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Effect of Coherent Breathing Versus Inspiratory Muscle Training on Risk of Falling and Functional Capacity in Older Adults

Sherif Osama Abdelsalam Elabd[1], Rana Hesham Mohamed Elbanna[2], Hany Ezzat Obaya[2], Gehad Ali Abdelhaseeb[2]

[1]May University Faculty of Physical Therapy, Department of Physical Therapy for Internal Medicine, Cairo, Egypt
[2]Cairo University Faculty of Physical Therapy, Department of Cardiovascular/Respiratory Disorders and Geriatrics, Giza, Egypt

Abstract

Objective: This study aimed to compare the impact of inspiratory muscle training (IMT) and the coherent breathing technique on the old population's gait, balance, and functional capacity.

Materials and Methods: This randomized controlled trial included 90 older individuals who were allocated into the IMT, coherent breathing, and control groups. The participants' ages varied between 62 and 68 years, and their body mass index was 25 to 30 kg/m^2. The IMT group received an IMT program, the coherent breathing group received a program of coherent breathing exercises, and the control group did not receive any intervention. The investigation was extended to 12 weeks, with a frequency of three sessions per week. The Tinetti performance oriented mobility assessment (POMA) was employed to assess the balance and gait level of the participants, while their functional capacity was assessed utilizing the six-minute walking test (6MWT) before and after the intervention.

Results: The POMA score and the 6MWT outcomes were significantly increased in the IMT and coherent breathing exercises ($p \leq 0.05$), and no significant variation was detected in the control group. However, the IMT group showed increased improvement in balance and functional capacity compared with the coherent breathing group.

Conclusion: Our study outcomes exhibited that both IMT and coherent breathing exercises played a vital role in enhancing functional capacity and decreasing the risk of falls in older individuals. However, the IMT exhibited more efficacy in improving balance, gait, and functional capacity compared with coherent breathing.

Keywords: Breathing exercises, respiratory muscles, quality of life, fall risk, older adults

Introduction

The advanced aging of people and the issues associated with the care of older society have become an emergency for all healthcare systems. Aging has increased the need for health and social services. There is a pressing need for a fundamental change in healthcare systems, switching from a focus on managing diseases to adopting a more functional strategy based on integrated, coordinated, continuous, and patient-centric care (1). The World Health Organization has stated that policies associated with health must be examined from the perspective of an older individual's functional capacity rather than focusing on illnesses or comorbidities encountered at certain moments (2). Falls are among the primary causes of morbidity and mortality in older adults. Interruptions in motor function (e.g., balance and gait) (3), impairment of functional ability, and a variety of other variables (4) determine fall risk. Multiple studies have shown that the onset of poor gait (5) or balance (6) is a significant marker of falls in older people. Although the frequency of falls among senior Egyptians is not dangerously high, it may be lowered because the goal should be zero falls. Recent investigations have indicated that rehabilitation and

Address for Correspondence: Sherif Osama Abdelsalam Elabd, May University Faculty of Physical Therapy, Department of Physical Therapy for Internal Medicine, Cairo, Egypt
Phone: +20 106 722 74 04 **E-mail:** sherif.osama@muc.edu.eg **ORCID:** orcid.org/0000-0003-2393-9961

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community interventions are used for training and educating older adults to increase their physical fitness and minimize their fear of falling (7). Diaphragmatic breathing training raises intra-abdominal pressure (IAP) and activates deep trunk muscles (8), leading to increased spine stiffness. Consequently, IAP modulation adds a method for the central nervous system to manage spinal stability during functional activities, as it may simplify this regulation by providing an indirect increase in stiffness (9). This acquisition of postural stability may result in positive gains in balance and functional capacity (10). Coherent breathing has been shown to modulate the production of stress hormones by supporting equilibrium in the autonomic nervous system by stimulating the parasympathetic system or secreting relaxation hormones, which help counteract the prevailing state of sympathetic dominance; consequently, coherent breathing has been shown to modulate sympathovagal balance, improving functional ability (11). Inspiratory muscle training (IMT) has been extensively utilized in many populations, including healthy individuals and those with medical disorders, particularly in older adults. Its benefits have been scientifically established not only in enhancing inspiratory muscle strength but also in reducing dyspnea, improving exercise capacity, enhancing quality of life (QoL), and impacting other medical aspects (12). Therefore, it is possible to hypothesize that different diaphragmatic training approaches, like IMT or coherent breathing, could improve gait balance and functional ability in older adults. Therefore, this investigation aimed to compare the impact of the two different breathing techniques on functional ability and balance in older individuals.

Materials and Methods

Ethical Approval

The Research Ethics Committee of Cairo University's Faculty of Physical Therapy authorized this study (approval number: P.T.REC/012/003819, date: 21.06.2022). The clinical trial registration number is NCT05767372. Before completing the informed consent form, each patient received a comprehensive description of the purposes and methodologies of the study.

Sample Size, Randomization, and Blinding

G* Power version 3.1.9.7 was used to identify the sample size. A prior type of power analysis was used with α error probability of 0.05 and power (1-β error probability) equal to 0.95. A total of 72 participants was the minimum sample size for the investigation. Considering a possible attrition of approximately 15%, the sample size was increased to 30 per group. The participants were separated into IMT, coherent breathing, and control groups at random by randomized block process (Figure 1). MS Excel 2013 software was used to produce the random sequence.

Participants

The investigation was designed as a prospective, parallel randomized controlled trial. This study was conducted in the outpatient clinic of Cairo University's faculty of physical therapy. Ninety older adults (62 to 68 years old) agreed to participate and were distributed equally at random into the IMT (received IMT program), coherent breathing (received coherent breathing program), and control (no intervention) groups. The participants were encouraged to consume various foods from each food group, focusing on the nutrients, including potassium, calcium, dietary fiber, and vitamin B12. In addition, they were instructed to choose foods with little to no added sugar, saturated fats, or sodium and to obtain enough protein portion (1.2-1.4 g/kg) with 800 IU of vitamin D daily. The inclusion criteria included those above sixty years old and nonsmokers. The exclusion criteria were as follows: age below 60 years, chronic pulmonary disorder (e.g., obstructive lung disease, asthma), low back pain with a moderate or severe degree (Oswestry low back pain disability questionnaire >21%), falling fear (activities balance confidence scale <67%), deficiencies of cognitive abilities (mini-mental state examination score <24), having fallen in the prior 2 years, cardiac disorders restricting physical activities, uncontrolled diabetes, taking beta-blocker medicine, vertigo in the previous six months, presently receiving balance training (like Tai Chi and pilates), using any assistive devices, and any metabolic, endocrinal, or respiratory disorder.

Intervention Procedure

Coherent Breathing Group

The key component of coherent breathing is achieving mental and physical relaxation by modulating the breathing pace to approximately five breaths per minute, inhaling for 6 s, and exhaling for 6 s so that one breath lasts for 12 s and five breaths per minute. After the evaluation, patients underwent a coherent breathing training program. They were placed in an upright, relaxed position with no inclination exceeding 45°. They were given the following instructions: take three or four deep breaths using their diaphragm, use a stopwatch to check the intervals, and put one hand on the abdomen and the other on the level of the diaphragm to assess their ability to perform breathing. Then, the participants were instructed to inspire for 4 s and then expire for 4 s, repeat this for 1 min, and repeat the previous step but elongate their inspiration and expiration for 5 s. Then, they were asked to inhale deeply and slowly for 6 s and then exhale for around 6 s. The set was continued for 10 min with two intervals for a total session duration of 30 min (13). The sessions were performed three times a week for 12 weeks.

IMT Group

This group used a threshold IMT (threshold IMT device HS730, Respironics NJ, USA) equipped with a spring-loaded one-way

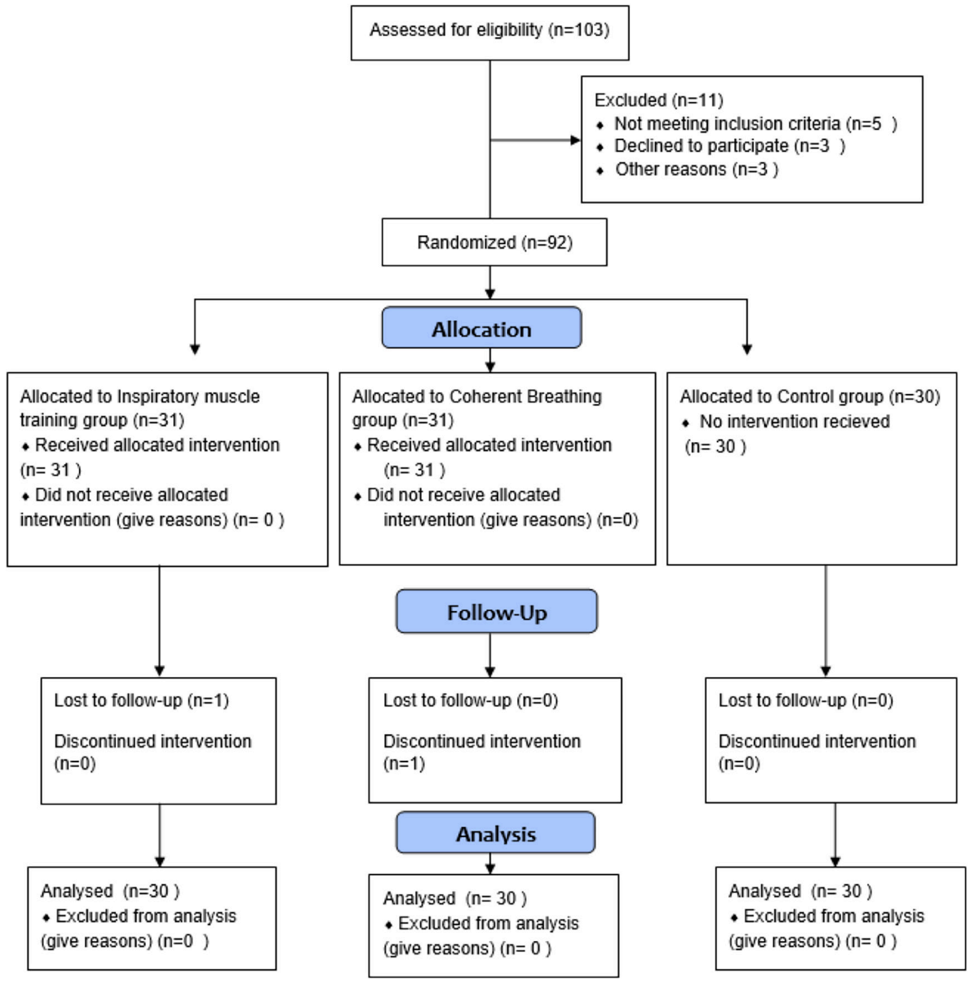

Figure 1. The flowchart

valve that offers adjustable resistance during inspiration within a spectrum ranging from 9 to 41 cmH_2O (14). The patient was lying in a high supine position (45 degrees). The participants were then instructed to put a nose clip on the nose to allow breathing through the mouth and ensure that the lips were positioned around the mouthpiece without blockage from the tongue. Then, maximum training was detected as follows: the participants detected the intensity at which they could efficiently achieve 10 breathing cycles at maximum resistance based on the individual's pace of apparent power. Subsequently, the application was initiated with a low-intensity load of 20-30% of the participants' maximum 10-repetition technique utilizing an IMT device. Then, the intensity was developed slowly and monitored carefully until achieving 50% of maximum effort over three weeks as tolerated. The subjects took complete inspiration (maximal and deep inspiration) and then expired slowly. This breathing pattern lasted for 10-20 breaths. The participants were then instructed to repeat 4-6 times with rest in between 30 s (15). The program was conducted thrice weekly over 12 weeks.

Control Group

Individuals in this group did not receive any intervention, but performed their routine activities of daily living. However, their functional capacity, balance, and gait were evaluated before and after the duration of the study (12 weeks) utilizing the assessment approaches of our investigation.

Outcomes Measures

Six-minute Walk Test (6MWT)

The functional capacity of the subjects was assessed using the 6MWT. The measurements were performed in accordance with the American Thoracic Society's directions. Participants were instructed to walk as far as they could along a 30-meter hallway at their own pace for 6 minutes. Individuals were permitted to pause and relax during the test, which was conducted before and after the intervention. The maximum 6-minute walking distance was detected in meters (16).

Tinetti Performance Oriented Mobility Assessment (POMA)

The POMA was used to evaluate the fall risk. The POMA is divided into two components: one for balance and one for gait. The balance part was used to assess balance when sitting or standing, while the other part was used to assess dynamic balance during walking. The total potential score was 28, including 12 for POMA gait and 16 for POMA balance, and a lower overall score suggests a higher risk of falling (17). According to Lin et al. (18), compared with different tests, the POMA has greater test-retest reliability, discriminant validity, and predictive validity for evaluating the risk of falling in older individuals.

Statistics

SPSS software version 22 was used to perform all statistical analyses. A comparison between the groups' features, including age, weight, height, and body mass index (BMI), was conducted using ANOVA, while the Kruskal-Wallis test was employed for comparing sex between groups. MANOVA was performed to compare the scores of 6MWT and POMA between the groups. However, multiple comparisons were conducted to identify differences between the groups. The significance level for all statistical tests was set at $p<0.05$.

Results

Typically, 90 participants were enrolled in this investigation and allocated equally and randomly into the following three groups: IMT, coherent breathing, and control groups. No significant variations were detected regarding the features of the individuals among all groups (p-value was 0.226, 0.059, 0.150, 0.066, and 0.835 for age, weight, height, BMI, and sex, respectively) (Table 1).

The findings indicated that the intervention of IMT or coherent breathing technique had a significant impact on the 6MWT in both groups, and no effect was detected in the control group; however, no significant variation was identified between the groups before the intervention (Table 2). Furthermore, significant variations were observed between all groups after intervention ($p=0.003$), and multiple comparisons exhibited significant differences between the IMT and control groups (Table 2). In addition, improvement was better in the IMT group (percent of change: 8.6%) compared to the group of coherent breathing (percentage of change: 2.7%), indicating that IMT had high efficacy (Table 2).

Table 1. Comparison of characteristics between groups

	IMT group (n=30)	Coherent breathing group (n=30)	Control group (n=30)	F-value	p
	X±SD	X±SD	X±SD		
Age (years)	65.2±2.7	64.9±3.1	66.1±2.7	1.511	0.226
Weight (kg)	73.6±6.9	77.2±7.6	77.6±6.4	2.925	0.059
Height (cm)	163.9±9.2	168.2±8.9	166±6.4	1.941	0.150
BMI (kg/m²)	27.4±1.6	27.3±1.3	28.2±1.8	2.807	0.066
	n (%)	**n (%)**	**n (%)**		
Male Female	18 (60%) 12 (40%)	16 (53.3%) 14 (46.7%)	18 (60%) 12 (40%)		0.835

IMT: Inspiratory muscle training, X: Mean, SD: Standard deviation, p: Probability value, n: Number of participants, BMI: Body mass index

Table 2. Comparison between groups regarding 6MWT (m)

	IMT group (n=30)	Coherent breathing group (n=30)	Control group (n=30)	Comparison between group	
	X±SD	X±SD	X±SD	F-value	p
Before intervention	512.8±37.9	519.1±37.3	511.4±36.7	0.360	0.699
After intervention	556.8±67.7	532±37.1	512.1±36.1	6.199	0.003*
Percentage of change	8.60%	2.70%			
Comparison within group	p≤0.05*	p≤0.05*	0.055		
			MD	**p**	
IMT group vs. coherent breathing group			23.83	0.178	
IMT group vs. control group			44.7	0.003*	
Coherent breathing group vs. control group			20.87	0.265	

IMT: Inspiratory muscle training, X: Mean, SD: Standard deviation, p: Probability value, *: Significance, MD: Mean difference, n: Number of participants, 6MWT: Six-minute walking test, m: Metre

The outcomes revealed that both IMT and coherent breathing exercises had a significant effect on POMA scores (p≤0.05), and no alteration was observed in the control group; however, the comparison between all groups before intervention regarding this score indicated no significant variations (Table 3). According to the POMA score findings, significant variation was detected between all groups post-intervention was detected (p≤0.05), and multiple comparisons indicated significant variations between every group and each other (Table 3). Moreover, enhancement was higher in the IMT group (percentage of change: 18.1%) than in the coherent breathing group (percentage of change: 6.2%), indicating that IMT was more effective (Table 3).

Discussion

The study outcomes revealed that both IMT and coherent breathing exercise had a vital impact on older adults' function ability, gait, and balance; however, IMT exhibited more efficacy than coherent breathing exercise.

Stressful life events result in excessive activation of the fight or flight response, known as sympathetic overload, which has significant implications for morbidity and mortality. This imbalance in the autonomic nervous system results in a persistent state of excessive activity across all bodily functions. It is characterized by elevated biochemical levels, such as cortisol and epinephrine, elevated energy expenditure, and the generation of free radicals as byproducts. Consequently, this chronic state of hyperactivity leads to the depletion of energy (19). Prior investigation exhibited that coherent breathing has been shown to modulate that imbalance in the autonomic nervous system (11), improving functional ability, which might explain our study findings.

Restricted diaphragmatic movement impairs bodily functions and exerts additional strain on cardiovascular and gastrointestinal systems. Coherent breathing refers to the practice of slow and deep breathing, maintaining a pace of five breaths per minute while consciously relaxing during the exhalation phase, which serves as a means of exercising the diaphragm (20). The use of this self-regulatory approach has the potential to facilitate an equilibrium between the mind and body, thus enhancing overall health and perceived wellness.

According to previous reports, increased respiratory muscle strength has been demonstrated to benefit individuals with heart failure. These include the postponement of diaphragmatic fatigue, enhancement of ventilatory efficacy, and reduction of blood flow demands placed on the respiratory muscles during exercise (21). Consequently, sympathetic activity is reduced, leading to enhanced systemic vasodilation and improved perfusion of peripheral muscles, thereby increasing functional capability (21). Subsequently, according to this mechanism, IMT might increase functional capacity in older individuals.

Consistent with our research findings, a previous study implemented a 12-week IMT intervention, which yielded statistically substantial enhancements in forced vital capacity, forced expiratory volume in 1 second, forced expiratory flow 25%-75%, peak expiratory flow, maximal inspiratory and expiratory pressures, as well as 6-minute walking distance among older adults with atrial fibrillation (22). In their meta-analysis, Gosselink et al. (23) found a statistically significant minimum difference of 32 m in the 6-minute walking distance when comparing individuals with chronic obstructive lung disease who underwent IMT to those in the control group. According to a previous study, a 6-week regimen of thoracic stretching and breathing exercises conducted at home had favorable outcomes regarding thoracic cage expansion and physical function. These outcomes were assessed using the pulmonary function test and the 6MWT in a sample of healthy older adults (24). In addition, previous research included 45 patients who had three times of respiratory therapy using

Table 3. Comparison between groups regarding POMA

	IMT group (n=30)	Coherent breathing group (n=30)	Control group (n=30)	Comparison between groups	
	X±SD	X±SD	X±SD	F-value	p
Before intervention	21±1.1	21.1±1.1	20.9±1.1	0.179	0.836
After intervention	24.8±0.8	22.4±0.8	21±1.04	13.79	p≤0.05*
Percentage of change	18.10%	6.20%			
Comparison within groups	p≤0.05*	p≤0.05*	0.577		
			MD	p	
IMT group vs. coherent breathing group			2.33	p≤0.05*	
IMT group vs. control group			3.83	p≤0.05*	
Coherent breathing group vs. control group			1.5	p≤0.05*	

IMT: Inspiratory muscle training, POMA: Tinetti performance oriented mobility assessment, X: Mean, SD: Standard deviation, p: Probability value, *: Significance, MD: Mean difference, n: Number of participants the active cycle of breathing approach per week for two consecutive months, and the findings illustrated a statistically significant enhancement in the outcomes of the 6MWT (25). Furthermore, the findings of a previous investigation have shown the efficacy of coherent breathing training in enhancing cardiorespiratory fitness among individuals in good health (26).

Furthermore, prior research exhibited that home-based pulmonary rehabilitation may have beneficial effects on functional ability, anxiety, depressive symptoms, and QoL in older individuals with chronic obstructive pulmonary disease and chronic respiratory failure (27). Moreover, a previous study indicated that a duration of 8 weeks of IMT resulted in enhancements in inspiratory muscle function, specifically peak inspiratory flow rate, maximal inspiratory pressure (MIP), peak inspiratory power, and dynamic balance capability, as evidenced by an increase in the mini-balance evaluation systems test score. Therefore, IMT was feasible and efficient for older adults without needing supervision, as it was conducted at home with no adverse consequences like falls or discomfort (28).

In contrast to the results obtained in our study, it was observed that in a cohort of older adults who were in good health and exhibited normal spirometry, respiratory muscle strength, and physical fitness, the implementation of IMT led to an increase in MIP and peak inspiratory flow; however, no significant changes were observed in other spirometry assessments, DNA damage levels in peripheral blood mononuclear cells, plasma cytokine concentrations, dynamic inspiratory muscle function, inspiratory muscle endurance, distance covered in the 6MWT, physical activity level, or QoL (29).

The outcomes of a previous study revealed that a thorough chest physiotherapy (PT) program lasting eight weeks led to notable enhancements in dynamic postural stability, spirometry, respiratory muscle strength, and functional capacity among pediatric patients diagnosed with cystic fibrosis; however, including IMT in chest PT did not result in further enhancements, except for the MIP value (30), which was in contrast with our findings.

Study Limitations

Some notable limitations should be addressed in this research. First, the physical activity history of the participants should be considered. Second, the psychological aspects of the individuals should be evaluated. Furthermore, our study participants comprised an integrated cohort of older individuals with a limited age range. Consequently, it is important to acknowledge that our findings may not be generalizable to the entire older adult population.

Conclusion

Coherent breathing technique and IMT can significantly improve functional capacity, gait, and balance in older individuals. However, the findings of our study indicated that IMT was more efficient than coherent breathing exercises.

Ethics

Ethics Committee Approval: The Cairo University Faculty of Physical Therapy's Research Ethical Committee provided written informed consent (approval number: P.T.REC/012/003819, date: 21.06.2022).

Informed Consent: Prior to completing an informed consent form, every patient received a comprehensive explanation of the objectives and methodologies of the research.

Authorship Contributions

Surgical and Medical Practices: S.O.A.E., R.H.M.E., H.E.O., G.A.A.E., Concept: S.O.A.E., R.H.M.E., H.E.O., G.A.A.E., Design: S.O.A.E., R.H.M.E., H.E.O., G.A.A.E., Data Collection or Processing: S.O.A.E., G.A.A.E., Analysis or Interpretation: S.O.A.E., H.E.O., Literature Search: S.O.A.E., G.A.A.E., Writing: S.O.A.E., R.H.M.E., G.A.A.E.

Conflict of Interest: No conflicts of interest were declared by the authors.

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References

1. Rodriguez-Mañas L, Rodríguez-Artalejo F, Sinclair AJ. The Third Transition: The Clinical Evolution Oriented to the Contemporary Older Patient. J Am Med Dir Assoc. 2017;18:8-9.
2. World report on ageing and health. World Health Organization; 2019. https://www.who.int/news-room/questions-and-answers/item/healthy-ageing-and-functional-ability
3. Härlein J, Dassen T, Halfens RJ, Heinze C. Fall risk factors in older people with dementia or cognitive impairment: a systematic review. J Adv Nurs. 2009;65:922-933.
4. Lee CH, Mendoza T, Huang CH, Sun TL. Comparative Analysis of Fall Risk Assessment Features in Community-Elderly and Stroke Survivors: Insights from Sensor-Based Data. Healthcare (Basel). 2023;11:1938.
5. Nakamura T, Meguro K, Sasaki H. Relationship between falls and stride length variability in senile dementia of the Alzheimer type. Gerontology. 1996;42:108-113.
6. Allan LM, Ballard CG, Rowan EN, Kenny RA. Incidence and prediction of falls in dementia: a prospective study in older people. PLoS One. 2009;4:e5521.
7. El Sayed AEHI, Said MT, Mohsen O, Abozied AM, Salama M. Falls and associated risk factors in a sample of old age population in Egyptian community. Front Public Health. 2023;11:1068314.
8. Amiri B, Zemková E. Diaphragmatic breathing exercises in recovery from fatigue-induced changes in spinal mobility and postural stability: a study protocol. Front Physiol. 2023;14:1220464.
9. Hodges PW, Eriksson AE, Shirley D, Gandevia SC. Intra-abdominal pressure increases stiffness of the lumbar spine. J Biomech. 2005;38:1873-1880.
10. Granacher U, Lacroix A, Muehlbauer T, Roettger K, Gollhofer A. Effects of core instability strength training on trunk muscle strength, spinal mobility,

dynamic balance and functional mobility in older adults. Gerontology. 2013;59:105-113.

11. Coyne Baker N. Boston College William F. Connell School of Nursing "Does daily meditation or coherent breathing influence perceived stress, stress effects, anxiety, or holistic wellness in college freshmen and sophomores?" a dissertation. Boston College; 2012.

12. Sheraz S, Ferraro FV, Siddiqui FA, Tariq H, Anthony Faghy M, Malik AN. The effects of inspiratory muscle training on balance and functional mobility: a systematic review. Postgrad Med. 2023;135:690-700.

13. Brown R, Gerbarg PL. The healing power of the breath: Simple techniques to reduce stress and anxiety, enhance concentration, and balance your emotions. Shambhala Publications; 2012.

14. Bissett BM, Leditschke IA, Neeman T, Green M, Marzano V, Erwin K, van Haren FM, Boots R, Paratz J. Does mechanical threshold inspiratory muscle training promote recovery and improve outcomes in patients who are ventilator-dependent in the intensive care unit? The IMPROVE randomised trial. Aust Crit Care. 2023;36:613-621.

15. Ebrahim G, Refaye E, Farid H, Elsisi EM, Al Salam Aljahmany A. Comparative Study of Inspiratory Muscle Strength Training and Incentive Spirometer on Ventilatory Function in Postmenopausal Asthmatic Women. Int J Appl Exerc Physiol. 2020;1:2322–3537.

16. ATS Committee on Proficiency Standards for Clinical Pulmonary Function Laboratories. ATS statement: guidelines for the six-minute walk test. Am J Respir Crit Care Med. 2002;166:111-117.

17. Tinetti ME, Williams TF, Mayewski R. Fall risk index for elderly patients based on number of chronic disabilities. Am J Med. 1986;80:429-434.

18. Lin MR, Hwang HF, Hu MH, Wu HD, Wang YW, Huang FC. Psychometric comparisons of the timed up and go, one-leg stand, functional reach, and Tinetti balance measures in community-dwelling older people. J Am Geriatr Soc. 2004;52:1343-1348.

19. Jacobs GD. The physiology of mind-body interactions: the stress response and the relaxation response. J Altern Complement Med. 2001;7 Suppl 1:S83-S92.

20. Elliot S, Edmonson D. Coherent Breathing: The New Science Of Breath (2005) - Coherent Breathing For Health, Well-being, Performance, And Longevity. 2nd ed. Texas: Coherence Press; 2006.

21. Plentz RD, Sbruzzi G, Ribeiro RA, Ferreira JB, Dal Lago P. Inspiratory muscle training in patients with heart failure: meta-analysis of randomized trials. Arq Bras Cardiol. 2012;99:762-771.

22. Zeren M, Demir R, Yigit Z, Gurses HN. Effects of inspiratory muscle training on pulmonary function, respiratory muscle strength and functional capacity in patients with atrial fibrillation: a randomized controlled trial. Clin Rehabil. 2016;30:1165-1174.

23. Gosselink R, De Vos J, van den Heuvel SP, Segers J, Decramer M, Kwakkel G. Impact of inspiratory muscle training in patients with COPD: what is the evidence? Eur Respir J. 2011;37:416-425.

24. Ekstrum JA, Black LL, Paschal KA. Effects of a Thoracic Mobility and Respiratory Exercise Program on Pulmonary Function and Functional Capacity in Older Adults. Physical & Occupational Therapy in Geriatrics. 2009;27:310–327.

25. Hamed Elsayed S, Kamal W, Basset MA, Fathy KA. "Impact of active cycle of breathing technique on functional capacity in patient with bronchiectasis." Int J Ther Rehabil Res. 2015;4:287–293.

26. Patel JK, Rajeshkumar SP. Effect of 1 Week Coherent Breathing Exercise Training on Cardiorespiratory Fitness in Healthy Young Adults: An Experimental Study. Indian J Physiother Occup Ther. 2022;16:79–90.

27. Gephine S, Saey D, Grosbois JM, Maltais F, Mucci P. Home-based Pulmonary Rehabilitation is Effective in Frail COPD Patients with Chronic Respiratory Failure. Chronic Obstr Pulm Dis. 2022;9:15-25.

28. Ferraro FV, Gavin JP, Wainwright T, McConnell A. The effects of 8 weeks of inspiratory muscle training on the balance of healthy older adults: a randomized, double-blind, placebo-controlled study. Physiol Rep. 2019;7:e14076.

29. Mills DE, Johnson MA, Barnett YA, Smith WH, Sharpe GR. The effects of inspiratory muscle training in older adults. Med Sci Sports Exerc. 2015;47:691-697.

30. Zeren M, Cakir E, Gurses HN. Effects of inspiratory muscle training on postural stability, pulmonary function and functional capacity in children with cystic fibrosis: A randomised controlled trial. Respir Med. 2019;148:24-30.