A COMPARATIVE STUDY BETWEEN EFFECTIVENESS OF INTERVAL TRAINING VERSUS CIRCUIT TRAINING OF AEROBIC EXERCISE PROGRAM FOR IMPROVING ENDURANCE CAPACITY AND QUALITY OF LIFE FOR PATIENTS WITH NON-SPECIFIC PULMONARY DISORDER

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ABSTRACT

BACKGROUND: Non-Specific Pulmonary Disorder (Non-Specific Lung Disease) is a chronic non-specific lung disease (CNSLD), a chronic disease with considerable prevalence and mortality rates, is not only a medical problem, it also has significant psychological and social consequences for the patients concerned. Prevalence showed wide variability across GBD super-regions, with the highest prevalence among both males and females in high-income regions, and the lowest in south Asia. Chronic obstructive pulmonary disease (COPD) is associated with a significant socio-economic burden. A range of symptoms and their impact on patients define the daily burden of COPD borne by an individual. The most common symptoms of COPD are dyspnea, cough, and sputum production, and less common but troublesome symptoms are wheezing, chest tightness symptom in patients with mild COPD .The American Thoracic Society (ATS) and European Respiratory Society (ERS)Nici L, Donner C, et al. (2006) states that all patients with chronic respiratory disease who present respiratory symptoms associated with diminished functional capacity or reduced quality of life, despite an optimized pharmacologic treatment, can benefit from pulmonary rehabilitation. **AIMS AND OBJECTIVES:** To compare the effectiveness between interval training versus circuit training of Aerobic exercise programs for improving endurance capacity and quality of life for patients with nonspecific pulmonary disorder. To compare theeffectiveness between interval training versus circuit training of Aerobic exercise programs for improving endurance capacity and quality of life for patients with non-specific Pulmonary disorder .**METHODOLOGY:** Acomparative study between effectiveness of interval training versus circuit training of aerobic exercise program for improving endurance capacity and quality of life for patients with non-specific pulmonary disorder– **Group A:** Interval training of Aerobic exercise program. **Group B:** Circuit training of Aerobic exercise program. **RESULT:** Results showed that there was a significant difference in the 6 min walk test and Mac new Questionnaire during the pre- exercise session and the 6 min walk test and Mac new Questionnaire were significantly higher during the post exercise session of group A and group B.**CONCLUSION:** This study concluded that interval aerobic training shows better and stable results as compared to circuit training and if we follow the interval training there will be significant results if continued for a longer period of tim

INTRODUCTION

Pulmonary disorder is a life-threatening disorder with high morbidity and mortality i.e. prevalent worldwide and is high with 3 years or more. Almost 14% of patients experience more than 3 exacerbations per year and 2 moderate/ severe exacerbations per year. Prevalence rates varying from about 2 to 22 per cent in men and from 1.2 to 19 per cent in women.1

Chronic obstructive pulmonary disease (COPD) and acute exacerbations of COPD (AECOPD) have major impacts both on the population and on health care costs. COPD morbidity and mortality, however, have increased over the past 40 years and this trend will continue. COPD, with its social, health care utilization, and economic consequences is currently the fourth leading cause of death in the United States and it is projected to be the third leading cause of death by 2020, with only cardiovascular diseases and cancer projected to be ahead.1,

AECOPD requiring inpatient interventions are particularly important in that they incur a large cost, and each one has the potential for a fatal outcome2. A better understanding of long-term outcomes of COPD patients following hospitalization, may help patients and their physicians to better manage the disease and in making healthcare decisions. The factors that determine acute exacerbations and hospitalization in COPD patients are poorly understood3.

However, these studies have produced inconsistent results with respect to the influence of FEV1, BMI and smoking4 . Most investigators have studied a limited number of specific risk factors in a single study, some of which did not fully take into account potential confounding among variables. Other potential risk or protective factors such as psychological well-being, patient adherence to care and social support have not been reported or rarely so5 .

Idiopathic pulmonary fibrosis (IPF) is the most common type out of the idiopathic interstitial pneumonias (IIPs) and also associated with the greatest mortality; it is characterized as a chronic disease with progressive parenchymal fibrosis of unknown etiology1. IPF has a high mortality rate with a median survival ranging from 2 to 5 years after diagnosis3. With disease progression, increased dyspnea and skeletal muscle dysfunction contribute to deterioration of exercise capacity, impairment in activities of daily living (ADL) and health-related quality of life (HRQL)4.

Non-specific pulmonary disorder (NSPD) is observed in asthma, COPD/emphysema, bronchiectasis, sarcoidosis, pulmonary hypertension, interstitial pneumonia and after bilateral lung transplantation and remains stable in the majority of patients. NSPD is the prevalence of preclinical or undiagnosed cases was identified by screening lung specimens from 510 autopsy cases. A total of 2,936 referrals were screened; 8.8% were prevalent cases and 6.9% were incident cases. Overall, the prevalence of ILDs was 20% higher in males (80.9 per 100,000) than in females (67.2 per 100,000)21

Exercise tolerance can be assessed by a cardiopulmonary exercise test using either cycle ergometry or a treadmill, including peak oxygen uptake (V′O2), peak heart rate and peak work performance. A less complex approach is to use a self-paced, timed walking test (eg:6-min walk test (6MWT))29,41 Endurance training is probably the most common exercise modality in patients with COPD. The main objectives to improve aerobic exercise capacity as aerobic activities.53 Exercise training (ET) is a major component in these programs, since significant improvements have been reported in exercise and functional capacities, level of dyspnea and QOL among COPD patients30,31

Deep-breathing exercises and stretching of the thoracic muscles that were used in our program resulted in a more efficient breathing pattern, improved strength of respiratory muscles, within the lung tissue, and decreased dyspnea perception following the ET program.61,63 Exercise tolerance and QOL are severely impaired in IPF, thus rehabilitative ET may be valuable in order to maintain function in daily living activity. Exercise training significantly improves exercise capacity and reduces dyspnea and fatigue symptoms in patients with ILD of varying etiology.62

The Mac New Heart Disease HRQL questionnaire [Mac New] is a self-administered modification of the original instrument. The Mac New can be recommended as a specific instrument for assessing and evaluating HRQL. The Mac New HRQL questionnaire have the potential to support quality clinical care, to serve as a foundation for shared medical decision making with patients, to evaluate treatment effectiveness by monitoring the impact of interventions, and to identify patients for prognostic discussions16,17,18 Therefore, main purpose of the study to compare the effectiveness between interval training and circuit training of aerobic exercise program for improving endurance capacity and quality of life for patients with non-specific pulmonary disorder. Streptococcus pneumoniae is an encapsulated Gram-positive pathogen with the potential to cause invasive disease. It is a major cause of community-acquired pneumonia and bacterial meningitis.

IPF patients derive gains in exercise capacity, dyspnea reduction, and ADL similar to COPD patients with PR9. Most exercise programs for IPF patients have included aerobic exercise such as walking and cycling, while others have included a combination of resistance training, inspiratory muscle training (IMT) and breathing exercises (e.g., diaphragmatic breathing 10. To date, beneficial effects from exercise interventions in individuals with IPF have been in various exercise programs, and thus the effectiveness of these training programs requires further verification11.

Some reviews have provided support for the effectiveness of PR for patients with interstitial lung disease (ILD) 8 ,12. However, two systematic reviews with meta-analyses only included 5 RCTs; both demonstrated the effectiveness of exercise-centered PR on exercise tolerance [improved 6-minute walk distance (6MWD)] and improved HRQL in patients with IPF13,14 but specific breathing exercises and IMT were not evaluated. Although several reports describe the effects of breathing exercise and IMT in COPD patients14-16, parallel studies examining these interventions in IPF patients are scarce17. Certainly, such interventions warrant synthesis in a systematic review because of their potential benefit to improve symptoms and daily function.

Aerobic capacity, which is expressed as peak oxygen consumption (VO2peak), is well-known to be an independent predictor of all-cause mortality and cardiovascular prognosis. This is true even for people with various coronary risk factors and cardiovascular diseases. Although exercise training is the best method to improve VO2peak, the guidelines of most academic societies recommend 150 or 75 min of moderate- or vigorous-

intensity physical activities, respectively, every week to gain health benefits. For general health and primary and secondary cardiovascular prevention, high-intensity interval training (HIIT) has been recognized as an efficient exercise protocol with short exercise sessions. Given the availability of the numerous HIIT protocols, which can be classified into aerobic HIIT and anaerobic HIIT [usually called sprint interval training (SIT)], professionals in health-related fields, including primary physicians and cardiologists, may find it confusing when trying to select an appropriate protocol for their patients. This review describes the classifications of aerobic HIIT and SIT, and their differences in terms of effects, target subjects, adaptability, working mechanisms, and safety. Understanding the HIIT protocols and adopting the correct type for each subject would lead to better improvements in VO2peak with higher adherence and less risk.

Only dynamic exercise will be considered here, as static exercise is associated with an increase in systemic vascular resistance, a limited increase in cardiac output or VO2, and eventual intrathoracic pressure changes131, making it a more complex stress that is less relevant for the study of pulmonary vascular mechanics and right ventricular function. High levels of dynamic exercise may be generated with variable levels of resistive effort, but how this affects the pulmonary circulation is not exactly known. Therefore, in this chapter, exercise will be considered as a cause of increased cardiac output affecting pulmonary vascular pressures, and pulmonary hemodynamics at exercise will be explained using reference models of flow-related changes in pulmonary vascular mechanics.

According to the latest Global Burden of Diseases Report, 2017, India has one of the highest-burden of chronic respiratory diseases. India contributes to 15.69% of Global Chronic Respiratory Diseases but 30.28% of all global deaths due to Chronic Respiratory Disease occur in India. India has the highest number of COPD (Chronic Obstructive Pulmonary Disease) cases in the world, a whopping 55.23 Million. The second-largest number of global deaths due to COPD, almost 0.85 million, occur in India. India also leads the world in deaths due to Asthma with 43% of global asthma deaths occurring in our country. Yet awareness in the healthcare community and the public remains low about these two chronic lung conditions which cause a huge health and economic burden on our health and health care system.

METHODOLOGY

STUDY DESIGN: It is a comparative study in which 30 Patients diagnosed with non-specific Pulmonary disorder randomly selected according to inclusion and exclusion criteria and divided into two groups

Group A: Interval training of Aerobic exercise program.
Group B: Circuit training of Aerobic exercise program.

All patients participating in the study after voluntarily signing the consent form. Study is conducted in Pacific Medical College and Hospital Udaipur, (Rajasthan) for 12 weeks (30 minute per session per day, 5 days/week.)

INCLUSION CRITERIA:

1. Age 30-50 years
2. Both male & female patients.
3. Patients diagnosed with non-specific pulmonary disorder

EXCLUSION CRITERIA:

1. Age below 30 and above 50
2. Patients with any neurological problem.
3. Patients with any kind of psychological disorder.
4. Patients suffering from recent injury in lower extremities.
5. Patient suffering from any renal problem.
6. Patient suffering from any skin infection

OUTCOME MEASURES:

1. 6 min walk test
2. Mac New Questionnaire

PROCEDURE

After collecting written consent form from 30 patients diagnosed with non- specific pulmonary disorder were randomly selected based on inclusion and exclusion criteria and equally divided into 2 groups Group A & Group B (15 subjects each group).
Subjects of Group A (15 subjects) received interval training of aerobic exercise program and group B consist of (15 subjects) received circuit training of aerobic exercise program.
All the subjects were informed that they are under the experiment and prior constant of subject was sought before assessment. The study period was of 30 minutes session per day, 5days/week, total of 12weeks. Data was collected at the beginning of the experiment (1st day) and at the end of experiment (12th week).

→ Warm-up (10 mints.)
Warm up exercise are given in both the groups before starting of the intervention.

1. Deep Breathing exercise,
2. Light jog
3. Side stretches
4. Marching
5. Heel raise
6. Wrist pump
7. Ankle toe movements

GROUP A

INTERVAL TRAINING OF AEROBIC EXERCISE PROGRAM

Workout (20 mints) Each exercise given below is done for 2 mints each and 30 sec rest.

1. Abdominal crunches
2. Sumo squat
3. Wall push up
4. Mountain climbers
5. Ankle tap
6. Diamond run
7. Jumping jacks
8. Fast feet

FIGURE 1 – ABDOMINAL CRUNCHES

FIGURE 2 – SUMO SQUAT

FIGURE 3-WALLPUSHUP

GROUP B:

CIRCUIT TRANING FOR AEROBIC EXERCISE PROGRAM

Each exercise have been given for 20 minutes without rest and for 2.5 seconds duration

1. Superman pose
2. Lunges
3. Planks
4. Burpees
5. Jumping jacks
6. Mountain climbers
7. Squats
8. Wallsit

FIGURE 4- SUPERMAN POSE

FIGURE 5- LUNGES

FIGURE6-PLANK

Both training exercise have 3 rounds each with active cycle of breathing techniques (ACBT). After completing each round ACBT is performed.

ACBT

Definition:

“ACBT is a active cycle of breathing technique that consists of repeated cycle of three ventilatory

phase:

- Breathing Control
- Thoracic expansion exercise &
- Forced expiratory technique (FET)"

BREATHING CONTROL

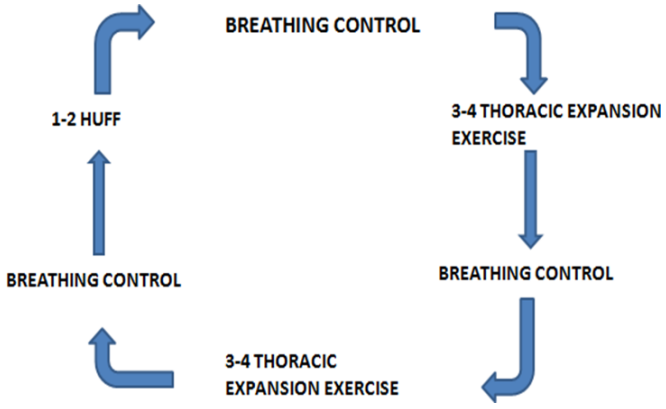
- Upper chest and shoulders should remain relaxed while the lower chest and abdomen should be active.
- Ask the patient breathe in a relaxed manner with tidal volume breathing.
- This phase may last as long as patient requires to relax and prepare himself for the next phase.
- Breathing control may require in between the cycle in order to prevent bronchospasm.

THORACIC EXPANSION EXERCISE

- After breathing control patient is instructed to take in a deep breathe to the inspiratory reserve volume, expiration is passive and relaxed.
- Chest percussion, vibration, shaking may be performed as the patient exhales.
- For surgical patients or those with lung collapse a breath hold or a sniff at the end of inspiration encourages collateral ventilation to redistribute air into collapsed segment and assist in re-expansion of lung.

FORCED EXPIRATORY TECHNIQUE

- It consist of huffing with breathing control.
- To mobilize secretion from peripheral airways, a huff after a medium sized inspiration will be effective. This huff will be longer and quieter.
- To clear secretion that have reach the larger, proximal airways, a huff after a deep inspiration will be effective. This huff will be shorter and louder.



ACBT Diagram

DATA ANALYSIS

Mean, Standard deviation, paired ‘t’ test and unpaired ‘t’ test would be performed for analysis of pre and post data evaluation within and between groups.

RESULT AND DATA INTERPRETATION

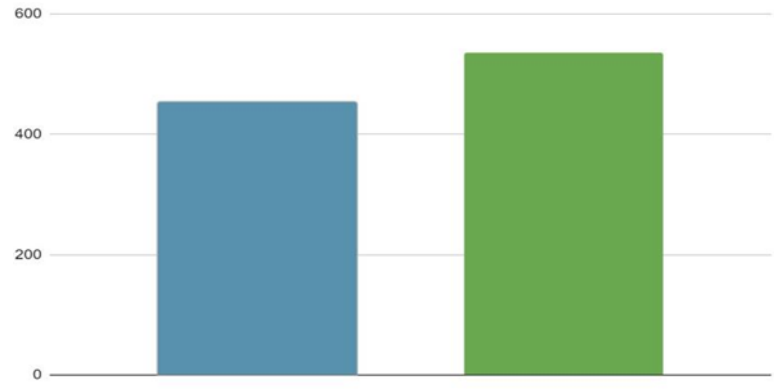
Analyses of pre and post test scores within and between the groups are tabulated with intervention of the result of the study.

TABLE 1

A. WITHIN GROUPS: GROUP A

6MWT	**N**	**Mean**	**SD**	**t**	**df**	**P**
Pre	15	453.8	63.21414851	3.7809	28	.000754
Post	15	535.6666667	55.10466232			

GRAPH 1



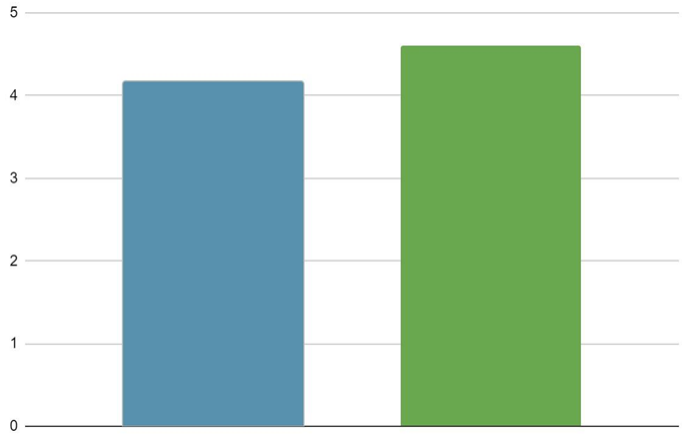
PRE TEST **POST TEST**

INTERPRETATION: The above table and graph shows the comparison of score for the 6MWT score within group A.

TABLE 2

Mac New questionnaire	N	Mean	SD	T	df	P
Pre	15	4.165333333	0.07827302643	10.208	28	< .00001
Post	15	4.610666667	0.1497362761			

GRAPH 2



INTERPRETATION:

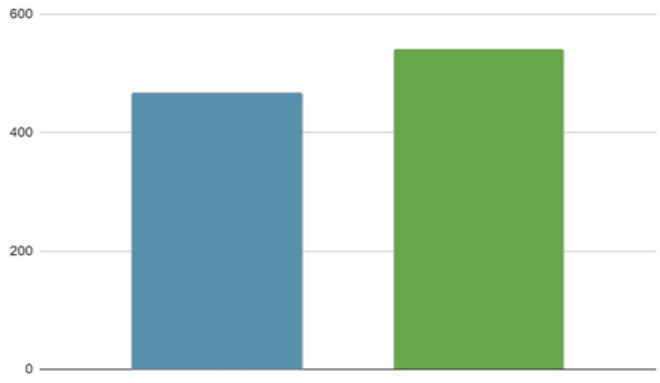
The above table and graph shows the comparison of score for Mac New Questionnaire within group A.

GROUP B

TABLE 3

6MWT	**N**	**Mean**	**SD**	**T**	**df**	**P**
Pre	15	467.2	43.80019569	4.4368	28	.000129
Post	15	540.6666667	46.84422005			

GRAPH 3



PRE TEST **POST TEST**

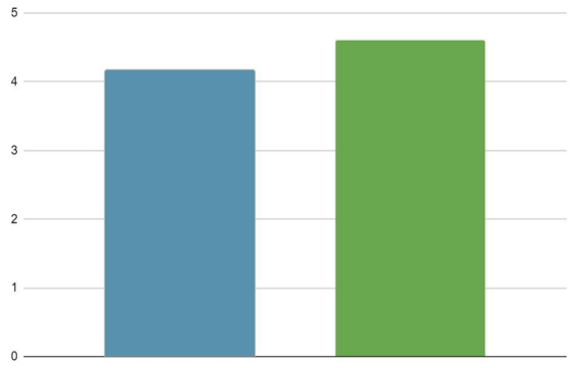
INTERPRETATION:

The above table and graph shows the comparison of score for **6MWT** within group B

TABLE 4

Mac New questionnaire	N	Mean	SD	T	df	P
Pre	15	4.165333333	0.078273026 43	10.208	28	< .00001
Post	15	4.610666667	0.149736276 1			

GRAPH 4



PRE TEST **POST TEST**

INTERPRETATION

The above table and graph shows the comparison of score for **Mac New Questionnaire** within group B.

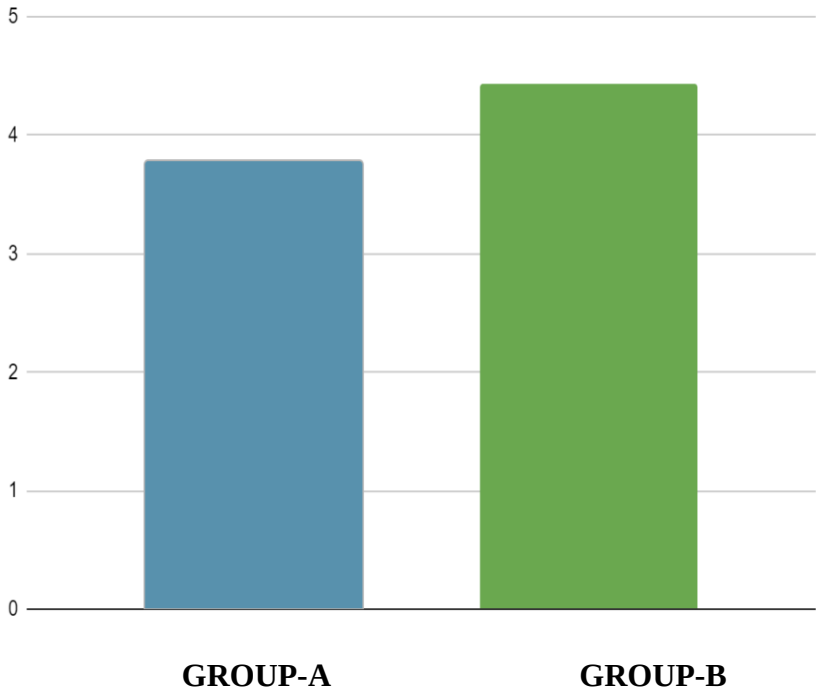
A. BETWEEN THE GROUPS:

TABLE 5

Group A and B

6MWT	T	df	P
Group A	3.7809	28	.000754
Group B	4.4368	28	.000129

GRAPH 5



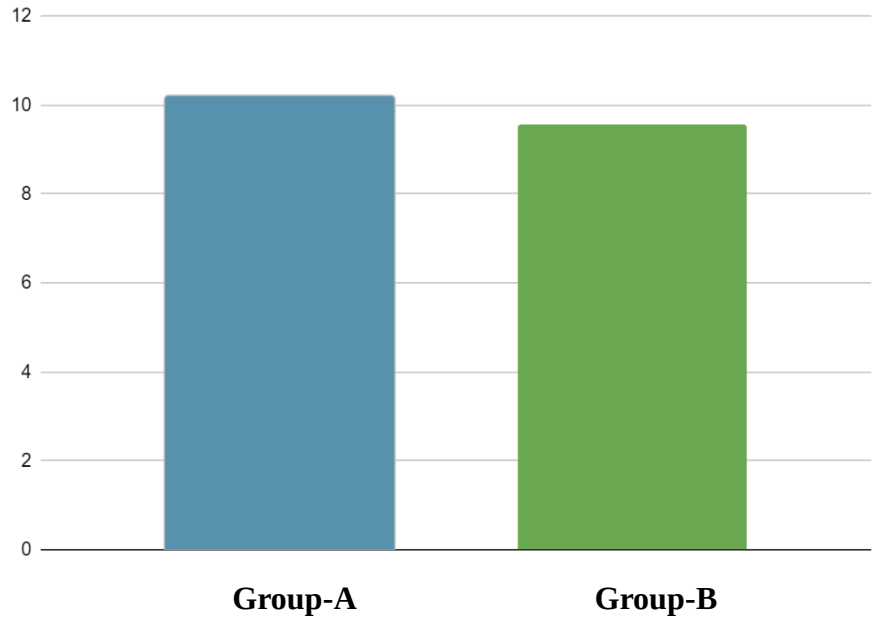
INTERPRETATION:

The above table and graph shows the comparison of post test score for the 6MWT between group A and group B.

TABLE 6

Mac new questionnaire	**t**	**df**	**P**
Group A	10.208	28	< .00001
Group B	9.5685	28	< .00001

GRAPH 6



INTERPRETATION:

The above table and graph shows the comparison of post test score for **Mac New Questionnaire test** between group A and group B.

DISCUSSIONS

The objective of the study was to compare the effectiveness of interval training a versus circuit training for improving endurance capacity and quality of life. The study undertaken included patients who had chronic bronchitis, bronchial asthma, lung emphysema, interstitial lung disease.

Although many treatment methods are currently in voguer in order to deal these kinds of patients that are in emergent need of applying the correct training which suits the patients need.

The growing demand for meeting various problems associated with pulmonary complications are indeed worth considering.

The study was detailed to find the effectiveness of which mode of exercise training program Was better in two groups using 6 MWT and Mac New questionnaire. The analysis of variance between both groups using 6 MWT and Mac New questionnaire exhibited significant improvement for interval training program than circuit training

THE result of this study shows that there was a significant difference in 6 MWT and Mac New questionnaire during pre-exercise session than post exercise session, thus improving the endurance capacity

This in accordance with the study by **Vogiatzis et al.** supported that interval training was more effective in enhancing the expression of metabolic need

The improvement were accompanied by a physiological and exertional changes at a given level of exercise including reduction in both ventilatory requirement and sense of breathlessness. The relief interval between both of hard work of interval training dear special regards to successful application of maximal intensity training.

Coppoelse et al. suggested that interval groups demonstrated the reduction in ventilatory requirement and dyspnea score in response to level of exercise. It is likely that ventilatory requirement is multi factorial and related to oxidative capacity, alter breathing pattern and improved work efficiency.

The improvement in measure of exercise tolerance were extrapolated to improve the quality of life, since the Mac New questionnaire overall score in both groups were increased after rehabilitation. Most notably patients demonstrated objective improvement in domestic functions being able to perform daily activities with less dyspnea, as evidence by the significant change in score for this domain.

The result of this study also have evidence by **Reshma Menon et al.** interval design and VO2 allows for rest period that makes it possible for subject to complete short work period as higher intensity thereby challenging the ability more than would be possible by circuit exercises.

The statistical analysis done above correlated that the group taken for study; group A treated by interval training aerobic exercise program and group B treated by circuit training aerobic exercise program in improving the endurance capacity and quality of life of patients with non-specific pulmonary disorder. It showed that the group A treated by interval training had higher significance when compared to group B treated by circuit training aerobic exercise program.

Whereas this study determines that interval training can produce an exercise strategy that can readily be implemented into clinical practice for people with chronic lung disease patients.

CONCLUSION

This study concluded that interval training of aerobic exercise program is significantly more effective than circuit training of aerobic exercise program for improving endurancecapacity and quality of life for patients with non-specific pulmonary disorder.

LIMITATIONS

- The study was limited to a shorter duration of time
- The study was limited due to less number of sample size
- The study was limited to age group between 30 to 50 years.

RECOMMENDATIONS

- Further study could be done for prolonged duration.
- Further study could be done on large number of sample.
- It may recommend that different interventions may be chosen in non-specific pulmonary disorder patients.
- It may recommend that study could be done on a comparison between specific and non-specific pulmonary patients

REFERENCES

1. Irfan Ullah Khattak et al (2020) “Effects of circuit training on cardiorespiratory endurance among college students” http://dx.doi.org/10.31703/grr.2020(V-III).05 DOI: 10.31703/grr.2020(VIII).05
2. Masatoshi Hanada et al (2020)“Aerobic and breathing exercise improve dyspnea, exercise capacity and quality of life in idiopathic pulmonary fibrosis patients; Systematic review and meta anaylysis” with IPF” 2020;12(3):1041-1055. doi:10.21037/jtd.2019.12.27.
3. Abbey Sawyer et al (2020) “Effects of High intensity interval training increases cardiorespiratory fitness and exercise capacity in people with chronic pulmonary conditions: a narrative review”BMC Sports Science, Medicine and Rehabilitation Article number: 22 (2020)
4. Anne E Holland et al (2018) “Short and long-term reliability of the 6 min walk test in people with idiopathic pulmonary fibrosis. 2018 Aug;63(8):994-1001. doi: 10.4187/respcare.05875.Epub 2018 Jun 26. PMID: 29945909
5. Vahan Moradians et al (2016) “Effect of Eight-Week Aerobic, Resistive, and Interval Exercise Routines on Respiratory Parameters in Non-Athlete Women Tanaffos. 2016;15(2): 96–100.PMID: 27904541
6. Zoran Milanovic et al (2015) “Effectiveness of high interval training and continuous endurance training for VO2 max improvements: a systematic review and meta analysis of controlled trial2015 Oct;45(10):1469-81. doi: 10.1007/s40279-015-0365-0. PMID: 26243014
7. Knowles A. M et al (2015) “Impact of low volume, high intensity interval training on maximal aerobic capacity, health related quality of life and motivation to exercise in ageing men.https://doi.org/10.1007/s11357-015- 9763-3
8. Shan Alphin et al. (2014) “The MacNew Heart Disease Health Related Quality of Life Questionnaire: A Scandinavian Validation Study’’ Soc indic Res. 2015;122(2):519- 537. doi:10.1007/s11205-014-0694-7. Epub 2014 Jul 24.
9. Annie E Holland et al. (2014) “Cardiorespiratory responses to 6 min walk test in interstitial lung disease: not always a submaximal test”. PMID: 25113781PMCID: PMC4139493DOI: 10.1186/1471-2466-14-136

10. Maryam Khosravi et al. (2013) “Effects of Eight Weeks of Circuit Resistance Training on Pulmonary Function of Inactive Women”, vol. 1, no. 2, pp. 11- 18, Summer 2013 http://aassjournal.com/article-1-45-en.html
11. Sloth M et al. (2013) “Effects of sprint interval training of aerobic exercise performance: a systematic review and meta-analysis PMID: 23889316DOI: 10.1111/sms.12092
12. Dunham C et al. (2012) “Effects of high intensity interval training on pulmonary function” .“PMID: 2219400 DOI: 10.1007/s00421-011-2285-5
13. Mohd. Ahsan et al. (2012) “A study of effective use of aerobic exercise for bodyweight reduction in overweight male” Education Vol.1 No 1 (July2012) 36-39
14. Ahmad Azad et al. (2011) “Effects of Aerobic Exercise on Lung Function in Overweight and Obese Students”. 2011; 10(3): 24–31. PMID: 25191372
15. Eleni A Kortianou et al. (2010) “Effectiveness of Interval Exercise Training in Patients with COPD 2010 Sep; 21(3): 12–1 PMID: 20957074
16. Gormley S E et al. (2008) “Effect of intensity of aerobic training on VO2 max”2008 Jul;40(7):1336- 43. doi:0.1249/MSS.0b013e31816c4839. PMID: 18580415
17. Helgerud J, et al. (2007) “Aerobic high intensity interval improves VO2 max more than moderate training”. 2007 Apr;39(4):665- 71.doi:10.1249/mss.0b013e3180304570.
18. Stefan Hofer et al. (2004) “The Mac New Heart Disease health related quality of life instrument: a summary”. 2004 Jan 8;2:3. doi:10.1186/1477-7525- 2-3.
19. I. Vogiatzis et al. (2002) “Interval training as an alternative modality to continuous exercise in patients with COPD PMID: 12166558DOI:10.1183/09031936.02.01152001Eur Respir J. 2002 Jul;20(1):4-5. doi:10.1183/09031936.02.00402002.
20. S.Hardiansyah , et al.(2019) “Effect of circuit and IT method on the improvement of physical fitness” DOI:10.2991/assehr.k.200824.203volume 464
21. Fletcher C.M, Elmes P.C, Fairbairn A.S, et al. The significance of respiratory symptoms and the diagnosis of chronic bronchitis in a working population. *Br Med J* 1959;2:257-66.10.1136/bmj.2.5147.257
22. Mahler DA, Wells CK. Evaluation of clinical methods for rating dyspnea. *Chest* 1988;93:580-6. 10.1378/chest.93.3.580

23. Mahler DA, Weinberg DH, Wells CK, et al. The measurement of dyspnea. Contents, interobserver agreement, and physiologic correlates of two new clinical indexes. *Chest* 1984;85:751-8. 10.1378/chest.85.6.751

24. Hayes MHS, Patterson D. Experimental development of the graphic rating method. *Psychol Bull* 1921;18:98-9.

25. Jones PW, Quirk FH, Baveystock CM, et al. A self-complete measure of health status for chronic airflow limitation. The St. George's Respiratory Questionnaire. *Am Rev Respir Dis*1992;145:1321-7. 10.1164/ajrccm/145.6.1321

26. Yorke J, Jones PW, Swigris JJ. Development and validity testing of an IPF-specific version of the St George's Respiratory Questionnaire. *Thorax* 2010;65:921-6. 10.1136/thx.2010.139121

27. Ware JE, Jr, Sherbourne CD. The MOS 36-item short-form health survey (SF-36). I. Conceptual framework and item selection. *Med Care* 1992;30:473-83.10.1097/00005650-199206000-00002

28. Downs SH, Black N. The feasibility of creating a checklist for the assessment of the methodological quality both of randomized and non-randomized studies of health care interventions. *J Epidemiol Community Health* 1998;52:377-84. 10.1136/jech.52.6.377

29. Munn J, Sullivan SJ, Schneiders AG. Evidence of sensorimotor deficits in functional ankle instability: a systematic review with meta-analysis. *J Sci Med Sport* 2010;13:2-12.10.1016/j.jsams.2009.03.004

30. Melsen WG, Bootsma MC, Rovers MM, et al. The effects of clinical and statistical heterogeneity on the predictive values of results from meta-analyses. *Clin Microbiol Infect* 2014;20:123-9. 10.1111/1469-0691.12494

31. Dowman LM, McDonald CF, Hill CJ, et al. The evidence of benefits of exercise training in interstitial lung disease: a randomized controlled trial. *Thorax* 2017;72:610-9.10.1136/thoraxjnl-2016-208638

32. da Fontoura FF, Berton DC, Watte G, Florian J, et al. Pulmonary rehabilitation in patients with advanced idiopathic pulmonary fibrosis referred for lung transplantation. *J Cardiopulm Rehabil Prev* 2018;38:131-4. 10.1097/HCR.0000000000000315

33. Kozu R, Jenkins S, Senjyu H. Effect of disability level on response to pulmonary rehabilitation in patients with idiopathic pulmonary fibrosis. *Respirology* 2011;16:1196-202.10.1111/j.1440-1843.2011.02029.x

34. Ozalevli S, Karaali HK, Ilgin D, et al. Effect of home-based pulmonary rehabilitation inpatients with idiopathic pulmonary fibrosis. *Multidiscip Respir Med* 2010;5:31-7.10.1186/2049-6958-5-1-31

35. Nishiyama O, Kondoh Y, Kimura T, et al. Effects of pulmonary rehabilitation in patients with idiopathic pulmonary fibrosis. *Respirology* 2008;13:394-9. 10.1111/j.1440-1843.2007.01205.x

36. Jackson RM, Gomez-Marin OW, Ramos CF, et al. Exercise limitation in IPF patients: a randomized trial of pulmonary rehabilitation. *Lung* 2014;192:367-76.10.1007/s00408-014-9566-9

37. Vainshelboim B, Oliveira J, Yehoshua L, et al. Exercise training-based pulmonary rehabilitation program is clinically beneficial for idiopathic pulmonary fibrosis. *Respiration* 2014;88:378-88. 10.1159/000367899

38. Swigris JJ, Fairclough DL, Morrison M, et al. Benefits of pulmonary rehabilitation in idiopathic pulmonary fibrosis. *Respir Care* 2011;56:783-9. 10.4187/respcare.0093939.

39. Rammaert B, Leroy S, Cavestri B, et al. Home-based pulmonary rehabilitation in idiopathic pulmonary fibrosis. *Rev Mal Respir* 2011;28:e52-7. 10.1016/j.rmr.2011.06.006

40. Arizono S, Taniguchi H, Sakamoto K, et al. Pulmonary rehabilitation in patients with idiopathic pulmonary fibrosis: comparison with chronic obstructive pulmonary disease. Sarco Vasc Dif lung dis 2017;34:283-289.

41. Holland AE, Hill CJ, Glaspole I, et al. Predictors of benefit following pulmonary rehabilitation for interstitial lung disease. *Respir Med* 2012;106:429-35.10.1016/j.rmed.2011.11.014

42. Rifaat N, Anwar E, Ali YM, et al. Value of pulmonary rehabilitation in patients with idiopathic pulmonary fibrosis. *Egypt J Chest Dis Tuberc* 2014;63:1013-7.10.1016/j.ejcdt.2014.06.004

43. Arizono S, Taniguchi H, Sakamoto K, et al. Endurance time is the most responsive exercise measurement in idiopathic pulmonary fibrosis. *Respir Care* 2014;59:1108-15.10.4187/respcare.02674

44. du Bois RM, Weycker D, Albera C, et al. Six-minute-walk test in idiopathic pulmonary fibrosis: test validation and minimal clinically important difference. *Am J Respir Crit Care Med* 2011;183:1231-7. 10.1164/rccm.201007-1179OC

45. Nykvist SM, Ferrara G, Faager G. Inspiratory muscle training in addition to physical exercise for idiopathic pulmonary fibrosis. *Eur Respir J* 2016;48:OA1518.

46. O'Donnell DE, D'Arsigny C, Webb KA. Effects of hyperoxia on ventilatory limitation during exercise in advanced chronic obstructive pulmonary disease. *Am J Respir Crit Care Med* 2001;163:892-8. 10.1164/ajrccm.163.4.2007026

47. Ryerson CJ, Cayou C, Topp F, et al. Pulmonary rehabilitation improves long-term outcomes in interstitial lung disease: a prospective cohort study. *Respir Med* 2014;108:203-10.10.1016/j.rmed.2013.11.016

48. Verma G, Marras T, Chowdhury N, et al. Health-related quality of life and 6 minute walk distance in patients with idiopathic pulmonary fibrosis. *Can Respir J* 2011;18:283-7.10.1155/2011/109635

49. Jones PW. St. George's Respiratory Questionnaire: MCID. *COPD* 2005;2:75-9.10.1081/COPD-200050513

50. Peter M, Athol U, Jenkins RG (2020) Pulmonary fibrosis and COVID-19: the potential role for antifibrotic therapy. Lancet 138:805–815

51. George P, Patterson C, Ak R (2019) Lung transplantation for idiopathic pulmonary fibrosis.Lancet Respir Med 7(3):271–282.

52. Carfì A, Bernabei R, Landi F (2020) For the Gemelli against COVID-19 post-acute care study group. Persistent symptoms in patients after acute COVID-19. J Am Med Assoc 324(6):603–605.

53. King CS, Nathan SD (2017) Idiopathic pulmonary fibrosis: effects and optimal management of comorbidities. Lancet Respir Med 5(1):72–84.

54. Richeldi L, du Bois R, Raghu G et al (2014) Efficacy and safety of nintedanib in idiopathic pulmonary fibrosis. N Engl J Med 370(22):2071–2082.

55. Jr King, Bradford WZ, Castro-Bernardini S et al (2014) A phase 3 trial of pirfenidone inpatients with idiopathic pulmonary fibrosis. N Engl J Med 370:2083–2092
56. Zarir F, Priyanka K, Awatansh K et al (2021) Fibrotic interstitial lung disease occurring assequelae of COVID-19 pneumonia despite concomitant steroids. Lung India 38(1):1–105
57. Carsana L, Sonzogni A, Nasr A et al (2020) Pulmonary post-mortem findings in a series COVID-19 cases from northern Italy: A two-center descriptive study. Lancet Infect Dis1473- 3099(20):30434-30435
58. Wu C, Chen X, Yanping C et al (2020) Risk factors associated with acute respiratory distress syndrome and death in patients with coronavirus disease 2019 pneumonia in Wuhan. China JAMA Intern Med 180(7):934–943.
59. Francone M, Iafrate F, Gorgio M et al (2020) Chest CT score in COVID-19 patients: correlation with disease severity and short-term prognosis. Eur Radiol 4:1–10
60. Pan F, Ye T, Sun P, Gui S, Liang B, Li L, Zheng D, Wang J, Hesketh RL, Yang L, Zheng C(2020) Time course of lung changes at chest CT during recovery from coronavirus disease 2019 (COVID-19). Radiology 295(3):715–721.
61. Tale S, Ghosh S, Meitei SP et al (2020) Post-COVID-19 pneumonia pulmonary fibrosis. Int JMed 113(11):837–838
62. Ademola S, Simon A, Oyeronke T et al (2020) Pulmonary fibrosis in COVID-19 survivors: predictive factors and risk reduction strategies. Pulmon Med 5:1–10
63. George PM, Wells AU, Jenkin RG et al (2020) Pulmonary fibrosis and COVID-19: the potential role for antifibrotic therapy. Lancet Respir Med 8(8):807–815.
64. Wong K, Antonio GA, Hui DS et al (2002) Severe acute respiratory syndrome: thin-section computed tomography features, temporal changes, and clinicoradiologic correlation during the convalescent period. J Comput Assisted Tomogr 28(6):790–795
65. Sansone A, Mollaioli D, Ciocca G, Limoncin E, Colonnello E, Vena W, Jannini EA (2021) Addressing male sexual and reproductive health in the wake of COVID-19 outbreak. J Endocrinol Invest. 44(2):223–231.