria, published between 2010 and 2021. IMT demonstrated improvements in respiratory muscle strength, dyspnea, balance, and cardiopulmonary function, though results varied for functional capacity. The mean PEDro score was 6.6, indicating moderate methodological quality.*
Conclusion: *IMT offers benefits in respiratory muscle strength, dyspnea, and balance in post-stroke patients. However, further studies are needed to clarify its impact on functional capacity and overall quality of life.*
Key Word*: Functional Status; Physical Therapy Modalities; Stroke.*

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I. Introduction

Stroke is a severe neurological condition resulting from the obstruction or rupture of cerebral blood vessels, leading to significant functional alterations. This condition can be categorized into five phases: hyperacute (0 to 24 hours), acute (1 to 7 days), early subacute (7 days to 3 months), late subacute (3 to 6 months), and chronic (more than 6 months) (Bernhardt et al., 2017). Data from the Brazilian Stroke Society (SBAVC) indicate that in 2020, there were 99,010 stroke-related deaths in Brazil, while globally, there were 6.55 million deaths in 2019.

The high mortality and significant functional limitations associated with stroke are evident, with the Ministry of Health reporting disability in 568,000 Brazilian individuals in 2013. Functional repercussions include hemiparesis/hemiplegia, muscle tone alterations, and muscle weakness. The impact on respiratory mechanics, due to diaphragm dysfunction (the primary muscle of respiration), results in compromised lung capacity, affecting daily activities and social participation of these patients (Britto et al., 2011).

Inspiratory muscle training (IMT) is a low-cost and easily executed intervention that has been studied in neurological populations, especially in post-stroke patients. Gomes-Neto et al. (2016) demonstrated in a systematic review and meta-analysis that IMT is effective in improving maximum inspiratory pressure (MIP), respiratory function, and exercise tolerance in post-stroke patients. However, this analysis did not include outcomes such as dyspnea and balance, which are crucial for functional capacity.
Additional studies, such as those by Vaz et al. (2021) and Menezes et al. (2019), reinforce the efficacy of IMT in exercise capacity, also evaluating secondary outcomes such as respiratory muscle strength, balance, and dyspnea. Vaz et al. (2021) reported improvements in walking capacity using the 6-minute walk test (6MWT), while Menezes et al. (2019) evidenced increases in respiratory muscle strength (MIP and MEP) and reductions in dyspnea using the BORG scale.
This study aims to analyze the effect of IMT on the exercise capacity of post-stroke individuals, with secondary focus on outcomes such as respiratory muscle strength, balance, and dyspnea. Understanding these outcomes is vital for effective rehabilitation and improving the quality of life of patients (Aydoğan Arslan et al., 2022; Wu et al., 2020; Cho et al., 2018).

II. Material And Methods

Study Design

This systematic review comprised randomized clinical trials (RCTs) and was structured based on the criteria established by the "Preferred Reporting Items for Systematic Reviews and Meta-Analyses" (PRISMA) guidelines (Moher et al., 2009). The objective was to address the clinical question: In adults who have suffered a stroke, is inspiratory muscle training (IMT), compared to conventional treatments or no intervention (simulation/placebo), effective in improving exercise capacity? The study was prospectively registered in PROSPERO under the number CRD42022338504.

Eligibility Criteria

Inclusion criteria were: (a) Randomized clinical trials; (b) Trials testing IMT against specific resistance; (c) Comparison with conventional physiotherapy techniques or simulation techniques (placebo); (d) Adults who have suffered a stroke in any of the five phases of the disease; (e) Primary outcomes of walking capacity and functional capacity; (f) Secondary outcomes of respiratory muscle strength, dyspnea, balance, and cardiopulmonary function; and (g) Studies available in full text. Exclusion criteria were: (h) Studies combining IMT with another intervention; (i) Studies associating stroke with another pathology; and (j) Studies not describing the IMT prescription protocol.

Outcome of Interest

Exercise capacity was defined as the trainable qualities of each individual, directly related to the ability to perform specific physical activities and motor skills, associated with the components of physical performance. The measurement of this variable included analysis of VO2 max (maximum oxygen consumption), respiratory muscle strength (PImax and PEmax), balance (Berg scale), dyspnea (BORG scale), and performance in the 6-minute walk test (6MWT), all widely validated and utilized parameters. This review includes studies that used these instruments as tools to assess functional capacity.

Search Strategy

The formulation of the search strategies utilized the PRESS initiative (McGowan et al., 2016), aiming for a peer review of the strategies for electronic searches, minimizing discrepancies, and increasing sensitivity/specificity. Searches were conducted in the databases PubMed/MEDLINE, PEDro, Portal da BVS/LILACS/Latindex, and SciELO by independent authors between February and March 2023. The descriptors were selected through the "Medical Subject Headings" (MeSH) and "Descritores em Ciências da Saúde" (DeCS): "Stroke". Additional keywords included "Inspiratory Muscle Training" and "Functional Capacity," and "Clinical Queries" were used in PubMed searches, as described in **Table 1.**

Table 1. Search Strategies for Electronic Databases

Database	Search strategy
PubMed/MEDLINE	"Inspiratory Muscle Training"[All Fields] AND "Functional capacity"[All Fields] AND ("stroke"[MeSH Terms] OR "stroke"[All Fields] OR "strokes"[All Fields] OR "stroke s"[All Fields])
PubMed/MEDLINE	"Inspiratory Muscle Training"[All Fields] AND "Stroke"[All Fields] AND (("clinical"[Title/Abstract] AND "trial"[Title/Abstract]) OR "clinical trials as topic"[MeSH Terms] OR "clinical trial"[Publication Type] OR "random*"[Title/Abstract] OR "random allocation"[MeSH Terms] OR "therapeutic use"[MeSH Subheading])
PubMed/MEDLINE	"Inspiratory Muscle Training"[All Fields] AND ("stroke"[MeSH Terms] OR "stroke"[All Fields] OR "strokes"[All Fields] OR "stroke s"[All Fields]) AND ("randomized controlled trial"[Publication Type] OR ("randomized"[Title/Abstract] AND "controlled"[Title/Abstract] AND "trial"[Title/Abstract]))

Database	Search strategy
PEDro	Inspiratory Muscle Training* Stroke*
Portal Regional BVS	("Inspiratory Muscle Training") AND (stroke)
SciELO	(Inspiratory Muscle Training) AND (Stroke)

Additional Resources

To identify other published, unpublished, or ongoing studies, we consulted the grey literature using Google Scholar. We conducted direct citation tracking of all included studies (and other relevant studies) using Google Scholar for additional references to relevant studies.

Study Selection and Data Extraction

Study selection was conducted by independent authors. In cases of disagreement, a third reviewer was consulted. The meticulous reading of titles and abstracts was followed by the final selection of those meeting the eligibility criteria. Eligible studies were read in full and re-evaluated against the selection criteria. Extracted data included: (1) Author and year of publication; (2) Population characteristics; (3) Intervention protocol; (4) Control; (5) Outcome measurement methods; (6) Main outcomes, and (7) Results. Reviewed and included references were analyzed to identify potential studies not found in electronic searches. **Figure 1** summarizes the study selection strategies.

Risk of Bias

The quality of the studies was assessed using the PEDro scale, based on the Delphi list (Verhagen et al., 1998). The PEDro scale includes 11 items, scoring from 0 to 10, evaluating the internal validity and statistical information of controlled clinical trials. The scale does not assess external validity, significance, or treatment effect size. Two reviewers familiar with the scale independently rated the articles, discussing discrepancies to determine the study scores. The cutoff point to distinguish high and low methodological quality studies was <6 (low quality) or ≥6 (high quality) on the PEDro scale.

III. Result

Database searches and analyzed references returned a total of 140 articles. After review by the authors, 77 duplicates were eliminated, leaving 63 studies. Another 30 were excluded based on titles and abstracts for not addressing stroke as the study pathology and IMT as the sole intervention. At another stage, based on eligibility criteria, 22 studies were excluded. Finally, 11 studies met the eligibility criteria, summarized in **Figure 1.**

The studies were published between 2010 and 2021, conducted with individuals over 18 years old diagnosed with stroke in all phases, most being over 6 months post-stroke. The IMT load varied from 30% to 80% of PImax, with an intervention protocol of up to 40 minutes daily, mostly divided into two sessions, 3 to 6 times per week, predominantly for 6 weeks. The load was typically adjusted based on new PImax measurements. Outcomes were primarily evaluated using manovacuometry (PImax and PEmax), the 6-minute walk test (6MWT) or cycle ergometer (functional capacity), the Berg scale (balance), and the Borg scale (dyspnea), as referenced in **Table 2**.

Inspiratory Muscle Strength

Nine RCTs analyzed inspiratory muscle strength in post-stroke patients. Eight studies found statistically significant differences ($p<0.05$) in favor of IMT, with p-values ranging from 0.043 to <0.001 **(Table 2)**. However, Vaz et al. did not find statistically significant differences ($p=0.164$). Among the eight studies with $p<0.05$, the means and standard deviations varied as described in Table 1. Vaz et al. did not present these values.

Expiratory Muscle Strength

Seven RCTs analyzed expiratory muscle strength in post-stroke patients. Five studies found statistically significant differences ($p<0.05$) in favor of IMT, with p-values ranging from 0.014 to <0.001 **(Table 2)**. The studies by Vaz et al. and Liaw et al. did not find significant differences ($p=0.102$ and $p=0.227$, respectively). The means and standard deviations of the five significant studies are in Table 1. Vaz et al. did not present these values, but Liaw et al. presented a mean and SD of 26.60 (26.92).

Functional Capacity and Walking Capacity

Five RCTs analyzed functional capacity in post-stroke patients. Two studies used the 6MWT as the evaluation method and found significant differences ($p<0.05$) in favor of IMT. Menezes et al. and Vaz et al. did not find significant differences ($p=0.29$ and $p=0.803$, respectively). Britto et al. used a cycle ergometer and also did not find significant differences (p=0.72). The means and standard deviations of the significant studies are in **Table 2**.

Balance

Four RCTs analyzed balance in post-stroke patients. Three studies found significant differences (p<0.05) in favor of IMT. The study by Tovar-Alcaraz et al. did not find significant differences (p=0.608). The means and standard deviations of the significant studies are in **Table 2**.

Dyspnea

Two RCTs (Sutbeyaz et al.; Liaw et al.) analyzed dyspnea in post-stroke patients and found significant differences (p<0.05) in favor of IMT. Liaw et al. presented a mean and SD of 0.05 (0.55). Sutbeyaz et al. did not report these data.

Cardiopulmonary Function

One RCT (Sutbeyaz et al.) analyzed cardiopulmonary function in post-stroke patients using VO2 max and found significant differences (p<0.05) in favor of IMT, with a mean and SD of 0.56 (0.2) for the IMT group.

Table 2. Qualitative Synthesis of Studies Analyzing IMT on Exercise Capacity Post-Stroke.

Author/year	Study type	Population	Intervention	Control	Methods	Main outcomes	Results
Sutbeyaz S, et al., 2010	RCT	45 inpatients with stroke (24 men and 21 women). G1(15) / G2 (15) and G3 (15)	G1: IMT with 40% of PImax, increasing 5-10% each session up to 60%, two sessions of 15 min per day, 6 times a week, for 6 weeks + conventional stroke rehabilitation program.	G2: 15 min diaphragmatic breathing with pursed-lip breathing, 5 min air shift techniques and 10 min voluntary isocapnic hyperpnea during 6 weeks + conventional stroke rehabilitation program G3: Conventional stroke rehabilitation program, two sessions of 15 min per day, 5 times a week, for 6 weeks	Spirometric measurements Borg Brunnstrom stages FAC Barthel index Medical Outcomes Study Short Form questionnaire	Cardiopulmonary function, exertional dyspnea, motor recovery stages, ADLs, and quality of life	Significant increase in PImax and PEmax in G2, and PImax in IMT. Improvement in dyspnea in IMT compared to others. Improvement in IMT in Vo2, PO, HR, and VE compared to BRT
Britto R, et al., 2011	RCT	18 adults (9 men and 9 women) chronic stroke survivors (EG: 9/ CG: 9)	Home-based IMT with 30% of PImax, 30 min per day, 6 sets of 5 min with 1 min interval between sets, 5 times a week, for 8 weeks	Home-based IMT without resistance valve, 30 min per day, 6 sets of 5 min with 1 min interval, 5 times a week, for 8 weeks	Manometer threshold cycle ergometer	PImax, EMS, functional performance	Significant increases in PImax and EMS measures in EG only at the end of training, no significant differences in other measures
Oh D, et al., 2015	RCT	23 patients with stroke (13 men and 10 women), (EG: 11/ CG: 12)	Abdominal strengthening exercises and general physiotherapy, 20 min per day, 3 times a week, for 6 weeks, + IMT with 30% of PImax, 10 sets of 15 repetitions, 3 times a week, for 6 weeks	Abdominal strengthening exercises and general physiotherapy, 20 min per day, 3 times a week, for 6 weeks	Spirometry B-mode ultrasound Berg scale	PF, abdominal muscle thickness, and balance	Significant increases in FVC, FEV1, and PEF in EG compared to CG. CG showed significant increases except in PEF
Messaggi-Sartor M, et al., 2015	RCT	109 patients with subacute ischemic stroke (EG: 56/ CG: 53)	IMTE with 30% of respiratory pressures, increased weekly by intervals of 10 cmH2O, 5 sets of 10 repetitions, twice a day, 5 days a week, for 3 weeks	IMTE with fixed load of 10 cmH2O, 5 sets of 10 repetitions, twice a day, 5 days a week, for 3 weeks	Portable dynamometer microRPM chest x-ray for pulmonary infections	Respiratory muscle strength (PImax and PEmax)	Increased respiratory muscle strength (PImax and PEmax) in the experimental group compared to the control group

Author/year	Study type	Population	Intervention	Control	Methods	Main outcomes	Results
Guilén-Solà A, et al., 2016	RCT	62 dysphagic patients post subacute stroke (38 men and 24 women)	G1: IMTE with 30% of PImax, increased weekly by intervals of 10 cmH2O, 5 sets of 10 breaths, with 1 min recovery, twice a day, 5 times a week, for 3 weeks + SST + speech therapy	G2: Simulated IMTE with 10 cmH2O during intervention + NMES + SST + speech therapy, 5 days a week, for 3 weeks G3: SST + speech therapy, 3 hours a day, 5 days a week, for 3 weeks	microRPM aspiration scale chest x-ray	Respiratory muscle strength, severity of dysphagia, and respiratory disorders	G1 and G2 showed improvements in swallowing safety, but only G1 was associated with improvements in respiratory muscle strength
Jung N, et al., 2017	RCT	20 patients with stroke (EG: 10/ CG:10)	NDT 30 min per day + IMT with 80% of PImax, 2 sets of 10 repetitions, 3 times a week, for 6 weeks	NDT 30 min per day, 3 times a week, for 6 weeks	TIS 6MWT	Functional performance	Significant improvement in balance and 6-minute walk test in EG
Menezes K, et al., 2018	RCT	38 individuals with stroke (16 men and 22 women) (EG: 19/ CG: 19)	High-intensity home-based IMT with 50% of baseline maximal strength, 40 min per day, divided into two sessions of 20 min, 7 times a week, for 8 weeks. Once a week, the physiotherapist adjusted the load	Home-based IMT 40 min per day, divided into two sessions of 20 min, 7 times a week, for 8 weeks	Digital manometer. powerbreathe. Research Council hospitalization frequency for respiratory reasons	Inspiratory muscle strength (PImax), expiratory muscle strength (PEmax), inspiratory endurance, and walking capacity	Significant increases in EG compared to CG in PImax, PEmax, inspiratory endurance, and dyspnea. No significant differences found for other measures
Liaw MY, et al., 2020	RCT	21 patients with stroke (12 men and 9 women), aged 35 to 80 years (EG: 10/ CG: 11)	Conventional rehabilitation + RMT: 30% to 60% of PImax, 6 sets of 5 repetitions. For RMT, 15% to 75% of MEP threshold load, 5 sets of 5 repetitions, 1 to 2 times a day, 5 days a week, for 6 weeks	Conventional rehabilitation	Spirometer pulmonary function parameters Borg	PImax, PEmax, pulmonary function, peak flow, and perception of dyspnea	Improvement in PImax, FEV1, and FVC in EG compared to CG
Vaz L, et al., 2021	RCT	42 adults post-stroke inpatients (EG: 19/ CG: 23)	IMT with 50% of PImax, 30 min per day, two sets of 15 min per day, 5 times a week, for 6 weeks, with weekly adjusted loads + interdisciplinary rehabilitation	IMT with 1 cmH2O, no adjustment, 30 min per day, two sets of 15 min per day, 5 times a week, for 6 weeks	6MWT analog manometer powerbreathe EuroQol	6MWT, PImax, PEmax, and inspiratory muscle endurance	Both groups similarly increased walking capacity. No variations in PImax and PEmax between the two groups
Arslan S, et al., 2021	RCT	21 adults (EG: 11/ CG: 10) with stroke, over 40 years old	NDT BOBATH, 5 days a week + IMT with 40% of PImax, 15 min in 2 sessions (30 min per day), 7 days a week, for 6 weeks	NDT BOBATH, 5 days a week for 6 weeks	Pocket-Spiro spirometer TIS TUG BBS 6MWT	Respiratory muscle strength, balance, trunk control, and functional capacity	Statistically significant increases in EG for respiratory muscle strength, PF (except FVC), functional capacity, trunk control, and balance compared to pre-treatment. Only balance improved in CG
Tovar-Alcaraz A, et al., 2021	RCT	16 stroke survivors, over 18 years old (EG: 8/ CG: 8)	High-intensity IMT with 15% of baseline PImax. In the first week with increases of 5-10% from the second week, up to 60%, which was maintained until the end of 4	Protocol similar to the experimental group, but without training load. Minimum resistance allowed of 7 cmH2O	Forced spirometry. Datospir easy touch PASS Berg scale	Pulmonary function, inspiratory muscle strength, trunk control, postural control, and balance	No significant changes in FVC, FEV1, and peak expiratory values for both groups. Both groups showed

Author/year	Study type	Population	Intervention	Control	Methods	Main outcomes	Results
			weeks. PImax was remeasured, and the training load adjusted to 60% of the new PImax for another 4 weeks. Daily sessions, 5 days a week, for 8 weeks				increases in PImax, but it was slightly higher in EG. No significant changes observed for trunk control and balance scale

Legend: RCT: Randomized Clinical Trial; Stroke: cerebrovascular accident; EG: Experimental Group; CG: Control Group; NDT: Neurodevelopmental Treatment; IMT: Inspiratory Muscle Training; TIS: Trunk Impairment Scale; TUG: Timed Up and Go Test; BBS: Berg Balance Scale; 6MWT: Six-Minute Walk Test; RMS: Respiratory Muscle Strength; PF: Pulmonary Function; FVC: Forced Vital Capacity; PImax: Maximal Inspiratory Pressure; PEmax: Maximal Expiratory Pressure; FEV1: Forced Expiratory Volume in 1 second; PEF: Peak Expiratory Flow; IMS: Inspiratory Muscle Strength; EMS: Expiratory Muscle Strength; FAC: Functional Ambulation Categories; ADLs: Activities of Daily Living; Vo2: Oxygen Consumption; PO: Power Output; HR: Heart Rate; VE: Minute Ventilation; SST: Standard Swallowing Therapy; NMES: Neuromuscular Electrical Stimulation.

Methodological Quality

The methodological quality assessment of the included RCTs was conducted using the PEDro scale. Most studies did not meet all the critical criteria, with scores ranging from 3 to 8, with an average of 6.6 points. This factor should be considered when interpreting study results, as the risk of bias may influence the reported outcomes **(Table 3)**.

Table 3. Quality Assessment of Studies Using the PEDro Scale.

Study	1*	2	3	4	5	6	7	8	9	10	11	Score
Sutbeyaz ST, et al., 2010	✓	✓	✓	✓			✓	✓		✓	✓	7
Britto R, et al., 2011	✓	✓	✓	✓			✓	✓		✓	✓	7
Oh D, et al., 2015	✓	✓		✓			✓			✓	✓	5
Messaggi-Sartor M, et al., 2015	✓	✓	✓	✓	✓		✓		✓	✓	✓	8
Guilén-Solà A, et al., 2016	✓	✓		✓			✓		✓	✓	✓	6
Jung N, et al., 2017	✓	✓		✓			✓	✓		✓	✓	7
Menezes KK, et al., 2018	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	8
Liaw MY, et al., 2020	✓	✓		✓			✓		✓	✓	✓	6
Vaz L, et al., 2021	✓	✓		✓	✓		✓		✓	✓	✓	7
Arslan S, et al., 2021	✓	✓		✓			✓	✓	✓	✓	✓	7
Tovar-Alcaraz A, et al., 2021	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	8

Legend: 1: Eligibility criteria and source of participants; 2: Random allocation; 3: Concealed allocation; 4: Baseline comparability; 5: Blinded participants; 6: Blinded therapists; 7: Blinded assessors; 8: Adequate follow-up; 9: Intention-to-treat analysis; 10: Between-group comparisons; 11: Point estimates and variability; *Item 1 does not contribute to the total score.

IV. Discussion

This systematic review aimed to investigate the effect of inspiratory muscle training (IMT) on the functional capacity of post-stroke patients, as well as secondary outcomes such as respiratory muscle strength, balance, and dyspnea. The main studies analyzed indicate that IMT has beneficial effects on inspiratory and expiratory muscle strength, balance, dyspnea, and cardiopulmonary function (Arslan et al., 2021; Gomes-Neto et al., 2016; Wu et al., 2020). However, when it comes to functional and walking performance, the results are controversial and inconclusive. The methodological quality of the randomized clinical trials (RCTs) was assessed using the PEDro scale, with an average score of 6.6 points (Vaz et al., 2021).

The mechanisms underlying the positive results of IMT include improved respiratory muscle strength, which contributes to better ventilation and oxygenation during physical activity. Gomes-Neto et al. (2016) demonstrated that IMT is effective in improving PImax, respiratory function, and exercise tolerance in post-stroke patients. These improvements in respiratory capacity can reduce dyspnea, allowing patients to perform physical activities with less effort and greater efficiency (Britto et al., 2011). The improvement in dyspnea can be explained by increased respiratory muscle strength and endurance, reducing the workload on the respiratory system during exercise, resulting in less shortness of breath (Sutbeyaz et al., 2010; Liaw et al., 2020).

Studies such as Aydoğan Arslan et al. (2022) and Wu et al. (2020) reported that IMT can also improve balance and functional capacity in post-stroke patients. Improved respiratory control can contribute to better postural control, reducing the risk of falls and increasing functional independence. Dyspnea, assessed by the Borg scale, was significantly reduced in studies such as Sutbeyaz et al. (2010) and Liaw et al. (2020), indicating that IMT can alleviate the sensation of breathlessness, providing greater comfort and confidence during physical activities. These results are explained because IMT strengthens respiratory muscles, not only enhancing ventilation efficiency but also positively impacting trunk stability, essential for balance and postural control (Britto et al., 2011).

However, the systematic review by Xiao et al. (2021) reported no significant differences for PImax and PEmax, possibly due to the small sample size and heterogeneity of the included studies. This inconsistency can be attributed to variability in IMT protocols used, participant characteristics, and the phases of stroke studied. Vaz et al. (2021) and Menezes et al. (2019) found divergent results regarding respiratory muscle strength, which can be explained by differences in stroke phases (subacute vs. chronic) and neuroplasticity capacity in each phase. Additionally, functional and walking performance presented controversial results, partially explained by the heterogeneity of assessment methods and variability in training protocols and IMT intensity (Arslan et al., 2021; Britto et al., 2011).

Clinical Implications

The findings of this review suggest that IMT can be an effective intervention in the rehabilitation of post-stroke patients, with notable benefits in respiratory muscle strength, balance, and dyspnea. The application of IMT can result in significant improvements in the functionality and quality of life of these patients, contributing to more effective rehabilitation and functional reintegration into society (Gomes-Neto et al., 2016; Wu et al., 2020). The implementation of IMT in rehabilitation programs can provide an additional and complementary approach to traditional methods, enhancing rehabilitation outcomes. Furthermore, IMT is a low-cost and easy-to-apply intervention, making it a viable option for most rehabilitation programs (Menezes et al., 2019).

Study Limitations

This review has several limitations that should be considered when interpreting the results. Firstly, most of the included RCTs did not describe intergroup differences and their respective 95% confidence intervals, limiting the interpretation of the results. Additionally, some studies presented only intragroup differences, preventing the determination of the effect size of IMT on the analyzed outcomes. The heterogeneity of functional capacity assessment methods also hindered the comparative analysis of the results. Finally, some studies did not present complete clinical data, such as mean and standard deviation, due to participant loss, making it impossible to evaluate the effect size for clinical practice. The variability in IMT protocols, stroke phases, and participant characteristics contribute to the inconsistency of the results and suggest the need for standardized research methods to obtain more robust conclusions (Xiao et al., 2021).

V. Conclusion

We conclude that the results of the studies included in this review have positive repercussions for secondary outcomes such as PImax, PEmax, balance, and dyspnea. However, the results regarding functional or walking capacity are controversial. The risks of biases in the studies should be considered when interpreting the results. Therefore, further studies are needed to highlight the clinical effects of IMT on the exercise capacity of post-stroke patients to optimize outcomes.

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