The Effects of Inspiratory Muscle Training on Balance and Functional Mobility: A Systematic Review

Abstract

Introduction

Inspiratory Muscle Training (IMT) has been widely used in both healthy and diseased population especially in older adults and its effects have been proven not only on inspiratory muscle strength but also on dyspnea, exercise capacity, quality of life and other health parameters.

Aim

The study aims to review the effects of IMT on balance and functional ability of healthy and diseased population.

Methods

A systematic literature search was conducted on MEDLINE, EMBASE, AMED, and Cochrane Central Register of Controlled Trials (CENTRAL). Randomized control trials having participants >18 years of age and having balance and functional mobility as primary or secondary outcomes were included. Two independent reviewers screened studies against the eligibility criteria, extracted the data, and assessed the quality of evidence. The protocol was prospectively registered on PROSPERO: CRD42021261652.

Results

Ten studies were included in the review out of which eight had balance and six had functional mobility as an outcome measure. There was a significant improvement in balance of the participants after treatment with IMT, however the effect on functional mobility was inconclusive.

Conclusion

The review provided evidence of improvement in balance and functional mobility following inspiratory muscle training in both healthy and diseased adults. Future studies should be conducted to determine optimal protocol and dosage of treatment.

Keywords:

Balance, Berg Balance Scale, Functional Mobility, Inspiratory Muscle Training, , 30 sec Sit to stand Test

1. Introduction

Inspiratory muscle weakness, especially in frailer population (e.g., older adults) has been demonstrated to have negative consequences on functional status and quality of life (1). Inspiratory muscle weakness is defined as a decrease in force generating capacity of respiratory muscles and is manifested by less than 70% of the predicted value of Maximum Inspiratory Pressure (MIP) occurring because of the persistent inability of respiratory muscles to perform their mechanical function (2-4). This weakness creates an imbalance between muscle load and capacity resulting in hypercapnic respiratory failure which is life threatening (5-8). Inspiratory muscle weakness is a common manifestation of multiple diseases including neuromuscular and chest wall conditions, cardiovascular diseases including acute and chronic heart failure patients, interstitial lung disease, chronic obstructive pulmonary disease, non-cystic fibrosis bronchiectasis (9-16).

Inspiratory Muscle Training (IMT) is defined as the techniques targeted towards improving the strength of the respiratory muscles by performing targeted breathing exercises that create resistance by altering pressure or flow. There is a structural and functional similarity of diaphragm with the skeletal muscles rendering it to follow the same principles of strengthening such as overloading, specificity, and reversibility (17). Increase in strength of diaphragm enhances pulmonary function and decreases the oxygen cost of breathing (18). Decreased work of breathing has also demonstrated broad physiological and perceptual benefits during exercise and functional tasks via a reduction in limb vascular resistance and systemic blood flow thereby enhancing the aerobic capacity and exercise tolerance of patient (19, 20).

The IMT has been reported to be effective in not only improving the pulmonary outcomes like dyspnea [20,22], strength of respiratory muscles[20,21,22], but also enhance the functional capacity and exercise tolerance [20,21,22], performance in daily life activities and quality of life [20,21,22] in populations including COPD, chronic kidney disease patients, CHF and healthy adults (18, 20, 21). Additionally, studies have suggested that IMT has proven effective for improving postural stability for both clinical (COPD, stroke [26, 27]) and healthy individuals [28] due to the diaphragm's attachment to the lumbar vertebrae providing mechanical stabilization during movements in upper limb and increasing intraabdominal pressure stabilizing lumber spine (22-26).

The results from multiple studies show increments in trunk stability in stroke patients [24,27] proprioceptive use in postural control in low back pain patients [25], and balance in COPD [26], stroke [27] and community dwelling older adults [28].

Multiple systematic reviews and meta-analysis have been conducted to assess the effects of IMT on dyspnea, pulmonary function, inspiratory muscle strength and quality of life (27-29). This is important because if proven effective, IMT can serve as a low-cost, home-based intervention that not only improves the strength of diaphragm and pulmonary function (19, 21) but also improves balance and mobility aspects of the patient's health thereby enhancing the overall health of the participants. However, there is no consensus on the type of inspiratory intervention (30). Indeed, it is still to be established to what extent IMT improves functional mobility and balance. This review aims to gather evidence and systematically review the effects of IMT for improving balance as well as functional mobility in both healthy and diseased populations.

2. Methods

This systematic review was registered prospectively (PRSOPERO registration number. CRD42021261652; https://www.crd.york.ac.uk/prospero/display_record.php?ID=CRD42021261652) and is reported according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (31).

2.1 Eligibility criteria

2.1.1 Types of studies

All the included studies were randomized control/ clinical trials which evaluated the effects of IMT on balance and functional mobility outcomes except one study by Ferraro et all which was nonrandomized parallel design study (32)..

2.1.2 Types of participants

The review included trials evaluating IMT effects on balance and functional mobility outcomes of both healthy and diseased population.

The eligibility criteria were to include controlled trials with balance and/or functional mobility outcomes. Qualitative studies, observational studies case reports, case series, editorials, commentaries, and grey literature were excluded.

2.1.3. Types of interventions

The review aimed to determine the effects of IMT as a therapeutic technique offered either alone or added to a traditional exercise protocol. Also, it was compared with an active control such as any other form of exercise or could be compared to an inactive control including no treatment or sham- IMT where IMT was provided with the same therapeutic device but with little or no resistance.

2.1.4. Types of outcome measures

The outcome measures were balance defined as "an individual's ability to maintain the center of mass over the base of support" (33) assessed by Berg Balance Scale (BBS), Mini Balance Evaluation System Test (mini-BEST) or any other relevant test. The outcome also included functional mobility, defined as "an individual's ability to move safely and independently in different environments." (34) Though there are multiple tools for assessment of functional mobility, the study only included outcome measures such as Timed Up and Go Test (TUG), 5 second sit to stand test (5STS) and 30 second sit to stand test (30sSTS) etc.

2.1.5. Search methods for identification of studies

Database of the National Library of Medicine (MEDLINE), Excerpta Medica Database (EMBASE), Allied and Complementary Medicine (AMED), and Cochrane Central Register of Controlled Trials (CENTRAL) were searched from searched from inception till September 2021 to identify the eligible studies. Restrictions for language (English) and age (adults) were applied where applicable.

2.1.6. Keywords:

Keywords employed during searches were inspiratory muscle training, breathing exercises, functional mobility, and balance.

2.1.7. Search strategy:

As reported in a systematic review in 2022 (35), an example of a complete search strategy employed for MEDLINE is given below.

(((inspiratory muscle* ADJ3 (train* OR exercis* OR strength*)) OR inspirat* OR IMT OR (respiratory muscle* ADJ3 (train* OR exercis* OR strength*)) OR respirat* OR RMT OR (breath* ADJ3 (train* OR exercis*)) OR breathe OR breathing OR (diaphragm* ADJ3 (train* OR exercis* OR strength*)) OR diaphragm*).ti, ab OR exp "BREATHING EXERCISES"/ OR exp *"INTERCOSTAL MUSCLES"/ OR exp *DIAPHRAGM/ OR exp *"RESPIRATORY MUSCLES"/)" AND (((balanc* ADJ3 (static OR dynamic OR reacti* OR berg OR anticipat* OR postur* OR improv*)) OR balanc* OR stable OR stabili* OR postur*).ti, ab OR "POSTURAL BALANCE"/ OR exp "DEPENDENT AMBULATION"/ OR exp "MOBILITY LIMITATION"/ OR ((mobil* ADJ3 (function* OR status OR depend* OR independen* OR "lower limb" OR "lower extremity" OR LL)) OR mobil*).ti, ab)

2.2 Data collection and analysis

2.2.1 Selection of studies

The articles retrieved as a result of electronic search were collated and uploaded into Endnote reference manager v9 (Clarivate Analytics, Philadelphia, PA) and the duplicate studies were removed. Screening was conducted by two independent reviewers (SS and FVF) to exclude the irrelevant studies based on titles and abstracts Two independent reviewers (SS and ANM) then did the full text screening based on inclusion criteria. All the discrepancies and disagreements were resolved through discussion or using a third reviewer (HT). A record having details of all mentioned steps was maintained using Microsoft Excel (Redmond, WA). The reasons for exclusion of studies after the full-text screening are documented in the PRISMA flowchart (figure 1).

2.2.2. Data extraction and management

Two independent reviewers (SS and ANM) extracted data from the included studies in an excel sheet following PRISMA guidelines. (31) The extracted information included but was not limited to the following: author names, year of publication, country of origin, study characteristics (e.g., setting i.e., home based or supervised, treatment in IMT group and control group), participant characteristics (e.g., diagnosis, sample size, age, and gender), the IMT protocol, outcomes measures and findings of the study. A narrative synthesis of studies was conducted because meta-analysis was not possible due to lack of homogeneity between the studies regarding the study population, treatment given in addition to IMT, devices used and IMT protocol and outcomes.

2.2.3. Assessment of risk of bias in included studies:

The methodological quality of the eligible studies was assessed by two independent reviewers (SS and ANM) to assess internal and external validity of the studies using PEDro quality scale (36). Scores ranging from 9-11 were considered excellent, 6-8 were considered as good, 4-5 fair and scores less than 3 were considered poor. However, no study was excluded based on poor quality.

3. Results:

3.1. Identification and selection of studies:

The initial search from the databases produced 49,710 results. Out of these, 922 studies were identified through AMED,16066 studies through EMBASE, 13667 studies from Medline and 19055 studies from Cochrane. Following the removal of 12053 studies, 37657 potentially relevant studies were screened for titles. One hundred and seven studies were retrieved after title screening. After round two of abstract screening, 51 studies were selected for full text screening results of which 10 studies met the eligibility criteria and were included in review.

3.2. Characteristics of included studies:

A summary of the characteristics of the included studies is presented in Table 1. Of the 10 studies included, five studies were conducted in Korea (37-41), 2 in the UK (25, 41), 01 in Brazil 01 in Turkey (42) and 01 in Saudi Arabia (43). Four studies had balance as an outcome measure (38-40, 42), two had functional mobility as an outcome (43, 44) and four had both balance and functional mobility as an outcome measure (26, 32, 37, 41).

3.3. Participants characteristics:

A total of 314 participants were included in 10 studies, the sample size ranging from 20 to 46 participants. The age of the participants ranged from 30 to 82 years, and all the studies included both male and female participants. The study included healthy participants (26, 32) as well as disease population with the diagnosis of stroke (hemiplegia causing asymmetrical posture and balance deficit) in four studies (37, 39-41) heart failure (reduced cardiac output decreases blood flow towards limbs, causes respiratory muscle weakness and affect lower limb function) (42) hemodialysis (Fluid and electrolyte imbalances, anemia induced fatigue, abnormalities in muscle structure and function, decreases strength and endurance of lower limb musculature affecting balance and functional capacity) (44) lumbar instability (causes muscular imbalances, compromising spinal stability affects balance) (38) and Type II Diabetes Mellitus (central and peripheral muscle weakness reducing exercise capacity and polyneuropathy affecting balance (43) in one study each. IMT session was supervised and hospital-based in two studies (40, 44). Home based session was given in two studies (26, 32), home based with one supervised session weekly was given in two studies (42, 43) and session supervision was not mentioned in four studies (37-41).

3.4. Methodological characteristics:

The risk of bias and quality assessment of the included studies is given in Table 1. Four studies were rated with a good score ranging from 6-8 on PEDro scale (26, 42-44). Five studies were rated as fair with the score ranging from 4-5 (37-41) and one study was rated as poor with the score <3(32).

3.5. Effects of Inspiratory Muscle Training on balance outcomes:

Eight studies had balance as an outcome measure out of which five studies had BBS as an outcome measure (37, 39-42). One study assessed balance via Wii Balance board to assess the sway of center of pressure (CoP) to derive path length, velocity, and area 95% (38). Two studies assessed balance via Mini-BEST test (26, 32) whereas participants of one study also underwent postural stability test on Biodex Balance system (26). The protocol of IMT in experimental group as well as treatment given in control group in each study is presented in Table 2. The treatment frequency varied from 3 to 7 days per week for a duration of 3-8 weeks. The intensity of IMT was kept at 30-50% of the baseline MIP adjusted weekly in most of the studies. In one study, instead of threshold device, flow oriented incentive spirometer was used (40). The rest of the studies used different inspiratory muscle trainers shown in Table 2. Participants in only three studies underwent IMT only in the experimental group (26, 32, 42). In the rest of the studies, IMT was given in addition to other treatments as per the requirement of the patients based on their diagnosis. Significant improvement in balance (p <0.05) was seen in all studies having BBS as an outcome (37, 39-42) However, there were no significant difference between group changes in postural stability test performed on Biodex (44) and Mini BEST test when compared with balance regimen in healthy adults (32).

3.6. Effects of Inspiratory muscle training on functional mobility outcomes

Six studies had functional mobility as an outcome out of which five studies had TUG as an outcome measure (26, 32, 37, 41, 43). Two studies had 30sSTS as an outcome measure (32, 44) and participants in one study performed 5STS for assessment of functional mobility (26). The protocol of IMT in experimental group as well as treatment given in control group in each study is presented in Table 3. The treatment frequency varied from 3 to 7 days per week for a duration of 4-8 weeks. The intensity of IMT was kept at 40-50% of the baseline MIP adjusted weekly in most of the studies. Different types of inspiratory muscle trainers were used in different studies shown in Table 2. Four studies assessed effects of IMT given solely in experimental group (26, 32, 43) additional exercises were performed in two studies (37, 41) according to the diagnosis of the patients. The results were inconclusive with 4/5 studies showing significant improvement ($p<0.05$) in TUG (26, 37, 41, 43) after multifactorial IMT in 2 studies and only IMT in two studies. None of the studies with stand-alone IMT showed improvement in 30sSTS or 5STS test (26, 32, 44)

4. Discussion

This systematic review aimed to summarize the potential effects of IMT on balance and functional mobility in both diseased and healthy adults. Despite the relatively small number of studies and huge variability in protocols, IMT appears to be effective for increasing the balance and functional mobility of participants. The methodological quality of most of the studies was fair to good on PEDro scale. None of the study was rated as excellent and one study was rated as poor thereby reinforcing that high quality clinical trials are needed for improving the evidence-based effect of IMT on balance and related measures.

4.1. Inspiratory Muscle Training as an intervention

The review included studies with both healthy and diseased individuals as participants. It included healthy community dwellers as well as patients with stroke, heart failure, hemodialysis, lumbar instability, and type II diabetes mellitus. Each disease condition has a different pathophysiology ultimately leading to inspiratory muscle weakness and inspiratory fatigue in most of the conditions. The IMT protocol given to these patients as mentioned in results section was highly variable where it is given in combination with exercises (25,26) in most of the studies and only limited studies are having IMT alone (28,41) as a treatment intervention for patients.

The treatment in control group was also variable based on the population and intervention. Different types of inspiratory muscle trainers were used to perform IMT in different studies included in review. The commonly used types of IMT trainers were pressure threshold devices, resistive load devices and voluntary isocapnic hyperpnea devices (45). The first two types are commonly used in trials assessing the effects of IMT. The targeted resistance devices are easy to use and less expensive but at the same time have same efficacy as compared to pressure threshold IMT (46). The evidence collated in the current review also concluded that balance when assessed through berg balance scale was improved in all the participants irrespective of the type of device used. The review includes both types of studies where IMT is given in a supervised session or home-based sessions with weekly supervision. Evidence suggests that both home based and supervised sessions are effective for improvement in balance (26, 32, 40).

4.2. Inspiratory Muscle Training effects on Balance:

Balance ability defined as the ability to maintain line of gravity over base of support (33) can be manifested as static and dynamic balance where the ability to maintain a controlled body movement at rest is static and during task performance and activities is dynamic balance (47). Multiple trials conducted to assess the effects of IMT on balance have reported improvement in balance ability in both healthy and diseases population. (26, 32, 48)

In the current review, the balance of most of the participants assessed through BBS significantly improved after IMT intervention. This finding is in-line with the current evidence where a retrospective analysis depicted association between inspiratory muscles and balance ability evident through improvement in balance ability with increase in inspiratory muscle function (49). The potential mechanism for improvement in dynamic balance might only be because of the activation of diaphragm in feedforward manner owing to rapid movements of upper limb.

Increased strength of diaphragm might have improved the dynamic balance by improving segmental linkages between upper and lower body (26). In most of the studies included in review, IMT was given in combination with other treatment which is also consistent with the results of a recent trial which concluded that IMT should be added as an additional training to the pulmonary rehabilitation program of COPD patients (24). In all the studies, there was an improvement in balance of the participants evident by significant p values (<0.05) and increase in their score on berg balance scale. However, no improvement was seen in static balance (26) similar to results of a pilot randomized control trial where there was no improvement in static balance of soccer players after IMT (50). This is probably because the role of diaphragm in postural control is evident by its relationship with upper limb movements signifying dynamic balance not static. Another trial on stroke survivors concluded uncertainty in effects of IMT on postural control and balance (51).

4.3. Inspiratory Muscle Training effects on functional mobility

Functional mobility is defined as “the ability of a person to move independently and safely in different environments to accomplish functional activities or to participate in the activities of daily living both at home, work and community” (20). The current review has used performance-based outcome measures for quantifying functional mobility, such as timed up and go test and sit to stand test which are most reported for assessing the effects of IMT in different studies.

The results of effects of IMT on functional mobility remain inconclusive with significant improvement in TUG but no improvement was seen in sit to stand tests (both 5STS, 30sSTS). The result of 10 weeks of home based IMT on sit to stand test in patient with multiple sclerosis was also inconclusive when assessed by P.Falzer et al similar to the results found in this review (48). Similarly, the improvement in TUG is consistent with the findings of a recent trial reporting significant improvement with decrease in the time of test performance in pre-frail older women (13). Another study conducted on patients with Parkinson’s disease reported improvement in functional mobility after treatment with IMT (52).

4.4. IMT as a stand-alone vs IMT as multifactorial treatment:

Among the studies included in the review, 3/8 studies having balance as an outcome measure were having IMT as a stand-alone intervention (26, 32, 42) whereas it was given in combination with other exercise regimens in rest of the studies.

Considering IMT as a stand-alone intervention, it can be beneficial for improving balance outcomes in patients. It offers a specific tailored strategy that directly engages the inspiratory muscles causing their strengthening that improves the core activation and positively influences balance. However, if there is any pathology that directly causes postural instability, owing to disease conditions like stroke or lumbar instability, IMT has to be given as a multifactorial treatment adding as suggested by a systematic review and meta-analysis that suggested use of multifactorial interventions for reducing fall risk in elderly (53). The current study endorsed better results of treatment when IMT was given in addition to other treatments highlighting its significance as a multifactorial treatment as compared to stand-alone treatment when assessing balance as an outcome measure.

When the studies were observed for improvement in functional mobility, 4/6 studies had performed IMT alone (26, 32, 43, 44) whereas 2 studies on stroke patients had performed additional interventions (37, 40). Those where IMT was given as an additional treatment proved significant between group results but when observing IMT as a stand-alone intervention, the results were variable and inconclusive. This again suggests better improvement in functional mobility when using IMT as a multifactorial approach. However, future research should be carried out to clarify the results of IMT alone vs given in addition to other exercises as part of comprehensive rehabilitation strategies for improvement of balance.

5. Strength and Limitations

This is the first systematic review to date to investigate the effects of IMT on balance and mobility and the review was conducted in line with the PRISMA guidelines. However, the main limitation of the review was a limited number of high-quality papers eligible for consideration. Also, the available studies exhibited a high degree of heterogeneity limiting the generalization of results.

6. Conclusion

Overall, the review provided evidence of improvement in balance and functional mobility following inspiratory muscle training in both healthy adults (>50 years of age) and diseased patients. However, it would be difficult to draw a concrete conclusion because of high heterogeneity and huge variation in IMT protocols particularly in terms of devices used, treatment regimen and treatments given in addition and combination with IMT. Future studies are needed to evaluate better the role of IMT as a component or alternative to different exercise protocols.

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Table 1: Demographics and clinical characteristics of studies:

Study	Year	Country of origin	Population	Sample size	Age	Gender M/F	Outcome	Supervision	PEDro Score
Bosnak-Guclu M et al	2011	Turkey	Heart Failure	16,14	69.5, 65.7	12/4, 12/2	Balance	1/7 session supervised	6/10
Oh Dongha et al	2016	South Korea	Chronic stroke	11,12	69.7, 71.6	6/5, 7/5	Balance	-	5/10
Yoo HJ et al	2018	Korea	Stroke	20, 20	57, 65	14/6, 12/8	Balance	Supervised	5/10
Lee HJ et al	2018	Korea	Stroke	10, 10	59.8, 60.2	5/5, 5/5	Balance & Mobility	-	4/10
Figueiredo PHS et al	2018	Brazil	Hemodialysis	11,13,13	52.8, 49.5, 45.2	7/4, 10/3, 9/4	Mobility	Supervised	8/10
Dong-Kyu Lee et al	2018	Korea	Chronic stroke	10,10	62.2, 64.2	5/5, 5/5	Balance & mobility	-	5/10
Park SH et al	2019	South Korea	Lumbar instability	20,23	30.9, 30.7	12/8, 12/11	Balance	-	5/10
Ferraro FV et al	2019	UK	Healthy older adults	23, 23	75, 72	9/14, 9/14	Balance & mobility	Home based	6/10
Ferraro FV et al	2020	UK	Community dwellers	11, 14	74, 82	4/7, 4/10	Balance & Mobility	Home based	2/10
Albarrati et al	2021	Saudi Arabia	Type II diabetes mellitus	15, 15	52,54	10/5, 10/5	Mobility	1/7 session supervised	6/10

*Sample size of IMT vs control group

Table 2: Inspiratory Muscle Training intervention description of studies having balance as an outcome.

	IMT group description								Result		
Study (year)	***Intensity (MIP)***	***Frequency (d /wk)***	***Duration (Wk)***	***Time (per day)***	***Training type/ device***	***Exp group***	***C group***	***Outcome***	***Exp group***	***C group***	***P***
Bosnak-Guclu M et al (2011)	IMT at 40% of MIP adjusted weekly	7 days	6 Weeks	30 min	Threshold IMT device (Respironics, USA)	-	sham IMT at 15% of MIP	Berg Balance Scale	Pre= 52.73±3.1 Post=54.25±2.3 P.C= 2.8	Pre= 54.77±3.1 Post=55 ±3.2 P.C=0.4	<0.001
Oh Dongha et al (2016)	warm-up and cool-down twice at 30% of MIP. IMT applied by divided betwee	15 times/ set, total 10 sets 3 days/ week	6 weeks	20 min	Inspiratory muscle trainer	Abdominal strengthening & general PT including breathing ex's	Abdominal strengthening & general PT including breathing ex's	Berg Balance Scale	Pre= 30.1±10.9 Post=32.6 ±11.1 P.C=8.3	Pre= 27.5±10 Post=29.4 ±9.7 P.C=6.9	<0.001

	n the more and less than 41 cmH2O during MIP										
Dong-Kyu Lee et al (2018)	Week 1: Difficulty level 1 without resistance Week 2: level 2 with 50% resistance Week 3: level 3 with 60% resistance Week 4: level 4 with 70%	5 days	4 weeks	20min	Respiratory exercise equipment (Lung Boost Respiratory Trainer MD8000)	Neurodevelopmental treatment	Neurodevelopmental treatment	Berg Balance Scale	Pre = 40.6±1.6 Post = 44.2±1.3 P.C=8.8	Pre = 39.4±2.5 Post = 40.2±2.2 P.C=2	<0.05

	resistance										
Yoo HJ et al (2018)*	Based on visual feedback of the patient's inspiratory flow	7 days	3 weeks	10min	Flow-oriented incentive spirometer	1. Conventional stroke rehab 2. Breath stacking exercise 3. IMT 4. EMT	Conventional stroke rehabilitation.	Berg Balance Scale	Median(range) Pre= 4.5 (0-39) Post = 34.5 (1-55)	Median(range) Pre = 5 (0-54) Post = 35 (3-56)	<0.001
Lee HJ et al (2018)	50% of MIP	7 time/wk, 10 times for 2-3 wks, 15 times for 4-5 wks, 20 times over 6 wks	6 weeks	20min	POWERbreathe (POWERbreath International Ltd., Warwickshire, UK)	Diaphragm and deep abdominal muscle exercise	Traditional exercises	Berg Balance Scale	Pre= 41.80± 8.95 Post= 44.60± 9.18 P.C=6.6	Pre= 40.40± 10.94 Post= 41.50± 10.69 P.C=2.7	<0.01
Park SH et al (2019)*	Resistance level was set to point where participants could	3 days	4 weeks	40min (overall sessionduration)	Respiration-resisting device (Expand-a-Lung, USA)	Progressive lumbar stabilization exercises along with respiratory resistance	progressive lumbar stabilization exercises	Static balance ability via CoP path length, velocity, and	CoP path length, velocity of balance ability p value = <0.05 CoP area 95% (cm2) p value = 0.18		

	stay below 14 in Borg's RPE							area 95%			
Ferraro FV et al (2019)	~50% of baseline MIP	7 days	8 weeks	30 quick breaths twice a daily	(POWERbreathe Plus, POWERbreathe International Ltd, Southam, UK)	-	60 slow breaths once daily at a load setting of 0 (corresponding to ~15% baseline MIP)	Mini-BEST, Biodex postural stability test	Mini-BEST: Pre=20.4± 3.5 Post= 24.1± 2.2 P.C=18.1 PST: Pre=2.8 ± 0.8 Post= 2 ± 0.7 P.C=-27.3	Mini-BEST: Pre=20.8± 3.3 Post= 21.3± 2.9 P.C=2.4 PST: Pre= 2.7±0.9 Post= 1.7±0.7 P.C=-37.0	Mini-BEST: P = 0.05 PST: P >0.05

Ferraro FV et al (2020)	~50% of baseline MIP	7 days	8 weeks	30 quick breaths twice a daily	(POWERbreathe Plus, POWERbreathe International Ltd, Southam, UK)	-	OTAGO exercise program	Mini-BEST	Mini-BEST: Pre=19± 4.1 Post= 24.2± 2.7 P.C=27.3	Mini-BEST: Pre=14.6± 4.9 Post= 19.5± 3.5 P.C=33.5	Mini-BEST: P >0.05

* = Percentage changes are not calculated because data are not presented as Mean and SD

Abbreviations: IMT = Inspiratory Muscle Training, MIP = Maximum Inspiratory Pressure, PT = Physical therapy, COP = center of pressure, RPE= Rate of perceived exertion, mini-BEST = Mini Balance Evaluation System Test, PST = Postural stability index, Exp group = Experimental group, C group = Control group, p value = Probability value, PC = Percentage change

Table 3: IMT intervention description of studies having functional mobility as an outcome:

Study (year)	**IMT group description**					***Exp group***	***C group***	***Outcome***	**Result**		
	Intensity (MIP)	***Frequency (days /week)***	***Duration (Weeks)***	***Time (per day)***	***Training type/ device***				***Exp group***	***C group***	***P value***
Figueiredo PHS et al (2018)*	50% of MIP	3 days	8 weeks	3sets of 15 deep inspirations	Threshold IMT1(Respironics, Murrysville PA, USA) or PowerBreathe light/ median Resistance (Powerbreathe, HaB International Ltd, Southam, UK)	-	Group 2: Low intensity aerobic training, Group 3: Combined training	30secSTS	IMT: 2.2 repetition (IC95% 1.1±3.2), AT: 3.1 repetition (IC95% 2.1±4.1) CT: 2.4 repetition (IC95%1.4 ±3.5)		0.671
Dong-Kyu Lee et al (2018)	**Week 1:** Difficulty level 1 without resistance	5 days	4 weeks	20min	respiratory exercise equipment (Lung Boost Respiratory	Neurodevelopmental treatment	Neurodevelopmental treatment	TUG test	Pre= 22.8±1.4 Post=18.2 ±2.9	Pre= 21.2±1.6 Post=20.4 ±1.1	<0.05

	Week 2: level 2 with 50% resistance **Week 3:** level 3 with 60% resistance **Week 4:** level 4 with 70% resistance				Trainer MD8000)				P.C=-20.1	P.C=-3.7	
Lee HJ et al (2018)	50% of MIP	7 times/week, 10 times over 2-3 weeks, 15 times for 4-5 weeks, 20 times over 6 weeks	6 weeks	20min	POWERbreathe (POWERbreath International Ltd., Warwickshire, UK)	Diaphragm and deep abdominal muscle exercise	Traditional exercises	TUG test	Pre: 15.62 ± 7.06 Post: 12.93 ± 6.23 P.C=-17.3	Pre: 16.54 ± 5.99 Post 16.20 ± 5.89 P.C=-1.8	<0.001
Ferraro FV et al (2019)	~50% of baseline MIP	7 days	8 weeks	30 quick breaths twice a daily	(POWERbreathe Plus, POWERbreathe	-	60 slow breaths once daily at a load setting of 0	TUG, 5STS	TUG: Pre=7.6±1.6 Post= 7.2±1.2	TUG: Pre=9±2.4 Post= 9.3±3.6	TUG: p = 0.03 5STS:

					– International Ltd, Southam, UK)		(corresponding to ~15% baseline MIP)		P.C=-5.2 5STS: Pre= 15.5±5.9 Post= 16.8±8.1 P.C=8.4	P.C= 3.3 5STS: Pre=18.6 ± 11.5 Post= 20.9 ± 8.9 P.C=12.4	p>0.05
Ferraro FV et al (2020)	~50% of baseline MIP	7 days	8 weeks	30 quick breaths twice a daily	(POWERbreathe Plus, POWERbreathe International Ltd, Southam, UK)	-	OTAGO exercise program	TUG, 30sSTS	TUG: Pre=8.9±1.1 Post= 7.9±1.4 P.C=-11.2 30sSTS: Pre=13.2±4.4 Post= 15.2 ± 5.1 P.C=15.1	TUG: Pre=16.8±13.7 Post= 14.1± 11 P.C=-16 30sSTS: Pre= 9.3±4.6 Post= 10.8±4.2 P.C=16.1	TUG: P >0.05 30sSTS: P >0.05

Albarrati et al (2021)	40% of MIP and adjusted weekly to maintain 40% of MIP at each supervised session	7 days	8 weeks	30 mins	threshold IMT device (Healthscan Products Inc., Cedar Grove, NJ, USA).	-	15% of MIP.	TUG	Pre=8.18± 1.1 Post= 6.64 ± 0.6 P.C=-18.8	Pre=8.23± 1.5 Post= 7.51± 0.8 P.C=-8.74	<0.05

* = Percentage changes are not calculated because data are not presented as Mean and SD

Abbreviations: IMT = Inspiratory Muscle Training, MIP = Maximum Inspiratory Pressure, TUG = Timed up & Go test, 5STS = 5 second sit to stand test, 30sSTS = 30 second sit to stand test, Exp group = Experimental group, C group = Control group, p value = Probability value, PC = Percentage change

Figure 1. PRISMA flow diagram.