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IMMEDIATE EFFECT OF STACKED BREATHING TECHNIQUE ON OXYGEN SATURATION AND PEAK EXPIRATORY FLOW RATE IN CARDIOTHORACIC SURGERY PATIENT-AN EXPERIMENTAL STUDY.

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ABSTRACT

Background: Cardiovascular Disease is the top leading cause of death in a south-Asian country like India. Cardiothoracic surgery is one of the treatments of choice in severe morbidity condition to reduce mortality rate and disability. Despite recent advances and updated technical instrumentation postoperative pulmonary complication is a critical problem. Physiotherapy works efficiently to minimise postoperative complication to improve the health status of the patient.

Aims and objectives: The purpose of the study is to evaluate the immediate effect of Stacked Breathing technique on Peak Expiratory Flow rate[PEFR] and Oxygen Saturation[SpO2] in Cardiothoracic surgery Patient.

Methodology: Out of a total of 119 screened patients, only 105 were able to complete the intervention. Stacked Breathing was performed by the patient twice daily [Morning and Afternoon] for 1st, 2nd and 3rd postoperative days termed as six-session [IA, IB, IIA, IIB, IIIA, IIIB where, A=morning, B= afternoon and I to III is Postoperative day 1 to 3] pre and postexercise outcome were measured and data collected.

Statistical analysis: Instant software was used for statistical analysis. As data is not normally distributed Dunn test [Non-Parametric repeated measure ANOVA] were used followed by post hoc test.

Result: Comparing IA Vs. IIIB, net 40.73% change in PEFR value is observed. Statistically significant improvement in PEFR with p-value <0.001 is seen. Oxygen saturation shows statistically significant improvement with p-value <0.001 with each session daily.

Conclusion: Stacked Breathing can be used as a treatment tool to increase Peak Expiratory Flow Rate and Oxygen Saturation in a patient with cardiothoracic surgery in their early postoperative days.

Keywords: Stacked Breathing, Cardio-thoracic surgery, Peak Expiratory Flow Rate, Oxygen Saturation.

Trial registration: Indian National Institute of Medical Statistics (Indian Council of Medical Research) was done. CTRI registration no. CTRI/2018/05/014193.

Introduction:

Cardiovascular Diseases (CVDs) have become the leading reason for mortality and morbidity in India (Reddy KS et al 1998). Epidemiological studies show a sizeable burden of CAD in rural (3-5%) and city (7-10%) populations (Murray CJ et al 1997). Surgical management was evolved to eradicate the harmful effect of Cardiovascular Disease and reduce the mortality rate and morbidity in many patients (Eagle KA 2004). Primary cardiovascular operations performed in India are Coronary Artery Bypass Grafting [CABG] procedure, followed by isolated aortic valve replacement, mitral valve replacement [MVR] and combination of CABG+MVR or Aortic Valve replacement (AVR)(Seder C et al. 2018). Despite the modernisation of the procedures utilised with technical advancement in cardiac surgeries, pulmonary dysfunction can still be there (Borghi Silva A et al.2005).

As heart and lungs are closely related organs surgical procedures can cause many pulmonary complications in early post-operative days. Patients develop a restrictive respiratory illness with reduced lung volumes and mismatch in gas exchange in the early surgical postoperative period (Telling At et al.1998 and Taggart D et al 2000). The physiotherapy techniques most commonly used to promotion of expiration, coughing up, diaphragmatic breathing and the development of inhalation with inhalation spirometer (Crisafulli E et al. 2013 and Restrepo R et al.2018). The inspiratory volume of a patient can be improved by enhancing the depth of every breath with every repetition, which prevents shallow breathing By the help of Stacked Breathing technique (Roth G et al.2018). Improvement in the inspiratory phase of breathing leads to increase in the expiratory period as well. Stacking of breath also promotes collateral ventilation, which assists in dislodging the secretions and moves it to the central airways, thereby helping

in the clearance of airway. Adequate expiratory flow rate is the required basis for deciding the coughing capacity of patient (Cleary et al. and Park JH et al. 2010). Adequate coughing promotes airway clearance and reduced pulmonary complication like hypoxia, atelectasis, and pneumonia (Northern L et al.2016 and Park JH et al. 2010).

As we come across many articles stressed the effect of Stacked Breathing technique to improve inspiratory volume, peak cough flow, and rib expansion in various categories of patients. Very few researches are available that give importance to the effect of Stacked Breathing Technique in Cardiothoracic surgery patients. Therefore, the objectives of this study are to evaluate the immediate effect of Stacked Breathing technique on oxygen saturation and peak expiratory flow rate in cardiothoracic surgery patient.

RESEARCH METHODOLOGY

This is a non-randomized, Quasi-Experimental study with pre and post test design. It was carried out in the Cardiac surgery and Rehabilitation unit, Ahmednagar [M.S]. Research is duly approved by the Institutional Ethical Committee under MUHS, Nashik [MS]. All the patients posted for Cardiac surgery with age group 40-70 years both Males and Females planned for surgery with mediastinal approach were screened pre-operatively for inclusion by convenient sampling method and patients diagnosed with any neuromuscular condition and having difficulty in cognitive function were excluded. All patients ready to participate was signed informed consent form after the provision of information regarding procedures, benefits, and possible complication. Screened subjects are developing post-operative complication like - ventricular arrhythmias, intra-operative myocardial infarction, and severe blood loss >1500ml. Hemodynamic instability, e.g., mean arterial pressure < 70 mmHg, reduced output requiring intra-aortic balloon pump or vasoactive drugs. Intubation duration > 72 hours and need reintubation were excluded.

Procedure:

Expiratory Flow Rate: is a person's maximum speed of expiration, as measured by a small, hand –held device developed by mini-Wright peak flow meter was used to monitor a person's ability to breath out. For healthy Females its values ranging from 380-460 L/min and for Males 480-660 L/min by EU (European scale] scale. It varies with age and height for both the sexes.

Figure 1: peak expiratory flow rate assessed by peak flow meter

Figure 2: (SpO2) oxygen saturation were measured by fingertip pulse oximeter.

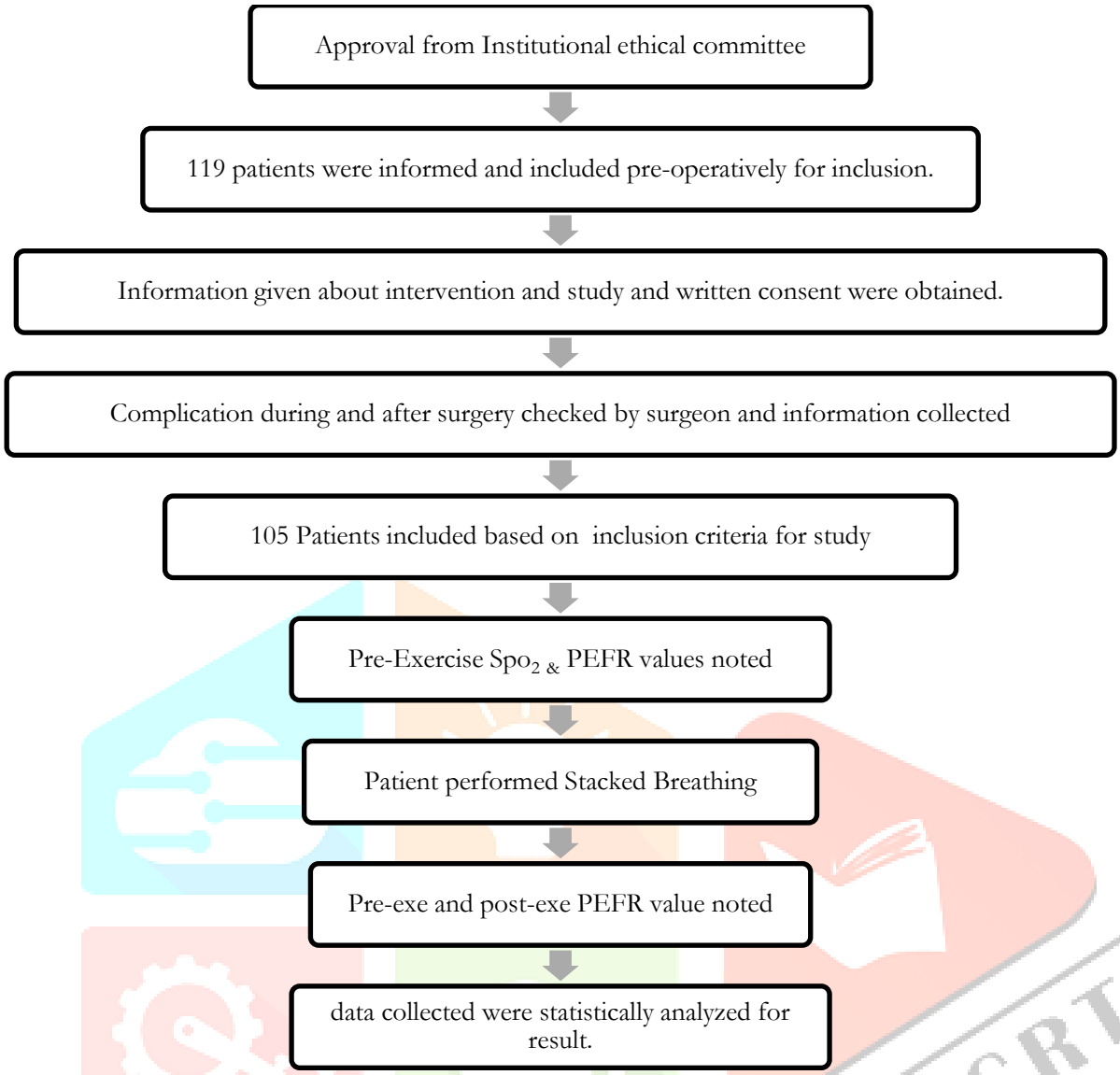
Stacked Breathing Exercise [SBE]:

Pilot study conducted prior to main study revealed that, patient with cardiothoracic surgery can hold breath for maximum 10 second without experiencing severe pain and hemodynamic instability. Hence, breath stacking time is revised to 10 seconds for intervention in this study, Patient was positioned in long sitting position on bed with continuous monitoring of hemodynamic parameters including SPO2 (oxygen saturation), pulse rate, non-invasive blood pressure, respiratory rate. Patient was instructed to take deep breath and take 3- 4 breath one over another till fullness of chest experience and was asked to hold the breath for maximum of 10 seconds then expire by pursed lip breathing or splinted coughing (if secretions are present). There was gap of 15-30seconds in each repetition to allow relaxation, 10 repetitions, and twice daily on 1st, 2nd and 3rd post-operative day. PEFR was checked as per standard guidelines. To restrict the effect of conventional physiotherapy protocol on outcome measures, we will administer the stacked breathing exercise before administrating the conventional therapy protocol.

Figure 3: Patient performing Stacked Breathing, holding the breath for 10 seconds achieved by instruction and closing nose with the help of nose clip.

Figure 4: Patient attempts splinted coughing at the end of Stacked Breathing to remove secretion.

There are total six sessions termed as IA, IB, IIA, IIB, IIIA and IIIB. Pre-exercise and post-exercise values for PEFR was collected in six treatment session from IA to IIIB [A=morning session, B=Afternoon session and I, II, III was POD-1,2and3 respectively] for ease of statistical calculations.



Outcome measures:

Primary outcome: 1]Oxygen saturation changes Pre and Post intervention session.
2] PEFR value changes Pre and Post intervention session.

Data analysis:

Statistical analysis done by GraphPad instat software. After passing through kolmogorov and Smirnov test of normality, we found that data are not normally distributed with $\alpha>0.005$. Nonparametric Dunn multiple ANOVA was used for statistical analysis.

RESULTS:

Our initial sample size consists of a total of 119 subjects, including 74 males and 45 female patients for the study evaluated pre-operatively. Out of which total of 14 patients was excluded based on exclusion criteria. So, a total of 105 patients completed the intervention and included for data analysis. [Data expressed by mean± SD, mean difference, % change= absolute value of change in value/sum of two value*100, POD = Post-operative day, exe= exercise, pre= before exercise, post= after exercise, * = slightly significant, ** = moderately significant, *** = extremely significant.]

TABLE 1- DEMOGRAPHIC AND BASELINE SURGICAL DATA WITH THE BASELINE OUTCOME MEASURE

Variables		**Patient population n=119 [mean± SD]**
Age [In years]		59.47± 10.82
Male/Female		74/45
BMI		23.2± 2.784
Type of surgery	CABG	95
	Valve surgeries	20
	CABG+ Valve surgery	4
Oxygen saturation at room air [in %]		97.90±1.25
PEFR [In L/Min]		364.32±64.14

[* 1min 30 seconds considers as 1.5 hours]

TABLE 2: COMPARISONS OF OUTCOME 1] PEAK EXPIRATORY FLOW RATE MEASUREMENTS BY DUNN MULTIPLE COMPARISONS POST-TEST

Comparisons of data	Rank sum difference	% change	Significance	P value
IA: pre-exe Vs. post-exe	-320	15.29	***	P<0.001
IIA: pre-exe Vs. post-exe	-403.5	12.19	***	P<0.001
IIIA: pre-exe Vs. post-exe	-399.5	10.93	***	P<0.001
IB: pre-exe Vs. post-exe	-386.5	12.10	***	P<0.001
IIB: pre-exe Vs. post-exe	-429.0	11.93	***	P<0.001
IIIB: pre-exe Vs. post-exe	-304.5	11.10	***	P<0.001
IA pre-exe Vs. post-exe IIIA	-981.0	35.27	***	P<0.001
IB pre-exe Vs. post-exe IIIB	-959.5	35.35	***	P<0.001
IA PRE-exe Vs post-exe IIIB	-1096.5	40.73	***	P<0.001

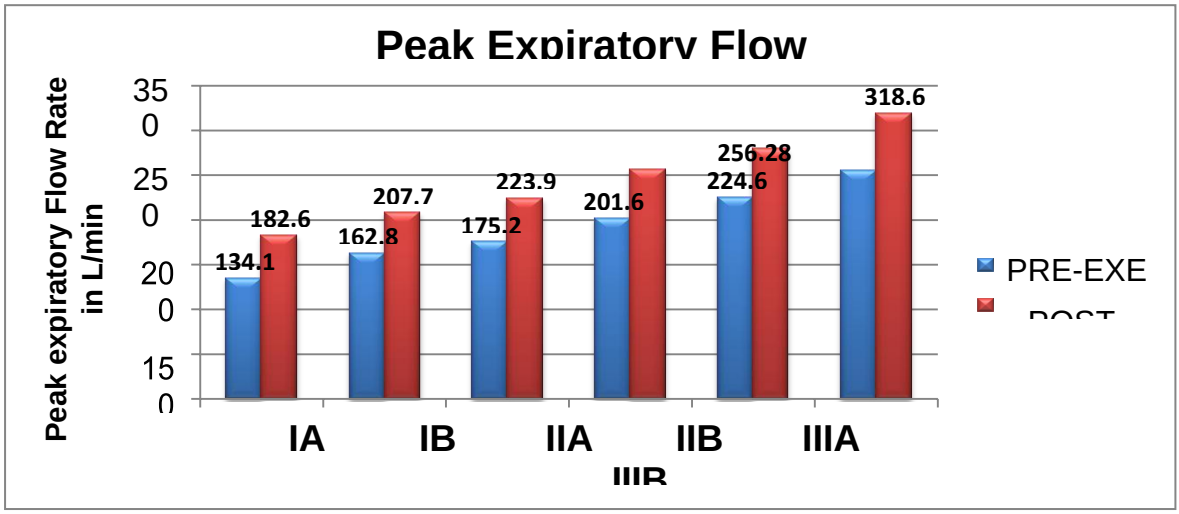


Diagram 1: Diagrammatic representation of Peak Expiratory Flow Rate [In mean and standard deviation] changes with stacked breathing each session and each day.

Table no 2 and Diagram 1, shows the changes in Peak Expiratory Flow Rate values measured before the Stacked Breathing and after the Stacked Breathing Technique with six sessions of the treatment protocol. Here we able to note measurable changes in Peak Expiratory Flow Rate with every session of exercise over preceding treatment session of the same day and with next day session.

TABLE 3: COMPARISONS OF OUTCOME 2] OXYGEN SATURATION MEASUREMENTS BY DUNN MULTIPLE MEASURES WITH POST HOC TEST [NON-PARAMETRIC REPEATED MEASURE ANOVA]

Comparisons of data	**Rank sum difference**	**Mean difference**	**% change**	**Significance**	**p-value**
IA: pre-exe Vs. post-exe	-464.0	2.18	1.13	***	P<0.001
IIA: pre-exe Vs. post-exe	-482.0	2	1.04	***	P<0.001
IIIA:pre-exe Vs. post-exe	-457.0	1.96	1.01	***	P<0.001
IB: pre-exe Vs. post-exe	-498.0	2.10	1.08	***	P<0.001
IIB: pre-exe Vs. post-exe	-560.0	2.33	1.21	***	P<0.001
IIIB: pre-exe Vs. post-exe	-522.0	2.25	1.16	***	P<0.001
IA pre-exe Vs. post-exe IIIA	-393.5	1.68	0.87	***	P<0.001
IB pre-exe Vs. post-exe IIIB	-528.5	2.1	1.08	***	P<0.001
IA pre-exe Vs. post-exe IIIB	-469.5	2.01	1.04	***	P<0.001

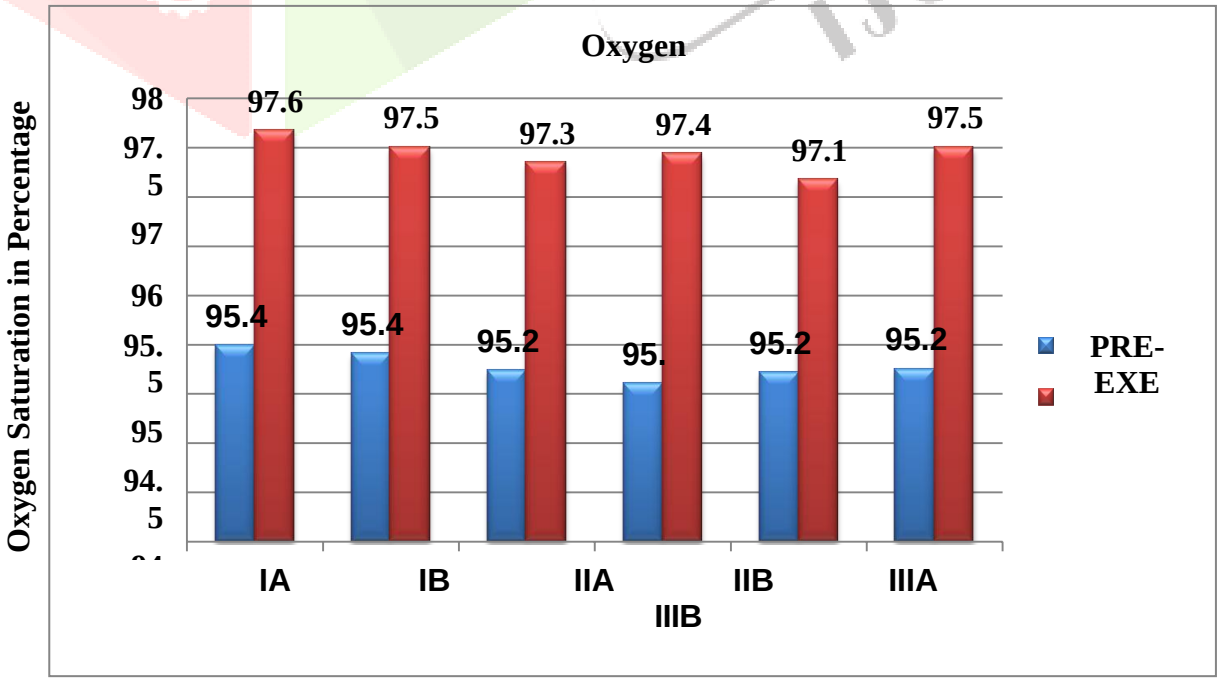


Diagram 2: Graphical representation of Oxygen Saturation changes pre and post Stacked Breathing session.

Table no 3 and Diagram 2, shows the changes in Peak Expiratory Flow Rate values measured before the Stacked Breathing and after the Stacked Breathing Technique with six sessions of the treatment protocol. Here we able to note measurable changes in Peak Expiratory Flow Rate with every session of exercise over preceding treatment session of the same day and with next day session.

DISCUSSION

Various researchers also supported for the pulmonary complication post-surgery was main contributory factor in morbidity and fatal health conditions(Hulzebros EH et al.2006 and Marbate R et al. 2019). Recent physiotherapy updates are working efficiently towards the improvement of postoperative health of the patient by providing postoperative cardiopulmonary rehabilitation (Pasquina P et al. 2003). Stacked Breathing is one of the treatment techniques which might be a better tool to improve the health status of the patient postoperatively and can be used to prevent and manage the cardiopulmonary complication postoperatively (Kang S et al. 2000 and Dias CM et al.2011).

To check the immediate effect of stacked breathing on Peak Expiratory Flow rate in cardiac surgery patient, we carried a pilot study before conducting our main study. Total 11 cardiac surgery patients were enrolled in the study and data were obtained. After statistically analysis, we found that, there was statistically significant improvement in Peak Expiratory Flow Rate values immediately after Stacked Breathing with p-value 0.001. Peak Expiratory Flow Rate was gained by 27% by stacked breathing over Pre-Exercise value (Marbate R et al.2019).

The result of present study showed that Stacked Breathing Technique performed by patient post-cardiothoracic surgery showed statistically significant improvement in Peak Expiratory Flow Rate with p value <0.001 after performing Stacked Breathing Technique [value comparing pre-exercise vs post-exercise] with each session of treatment regimen during their early postoperative days, resulting in the better improvement of Peak Expiratory Flow Rate.

The reason of improvement in Peak Expiratory Flow rate after performing Stacked Breathing Technique in post-cardiothoracic surgery patient can be because of two reasons 1] Improvement in the physiological function of the pulmonary system and 2] biomechanical response to chest expansion and diaphragm function after breath stacking exercise (Kang S et al.2000 and Gupta S et al. 2013). Physiologically, because of general anaesthesia given during surgery respiratory muscle weakness can occur in early post-operative days for up to 72 hours. Also, intubation during surgery for at least 6 hours causes an increase in dead spaces as a result of which the lung volumes are reduced in such patient (Kang S et al.2000 and Gupta S et al. 2013). Stacked Breathing Technique after extubation can cause improvement in lung volume and inspiratory capacity of the patient by enhancing collateral ventilation and reaching to the maximum inspiratory capacity of the patient during every repetition of the exercise (Collins J et al.2015 and Bilo G et al.2012). Also due to biomechanical response with Stacked Breathing, maximum inspiration produces better chest expansion over the pre-intervention.

A research was carried out by Antonio Sarmanto et al. (2017) on 20 healthy young adults. They studied an immediate effect of air stacking [air stacking synonyms to stacked breathing by procedure] and its physiological effect checked by optoelectronic plethysmography. It stated that, Stacked Breathing in a healthy adult individual can result in (1) significant improvement in peak expiratory flow rate immediately after the maneuver; (2) improvement in inspiratory capacity, 3) increase chest wall tidal volume without substantial changes in end-expiratory volumes. The reason for this improvement is, more the amount of air one inspired, more is the amount of air he or she can expel out during coughing or blowing. Increase in inspired volume post-exercise produced by more displacement of chest wall [mainly pulmonary rib cage] and an increase in lung volume positively causes more increase in chest recoil capacity and hence peak expiratory flow rate increase (Sarmento A et al. 2017). This explanation is similar to the biomechanical response of Stacked Breathing in present study.

Similar study as done by Sang-Kyun-an et al. shows breath stacking technique is responsible for significant improvement in Peak cough Flow [PCF Synonyms to PEFR]. The potential reason explained for the improvement was, air stacking training significantly improved the forced vital capacity [FVC]. In restrictive or obstructive lung conditions, lung volume is reduced, causing prolonged hypoventilation. Improvement in lung compliance and respiratory muscle activation that causes improvement in overall respiratory function. More the ability of the patient to inspire, more he can expire and hence, peak cough flow is increased after Stacked Breathing (An SK et al.2018).

These all researches explain the same physiological and biochemical, functional improvement with Stacked Breathing technique, though it is used in different types of the study population. Hence, these studies support our result and reason behind the

improvement in Peak Expiratory Flow Rate after Stacked Breathing Technique performed by the patient in early post- operative days of Cardiothoracic Surgery.

In present study, we also found an immediate effect of Stacked Breathing on oxygen saturation. There was statistically significant improvement in oxygen saturation with p-value <0.001 post-exercise. Pre-exercise oxygen saturation values were approximately similar during all six treatment session and post-exercise oxygen saturation was also approximately identical for all six treatment session. Still, comparing pre-exercise vs post-exercise shows extremely significant improvement with each session each day.

The reason behind this improvement in oxygen saturation might be, Stacked Breathing induce slow and deep breathing. Stacking of air for 10 seconds improves the collateral ventilation and surface area for the better oxygenation purpose. There is an improvement in inspiratory capacity and lung volume which resulted in better ventilation and effective gaseous exchange thereby improving oxygen saturation (Collins J et al.2015 and Guion L et al. 2019).

In scientific research by, Charlotte Urell et al., (2012) he describes the reason behind lower lung volume causing decreased oxygen saturation in open heart surgery patient performed by sternotomy and also termed it as a restrictive lung condition based on reduced inspiratory lung volume(Urell C et al. 2012). Grzegorz Bilo et al. revealed the physiology behind the improvement in oxygen saturation is an improvement in ventilation efficiency. Due to a reduction in dead space ventilation and improvement in alveolar ventilation possibly because of slow and deep breathing (Bilo G et al. 2012) like Stacked Breathing. Physiologically these explanations supported the result of my study for the improvement in oxygen saturation. Hence, present study shows a statistically significant change in Peak Expiratory Flow Rate and oxygen saturation by Stacked Breathing Technique performed by cardiothoracic surgery patient in their early postoperative days. By this improvement, it can help patients to get rid of the postoperative pulmonary complications like atelectasis, collapse, pneumonia caused because of retention of secretion. By improving breathing pattern and oxygen saturation, it helps the patient to achieve optimal saturation without extra oxygen support in their early postoperative days. So as cardiac rehabilitation protocol is a well established one, still we can add Stacked Breathing as an excellent treatment of choice for a better outcome. It can help the patient to provide better health status postoperatively.

Conclusion: Based on the statistical analysis, it is concluded that Stacked Breathing Technique is significantly effective in improving Peak Expiratory Flow Rate and Oxygen Saturation.

Hence Stacked Breathing Technique can be an effective tool to upgrade patients Peak Expiratory Flow Rate [PEFR] and subsequently helps to improve the strength of cough and promote easy airway clearance.

Study Limitations

Present study is single group experimental study, control group can be compared for better result.

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Competing Interests: *No conflict of intrest.*

Ethical Approval

Study is ethically approved by institutional ethical committee board under Maharashtra university of health and sciences, Nashik[M.S], India.

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