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Effects of high intensity inspiratory muscle training to increase exercise capacity in bronchiectasis

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Abstract
Background and Objective: Bronchiectasis is a chronic lung disease caused by a cycle of infection and inflammation that results in permanent structural damage to the small airways and sometimes causes destruction of adjacent lung parenchyma. It consist of major symptoms as cough, excessive secretions, dyspnoea, exercise intolerance and fatigue. Respiratory muscle weakness is present in patients with bronchiectasis. Current evidences suggest that Inspiratory muscle weakness may lead dyspnoea, decreased exercise tolerance, hypoventilation and respiratory failure. So the purpose of the study is to find out the effect of high intensity inspiratory muscle training (H-IMT) to increase exercise capacity in bronchiectasis.
Methodology: 30 subjects who fulfill the inclusion criteria were recruited for the after obtaining an informed consent. Then the subjects were divided into two equal groups. Group A as experimental Group B as control. Group A subjects received H-IMT and conventional physiotherapy, Group B subjects received conventional physiotherapy. Each techniques was given 3 days per week for 5 weeks. Exercise capacity was measured using 6 minute's walk test (6MWT) and dyspnoea by modified Borg scale (MBS).
Results: The post test score of 6MWT and modified Borg scale of experimental and control group were analysed using two sample test and paired t test. The data analysis showed that statistically significance difference in the post test scores of 6MWT and modified Borg scale of experimental group over control group at 5% level.
Conclusion: The result of the study shows that High intensity inspiratory muscle training along with conventional physiotherapy have greater effect on increasing exercise capacity and reducing dyspnoea in patients with bronchiectasis.

Keywords: High intensity inspiratory muscle training, six minutes-walk test, modified borg scale, inspiratory muscle training

Introduction

Bronchiectasis is a chronic lung disease caused by a cycle of infection and inflammation that results in permanent structural damage to the small airways and sometimes causes destruction of adjacent lung parenchyma. It is a heterogeneous disease severity is variable and is impacted by the extent of lung involvement, the microbiologic complications and co-existing disorders [1]. Bronchiectasis may be caused by a variety of underlying conditions, including genetic abnormalities, immunologic conditions, autoimmune diseases, obstructing airway lesions or chronic aspiration. It can also be related to pre-existing chronic obstructive pulmonary disease or asthma [2].

The European lung white book says that bronchiectasis prevalence in Asian higher than compared to Africans and Europeans Americans [3]. In 2014 The European multicentre bronchiectasis audit and research collaboration (EMBARC) was establish an Indian bronchiectasis registry. It is the first result of the Indian national bronchiectasis registry describing the clinical characteristics, severity of disease and clinical phenotypes of bronchiectasis in India. They found that marked difference were observed between India, Europe and USA. Patients in India were younger (median age 56 years) more likely to be men (56.9%). The most frequent cause was tuberculosis (35.5%) followed by post infection (22.4%). Allergic bronchopulmonary aspergillosis was also highly prevalent as a cause of bronchiectasis (8.9%). Pseudomonas aeruginosa was the most common organism in sputum culture (13.7%) in India [4].

Bronchiectasis is a chronic lung disease not traditionally included in the definition of COPD. It consist of major symptoms as cough, excessive secretions, dyspnoea, exercise intolerance and fatigue [5, 6]. Patients with bronchiectasis have impaired mucociliary clearance and accumulation of secretions, pre dispose them to a vicious circle of bacterial infection and inflammation and the excessive inflammation causes damage or weakness of bronchial wall and impairment of effectiveness of cough [7].

In healthy subjects, exercise is limited by cardiac mechanisms, i.e.; the circulatory delivery of oxygen, not the lung. Oxygen consumption generally increases till it reaches a plateau and minute ventilation and cardiac output increase linearly with work rate. The arterial oxygen and carbon dioxide levels remain relatively stable during exercise. In contrast aerobic capacity and maximal ventilation achieved by patients with bronchiectasis were both significantly lower than age and sex. The inability to exercise maximally was mainly due to failure to increase minute ventilation which could not meet the increased oxygen demand during exercise. Maximal uptake correlated with resting FVC and negatively with RV/TLC ratio indicating that a reduced vital capacity and hyperinflation adversely affect exercise tolerance [8].

Respiratory muscle weakness is present in patients with bronchiectasis [7]. The underlying cause is not known, but the possible mechanisms are primary weakness and hyperinflation related functional weakness [9]. Inspiratory muscle weakness may lead to muscle load and capacity discordance and there by dyspnoea, decreased exercise tolerance, hypoventilation and respiratory failure. Decrease in expiratory muscle strength impairs the effectiveness of coughing and decreased the removal of airway secretions [10]. Presence tidal expiratory flow limitation in patients with bronchiectasis related to an increase dyspnoea and a reduced exercise tolerance was also postulated to be a result of dynamic hyperinflation and consequent inspiratory muscle loading [11].

Threshold devices are used for inspiratory muscle training. It is a light weight clear plastic cylinder that contains a spring loaded valve at one end and a mouth piece on the other. Subjects can generate flow through the device to achieve a predetermined pressure independent of inspiratory flow rate and obtain constant specific resistance. In addition threshold loading enhances the velocity of inspiratory contraction which appears favorable by shortening inspiratory time thus allowing more time for exhalation and lung emptying [12, 13].

Six minute walk test is a practical simple test requires a 100 feet hallway but no exercise equipment or advanced training for technicians. The test measure the distance that a patient can quickly walk on a flat, hard surface in a period of six minutes. It evaluates the global and integrated responses of all the systems involved during exercise. Strongest indication for six minute walk test is for measuring the response to medical interventions in patients with moderated to severe heart or lung disease. It can used as a one-time measure of functional status of a patients as well as a predictor of morbidity and mortality [14]. The modified Borg scale is a reliable and valid assessment tool for dyspnoea [15].

Some studies are explore the effect of high intensity inspiratory muscle training (H-IMT) and low intensity inspiratory muscle training (L-IMT) on exercise capacity in patients with clinically stable non-cystic fibrosis bronchiectasis. Studies done to ensure the benefits of H-IMT with other components of pulmonary rehabilitation is limited [10]. Based on this information present study trying to find out the effect of H-IMT to increase exercise capacity in patients with bronchiectasis.

Methodology

Sample design: Non-probability convenient sampling.
Sample size: 30 (15 in each group).
Study design: Experimental study design with pre-test post-test.

Control group

Study setting: K.V.M Hospital Cherthala.
Study duration: 6 month.

Outcome measures

- 6 minute walk test.
- Modified Borg scale.

Inclusion criteria

- BSI score low (0-4) to moderate (5-8).
- Non cystic fibrosis bronchiectasis.
- Age 18-65.
- Both male and female.
- Ability to walk.
- Willingness to cooperate study.
- No coexisting disease affecting ability to undertake exercise.

Exclusion criteria

- Patients with neurological complication.
- Advanced orthopaedic condition.
- Heart failure.
- Acute exacerbation in last 3 week.
- Lung carcinoma.

Procedure

Thirty subjects who fulfill the inclusion criteria will be selected and divide into two groups, Group A and Group B with fifteen in each group.

On the first day pre-test will be conducted on Group A (experimental) and Group B (control) by 6 minute's walk test and modified Borg scale.

After a brief demonstration Group A subjects will given high intensity inspiratory muscle training (H-IMT) and conventional physiotherapy.

After a brief demonstration Group B subjects will given conventional physiotherapy shall includes local chest expansion breathing exercise and free weight peripheral muscle strengthening exercise.

Post-test will be conducted on Group A and Group B by 6 minute's walk test and modified Borg scale after 5 weeks.

H-IMT procedure

- H-IMT given with threshold inspiratory muscle training devices.
- Muscle load calculated according to the maximum inspiratory pressure (MIP) value.
- MIP value measured using portable capsule sensing pressure gauge.
- In the first session H-IMT given with one minutes warm up on an inspiratory load about 15% of maximum inspiratory pressure.
- In the second session inspiratory load about 30% of maximum inspiratory pressure.
- In the third session inspiratory load is targeted at least 70% of maximum inspiratory pressure.

- During exercise training rest ratio is 2:1. Two minutes loaded breathing with one minute rest.
- Each session lasted 21 minutes that means 3 minutes cycle (2:1) repeated seven times.
- Total period of 14 minutes loaded breathing and 7 minutes recovery.
- Programme conducted 3 days per week for 5 weeks.

Conventional therapy procedure

Local chest expansion exercise

a) Apical
b) Bilateral basal

Free weight upper and lower limb peripheral muscle strengthening exercise for following muscles;

a) Deltoid
b) Bicep brachii
c) Quadriceps
d) Hamstrings

10 repetitions 3 days a week for 5 weeks.

Result

Table 1: Comparison of the Pre 6MWT Score of the two groups

Pre6 MWT	Number	Mean	S.D	Value of t statistic	d.f	Significance
Group A	15	581.56	95.43	1.84	28	0.077
Group B	15	520.67	85.76			Not Significant

Table 2: Comparison of the pre MB scale score of the two groups

Pre MB Scale	Number	Mean	S.D	Value of t statistic	d.f	Significance
Group A	15	2.93	0.88	1.29	28	0.208
Group B	15	3.33	0.82			Not Significant

Table 3: Comparison of the Post 6MWT Score of the two groups

Post6MWT	Number	Mean	S.D	Value of t statistic	d.f	Significance
Group A	15	595.5	98.80	2.074	28	0.047
Group B	15	526.79	81.91			Not Significant

Table 4: Comparison of the post MB scale score of the two groups

Post MB Scale	Number	Mean	S.D	Value of t statistic	d.f	Significance
Group A	15	1.60	0.80	2.158	28	0.04
Group B	15	2.27	0.88			Not Significant

Effectiveness of experimental group (Group A)

Table 5: Comparison of Pre 6MWT and Post 6MWTScores

Variable		Value of t	d.f	Correlation	Significance
6MWT	Pre6MWT	9.47	14	0.99	0.000
	Post6MWT				(Significant)

Table 6: Comparison of Pre MB Scale and Post MB Scale Scores

Variable		Value of t	d.f	Correlation	Significance
MB Scale	Pre MB Scale	11.48	14	0.862	0.000
	Post MB Scale				(Significant)

Effectiveness of controlled group (Group B)

Table 7: Comparison of Pre 6MWT and Post 6MWTScores

Variable		Value of t	d.f	Correlation	Significance
6MWT	Pre 6MWT	3.11	14	0.97	0.008
	Post 6MWT				(Significant)

Table 8: Comparison of Pre MB Scale and Post MB Scale Scores

Variable		Value of t	d.f	Correlation	Significance
MB Scale	Pre MB Scale	12.47	14	0.913	0.000
	Post MB Scale				(Significant)

Descriptive statistics

Table 9: Frequency distribution of age of two groups

Age		Frequency	Percentage
Group A	40-50	4	26.665
	50-60	8	53.335
	60-70	3	20
	Total	15	100
Group B	40-50	6	40
	50-60	7	46.665
	60-70	2	13.335
	Total	15	100

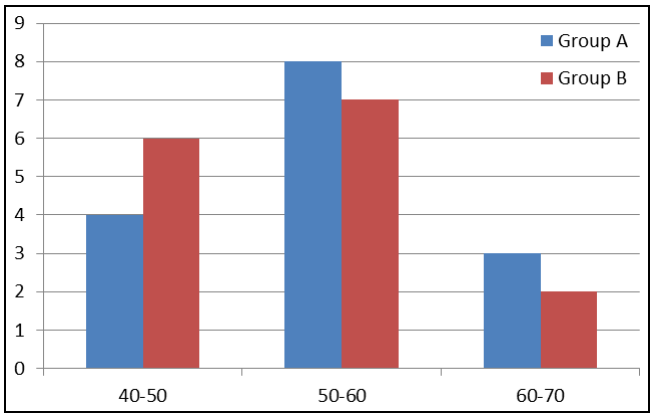
Table 10: Frequency distribution of sex of two groups

Group			Frequency	Percentage
Group A	Valid	Male	8	53.335
		Female	7	46.665
		Total	15	100.0
Group B	Valid	Male	6	40
		Female	9	60
		Total	15	100.0

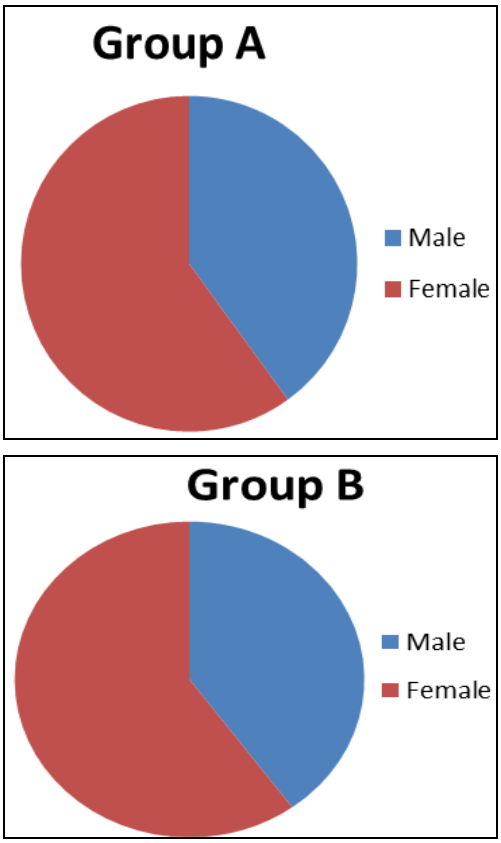
Table 11: Mean and Standard deviation of pre and post 6 MWT and MB SCALE in both groups

		Mean	N	Std. Deviation
Pair 1	Pre 6MWT A	581.560	15	95.4303
	Post 6MWT A	595.500	15	98.8052
Pair 2	Pre MBSCALE A	2.933	15	.8837
	Post MBSCALE A	1.600	15	.8062
Pair 3	Pre 6MWT B	520.673	15	85.7641
	Post 6MWT B	526.787	15	81.9109
Pair 4	Pre MBSCALE B	3.333	15	.8165
	Post MBSCALE B	2.200	15	.8619

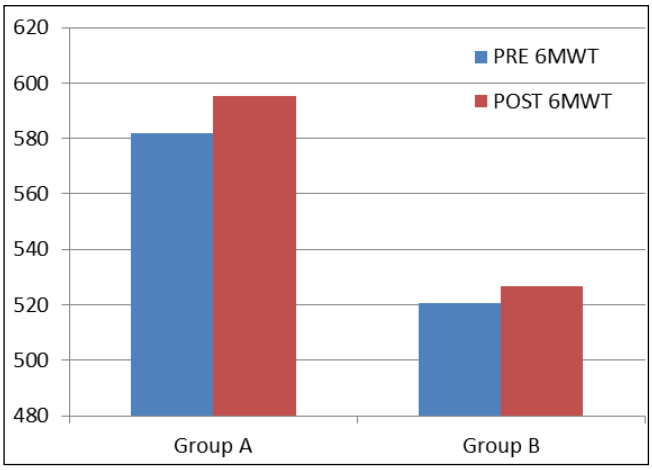
Graphs



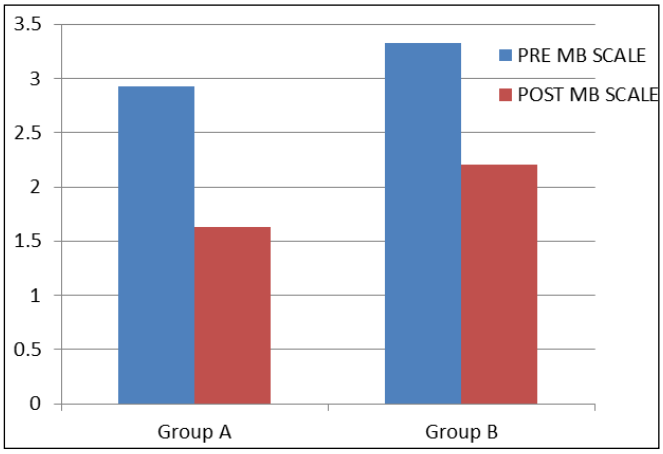
Graph 1: Comparison of Age of Group A and Group B



Graph 2: Comparison of Sex of Group A and Group B



Graph 3: Comparison of mean Pre 6MWT and Post 6MWT of Group A and Group B



Graph 4: Comparison of mean Pre MB SCALE SCORE and Post MB SCALE SCORE of Group A and Group B

Discussion

This study was conducted to investigate the effects of high intensity inspiratory muscle training (H-IMT) to increase exercise capacity in bronchiectasis. 30 subjects who fulfill in the inclusion criteria were recruited for the study. Then they allocated into two groups using non-probability convenient sampling design Group A (experimental group) Group B (control group), 15 in each group.

A brief explanation about the procedure of the intervention and possible risk factors are given to the subjects. A written consent form was obtained from each of the subjects. Group A subjects received H-IMT and conventional physiotherapy. H-IMT given with threshold inspiratory muscle training device. Group B subject's undergone conventional physiotherapy include local chest expansion breathing exercise and free weight peripheral muscle strengthening exercise. Programme conducted 3 days per week for 5 weeks. All subjects well tolerated the interventions given and no one was dropped out of the study. Exercise capacity and dyspnoea were measured using reliable and valid tools. Exercise capacity was measured using 6 minute's walk test (6MWT) and dyspnoea were measured using modified Borg scale. All outcome measures were collected before on the first day and after on the last day of treatment session.

Respiratory muscle weakness present in patients with bronchiectasis. Inspiratory muscle weakness may lead to dyspnoea and decreased exercise tolerance. The flow limitation and reduced exercise capacity are both associated with more severe dyspnoea. In healthy subjects arterial oxygen and carbondioxide levels remains relatively stable during exercise. In contrast aerobic capacity and maximal ventilation achieved by patients with bronchiectasis are lower. So the exercise limitation maximally was mainly due to failure to increase minute ventilation which could not meet the increased oxygen demand during exercise. This can also contribute the occurrence of dyspnoea by pulmonary ventilation not matching the drive to breathe. The above mentioned statement suggested the need for inspiratory muscle training in bronchiectasis.

In the present study both groups paired t test was used to compare the pre and post-test values. The post-test scores of both groups were analyzed using two sample test. The result shows that there is significant improvement in the post-test experimental group mean value of 6 MWT from 581.560 – 595.500, shows high significance with the t value of 2.074 and p value of 0.047. While the modified Borg scale value of post-test experimental group with significant reduction of mean value from 2.933-1.600 and it shows high significance with t value of 2.158 and p value of 0.04. The study result shows that significant difference in post-test value of experimental and control group with 5% level of significance. So the study rejects the null hypothesis and hence concluded as high intensity inspiratory muscle training along with conventional physiotherapy shows drastic improvement of exercise capacity in bronchiectasis patients.

The result of the study is in accord with Ozge Ozalp *et al.* (2018) observed that H-IMT increase exercise capacity in patients with non-cystic fibrosis bronchiectasis. It has also positive effects on respiratory muscle strength and endurance and social aspects of quality of life. It is also shows that an interval-based H-IMT protocol is a reliable method for adequate loading in bronchiectasis patients. It revealed that respiratory muscles are capable of H-IMT and it could used in home based. Here the authors explore the effects of H-IMT and L-IMT on exercise capacity in patients with clinically

stable non-cystic fibrosis bronchiectasis. But they not compare H-IMT with the other components of pulmonary rehabilitation.

According to the study conducted by the Andrew LR *et al*, (2007) [11] concludes that pulmonary rehabilitation is beneficial for patients with COPD and other chronic lung diseases. Rational for applying inspiratory muscle training is that it can increase the strength and or endurance of the respiratory muscles. Major training method of inspiratory muscle training is threshold loading, resistive breathing and targeted flow. In which threshold loading which has the advantage of being independent of inspiratory flow rate but requires a buildup of negative pressure before flow begins. In addition threshold loading enhances the velocity of inspiratory muscle contraction, which appears favorable by shortening inspiratory time thus allowing more time for exhalation and lung emptying.

Rochester DF *et al*. (1988) [26] observed an important information about the rational of applying inspiratory muscle training to bronchiectasis patients is that inspiratory muscle training can increase the strength and or endurance of respiratory muscle as the force generated by inspiratory threshold loading training can increase the cross-sectional surface areas of inspiratory muscles by hypertrophy which will then have an effect on exercise capacity, quality of life and perception of dyspnoea.

According to the study conducted by Lisboa C *et al*. (1994) [23] observed that patients with chronic airflow limitation, inspiratory muscle training with high enough load improves inspiratory muscle strength and power output, reduce dyspnoea and makes the pattern of breathing adequate during loaded breathing. These changes may allow patients to cope better with increased loads imposed by physical effort and exacerbation of symptoms. Also state that inspiratory muscle training using threshold devices can increases the velocity of contraction of inspiratory muscles and it's a simple procedure since the load is practically independent of the breathing pattern and does not need constant supervision.

The above mentioned studies suggested that inspiratory muscle training using threshold inspiratory muscle training devices can improve the respiratory muscle function, exercise capacity and dyspnoea.

Conclusion

The result of the study shows that High intensity inspiratory muscle training along with conventional physiotherapy have greater effect on increasing exercise capacity and reducing dyspnoea in patients with bronchiectasis. So this method can be recommended as simple cost effective method for the management of bronchiectasis.

References

1. Anne EOD. Medical management of bronchiectasis. J thorac dis. 2018 Oct;10(28):3428-3435.
2. Pamela JM, Edward TN, Gregory T, Mary ES. Non-cystic fibrosis bronchiectasis. American Journal of Respiratory and Critical Care Medicine. 2013;188(6):647-656.
3. Dhar R, Singh S, Talwar D, Mohan M, Tripathi SK, Swaranakar R, *et al*. Bronchiectasis in India: results from the European multicentre bronchiectasis audit and research collaboration and respiratory research network of Indian registry. 2019 Sept;7(9):1269-1279.
4. Newall C, Stockley RA, Hill SL. Exercise training and inspiratory muscle training in patients with bronchiectasis. Thorax. 2005;60:943-948.
5. Paul TK, Stephen RH, Nicholas JF, Elmer V, Peter WH. Characterisation of the onset and presenting clinical features of adult bronchiectasis. Respiratory medicine. 2006;100:2183-2189.
6. Mei YL, Yi HW, Yu CT, Kuo TH, Pie WC, Yung CC, *et al*. Inspiratory muscle training in bronchiectasis patients: A prospective randomized controlled study. Clinical rehabilitation. 2011;25(6):524-536.
7. Soumya S, Kuppurao KV, Somu N, Vijayan VK. Reduced exercise capacity in non-cystic fibrosis bronchiectasis. Indian journal of pediatrics. 2003 Jul;70(7):553-556.
8. Simone DOS, Nicholas FT, Jennifer P. Peripheral muscle strength training in copd. A systemic review. Chest 2004;126:903-914.
9. Ozge O, Deniz II, Aslihan C, Ebru CK, Melda S, Sema S, *et al*. High-intensity inspiratory muscle training in bronchiectasis: A randomized controlled trial. Respirology. 2019;24(3):246-253.
10. Koulouris NG, Retsou S, Kosmas E, Dimakou K, Malagari K, Mantzikopoulos G, *et al*. Tidal expiatory flow limitation, dyspnoea and exercise capacity in patients with bilateral bronchiectasis. European respiratory journal. 2003;21:743-748.
11. Andrew LR, Gerenes B, Brian WC, Richard C, Charle FE, Donald AM. Pulmonary rehabilitation: joint ACCP/AACVPR evidence based clinical practice guidelines. Chest journal, c2007 May, 131(5).
12. Margaret AN. Inspiratory muscle training protocol using a pressure threshold device: effect on dyspnoea in chronic obstructive pulmonary disease. Arch Phys med Rehabi. 1999;80(1):100-102.
13. Crapo RO, Richard C, Coates AL, Enright PL, Macintyre NR, Mckay RT. ATS statement: guidelines for the six minute's walk test. American journal of respiratory and critical care medicine. 2002;166(1):111-117.
14. Karla RK, Sunita CB, Rober MS. Usefulness of the modified 0-10 Borg scale in assessing the degree of dyspnoea in patients with COPD and asthma. Journal of emergency nursing. 2000;26(3):216-222.
15. Alba RS, Mauricio OL, Rosa G, Easther B, Nuria H, Susana M. Inspiratory muscle training in patients with COPD: structural adaptation and physiologic outcomes. American journal of respiratory and critical care medicine. 2002;166:1491-1497.
16. Chris B, Helge H. Rehabilitation in patients with chronic respiratory disease other than chronic obstructive pulmonary disease: exercise and physical activity interventions in cystic fibrosis and non-cystic fibrosis bronchiectasis. Respiration. 2015;89:181-189.
17. Grosselink R, Devos J, Vandenheuvel SP, Segers J, Decramer M, Kwakkel G. Impact of inspiratory muscle training in patients with COPD: what is the evidence? European respiratory journal. 2011;37(2):416-425.
18. Gavin S, David H, Daniel G, Sue J, Nola C, Peter E. Feasibility of high-intensity, interval based respiratory muscle training in COPD. Chest. 2003;123(1):142-150.
19. Henrik H, Nina Be, Anne F, Nina G, Theresa B. Intra-and inter-rater reproducibility of the 6-minute walk test and the 30-second sit-to-stand test in patients with severe and very severe COPD. International journal of COPD. 2018;13:3447-3457.
20. Hill K, Jenkins SC, Philippe DL, Cecins N, Shepherd KL, Green DJ, *et al*. High-intensity inspiratory muscle

training in COPD. European respiratory journal. 2006;27:1119-1128.
21. Lee AL, Button BM, Ellis S, Stirling R, Wison JW, Holland AE, *et al*. Clinical determinants of the 6 minute walk test in bronchiectasis. Respir Med. 2009;103(5):780-785.
22. Liang HH, Yu-Juc. The 6 minute walk test to assess exercise capacity of patients with COPD. European respiratory journal; c2016 Nov, 48.
23. Lisboa C, Munoz V, Beroiza T, Leiva A, Cruz E. Inspiratory muscle training in chronic airflow limitation: comparison of two different training loads with a threshold device. European respiratory journal. 1994;7(7):1266-1274.
24. Lotters F, Vantol B, Kwakkel G, Gosselink R. Effects of controlled inspiratory muscle training in patients with COPD: a meta-analysis. European respiratory journal. 2002;20(3):570-576.
25. Pehlivan E, Niksarlioglu EY, Balci A, Kilic L. The effect of pulmonary rehabilitation on the physical activity level and general clinical status of patients with bronchiectasis. Turk Thorac J. 2019;20(1):30-35.
26. Rochester DF. Tests of respiratory muscle function. Chest medicine. 1988 Jun;9(2):241-261.
27. Nikita SJ, Sonam SD, Seemi SR, Savita A Rairikar, Ashok M Shyam, Parag K Sancheti. Intra-and inter-rater reliability of maximum inspiratory pressure measured using a portable capsule-sensing pressure gauge device in healthy adults. Can j respire ther. 2015;51(2):39-42.
28. Yueh CC, Kun CC, Li HL, Yi LW, Te JL, Chun HW. Validating the 6-minute walk test as an indicator of recovery in patients undergoing cardiac surgery A prospective cohort study. Medicine. 2018;97:42.
29. Paulo C, Miguel G, Paulo P, Jose M, Luis V. Non-cystic fibrosis bronchiectasis. Interactive cardiovascular and thoracic surgery. 2011;13(6):619-625.
30. Akansha D, Shashwat P. Effects of threshold inspiratory muscle training versus conventional physiotherapy on the weaning period of mechanically ventilated patients: a comparative study. International journal of physiotherapy and research. 2014;2(2):424-28.
31. Caine MP, Mcconnell AK. Development and evaluation of a pressure threshold inspiratory muscle trainer for use in the context of sports performance. Sports engineering. 2000;3:149-159.
32. Rik G, Rober CW, Marc D. Reliability of a commercially available threshold loading device in healthy subjects and in patients with chronic obstructive pulmonary disease. Thorax. 1996;51:601-65.
33. Ong HK, Lee AL, Hill CJ, Holland AE, Denehy L. Effects of pulmonary rehabilitation in bronchiectasis: a retrospective study. Chronic respiratory disease. 2011;8(1):21-30.
34. Andrew H, Donald AM, Andrew D. Targeted inspiratory muscle training improves respiratory muscle function and reduce dyspnoea in patients with chronic obstructive pulmonary disease. Annals of internal medicine. 1989;111:117-124.
35. Larson JL, Kim MJ, Sharp JT, Larson DA. Inspiratory muscle training with a pressure threshold breathing device in patients with COPD. American Review of respiratory disease. 1988;138(3):689-696.
36. Rasmi M, Alison KM, Marinella B, Paltiel W. Inspiratory muscle training in pulmonary rehabilitation program in COPD patients. Respiratory medicine. 2007;101(7):1500-1505.
37. Lee AL, Catherine JH, Nolac Susan J, Christine FM, Angela TB, *et al*. Minimal important difference in field walking tests in non-cystic fibrosis bronchiectasis following exercise training. Respiratory medicine. 2014 Sept;108(9):1303-1309.
38. James DC, Pieter G, Stefano A, Melissa JM, Sara L, John D. The bronchiectasis severity index. An international derivation and validation study. American journal of respiratory and critical care medicine. 2014;189(5):576-585.
39. Walter C, Robert CW, Tim WK, Ton VK, HN CGK. The long term effects of pulmonary rehabilitation in patients with asthma and chronic obstructive pulmonary disease: a research synthesis. Archieves of physical medicine and rehabilitation. 1999;80(1):103-111.
40. Foglio K, Binachi L, Ambrosino N. Is it really useful to repeat outpatient pulmonary rehabilitation programs in patients with chronic airway obstruction? a 2 year controlled study. Chest. 2001;119(6):1696-1704.
41. Lisboa C, Vellafranca C, Levia A, Cruze Pertuze J, Borzone G. Inspiratory muscle training in chronic airflow limitation. European respiratory journal. 1997;10(3):537-542.
42. Weiner P, Magadle R, Beckerman M, Weiner M, Berar YN. Maintenance of inspiratory muscle training in COPD Patients: one year follow up. European respiratory journal. 2004;23(1):61-65.
43. Martinez GMA, Soler CJJ, Perpina TM, Roman SP, Sorlano J. Fctors associated with lung function decline in adult patients with stable non-cystic fibrosis bronchiectasis. Chest. 2007;132(5):1565-1572.
44. Smith K, Cook D, Guyatt GH, Madhavan J, Oxman AD. Respiratory muscle training in chronic airflow limitation: a meta-analysis. American review of respiratory disease. 1992;145(3):533-539.
45. Hernandez MT, Rubio TM, Ruiz FO, Riera HS, Gil RS, Gomez JC. Results of a home-based training program for patients with COPD. Chest. 2000;118:106-114.