International Journal of Health Sciences and Research
Vol.12; Issue: 8; August 2022
Website: www.ijhsr.org
ISSN: 2249-9571

Original Research Article

Comparison of Effect of Flow and Volume Incentive Spirometry on Peak Expiratory Flow Rate and Single Breath Count in Post Sternotomy

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DOI: https://doi.org/10.52403/ijhsr.20220824

ABSTRACT

Background: Thoracic surgery may cause reduce respiratory function and pulmonary complications, with associated increased risk of mortality. Devices like Flow and Volume incentive spirometry play an important role to improve lung function hence physiotherapy aims to improve respiratory function.
Aim: To compare the effect of 2 devices (flow & Volume incentive spirometers) on peak expiratory flow rate and single breath count.
Method: In this a Comparative, interventional study of 38 postoperative patients, between the age group of 18-60 years, admitted in the intensive care units and step down units of a tertiary care hospital, who were able to perform flow & Volume incentive spirometers on PEFR and SBC from day 1 to day 5. The patients were asked to perform PEFR & SBC before & after each treatment session, for both groups that is FIS and VIS groups from post-operative day 1 to day 5. PEFR and SBC were recorded pre and post treatment session from day 1 to day 5. The difference between day1 and day 5 were statistically analysed to study the effectiveness of the intervention.
Result: Comparison between group A and group B for all parameters was done by using Mann-Whitney U test. The p value is not statistically significant on comparing between the groups, but the improvement in PEFR and SBC from day 1 to day 5 is clinically significant, which indicates that both the devices contribute equally in improving the pulmonary status.
Conclusion: The present study concludes that flow targeted incentive spirometry and volume targeted incentive spirometry were equally effective in Improving peak expiratory flow rate and single breath count in post sternotomy for valve replacement.

Keywords: Flow incentive spirometry, Volume incentive spirometry, Peak expiratory flow rate, Single Breath Count.

INTRODUCTION

Sternotomy is a surgical procedure in which a horizontal incision is made along the sternum to provide access to the thoracic cavity. This makes it easy to access the heart and lungs for surgeries such as valve replacement, corrective surgeries for congenital heart defects, coronary artery bypass surgery and heart transplant.[1] Common postoperative pulmonary complications include hypoxemia, atelectasis, respiratory dysfunction, pneumonia and pleural effusion.[2] The factors that are directly related to physiological changes include general anaesthesia, the type of incision, surgical technique used which may lead to reduction in the Forced Vital Capacity (FVC) and Forced Expiratory Volume in first second (FEV1), resulting in respiratory infection.[3] Basic mechanism behind lack of lung inflation is altered breathing pattern due to post-operative pain leading to reduce excursion of respiratory muscle. Few studies stated that an incidence of pulmonary complications like atelectasis occurred in 42% subjects in the control group and 27% of subjects treated with post-operative physiotherapy.[4, 5, 6]

Impaired lung expansion, collapse, accumulation of secretions reduces ventilation leading to pulmonary infection. Analgesics administered postoperatively not only reduce pain but also have sedative effect. This reduces the mucociliary clearance in the bronchial tree, [7] therefore suppressing the cough reflex or producing less force for effective cough. Due to the effect of anaesthesia, there is altered respiratory mechanism, decreased functional capacity, reduced thoracic excursion. The pattern of respiratory muscle contraction particularly diaphragm and intercostal muscle changes. Total lung capacities, Functional residual capacity, Residual volume, are significantly reduced. Because of reduction in Forced expiratory capacity, compliance is reduced and work of breathing increases. Both intravenous and inhalation anaesthetic agents affect the Central nervous system and cardio respiratory system.[8, 9]

Incentive spirometer are used for improving lung ventilation, thoracic excursion and as prophylaxis during pre and post-operative cardiac, thoracic, and abdominal surgeries.[10] Incentive spirometers are goal oriented exercises using sustained maximal inspiration to promote bronchial hygiene and prevent atelectasis. It is designed to encourage the patient to take slow, long, deep breaths, when inhaled at a predetermined volume or flow rate and sustain inspiration for few seconds.[11, 12] It also helps to maintain and/or improve lung function through controlled breathing pattern and is effective in preventing post-operative complications. After surgery due to pain and longer duration of bed rest leads to cessation of deep breaths and poor cough force, thus clearing the secretions becomes difficult, subjecting the patient to post-operative pulmonary complications. Therefore accumulation of secretions and atelectasis can be avoided with incentive spirometry exercises. The implementation of use of devices like the flow incentive spirometry or volume incentive spirometry which not only improves the lung ventilation but also provides a visual feedback to the patient, encouraging to perform better with subsequent breathes.[12,13]

Incentive spirometry aims at increasing the pulmonary pressure and inspiratory volume, improves inspiratory muscle performance, re-establishes the normal pattern of pulmonary hyperventilation, enhances controlled breathing pattern and increases the vital capacity and peak expiratory flow rate.(PEFR)

The flow and volume targeted incentive spirometer works on patient’s effort which generates a sub atmospheric pressure raising the ball in the chamber. The devices have one-way valve to prevent exhalation in to the unit. The pointer indicates the prescribed inspiratory flow and an inspiratory volume guide coaches the patient to inhale slowly. Both provide visual positive feedback aimed at improving pulmonary expansion, Earlier studies show that volumetric incentive spirometry is better in cardiac and thoracic surgeries since it provides an appropriate feedback for a slow sustained inspiration and volume. Studies show that low sustained inspirations are much more effective to promote lung expansion rather than fast inspirations. Also, Flow targeted IS demands higher inspiratory flow than does Volume targeted incentive spirometry.[14, 15]

Studies suggest a biologically significant difference in the effect of the volume targeted and flow targeted incentive spirometer devices. Flow targeted devices (Triflow device) increase accessory muscular activity of the upper chest and enforce more work of breathing. Volume incentive spirometry devices (Coach 2 device) improve diaphragmatic activity; impose less work of breathing and higher pulmonary volume. Both of these might be suitable for postoperative training.[16, 17]

The PEFR has been defined by the European Respiratory Society as “the maximal flow which is achieved during the expiration which is delivered with maximal force, starting from the level of maximal lung inflation”. The unit of PEFR is expressed in litres/min.[18] PEFR also called as wright peak flow meter is used to measure the PEFR of a patient. PEFR is an effort-dependent device, which is generating from the larger airways. It varies with age, height, heath status of the person.[19] Surgeries like sternotomy for valve replacement reduce flow rate and the capacity to huff. In order to generate effective force while coughing to clear secretions from the airways. Thus, the PEFR is used to measure an individual’s strength to huff. Flow rates are altered because of restrictive pattern of ventilation and force is generated primarily by abdominal muscles that are expiratory muscles. This depends on the length force relationship and, hence varies with the level of lung inflation. PEFR is impaired with obstruction in airways, conditions which limit chest expansion or which affect respiratory muscle function.

Bhandare SA et al, studied the correlation of peak expiratory flow rate and single breath count in normal adults. SBC showed a strong positive correlation to PEFR. SBC is a simple, alternative bedside assessment test to measure airway function when compared to PEFR. It is inexpensive and an easy to perform test which can be timely repeated as needed. Thus, SBC can be suitably used as a substitute for device-oriented measures, as it requires the use of no common device which could be a cause of risk of spread of infection amongst individuals.[19]

Single breath count (SBC) is an economical and easily accessible parameter to assess the pulmonary functioning in an emergency setting where spirometry is not available. It is easy to perform and requires a simple tuning device (metronome). Single breath count is the measurement of how far an individual can count in serial numbers in normal speaking voice after maximal effortful inhalation without taking another breath. Studies in the past have concluded that SBC correlates with standard measures of pulmonary function in adult.[20, 21, 22]

MATERIALS & METHODS

This Comparative, interventional study was approved by the Institutional Ethics Committee. Participants were selected on basis of inclusion and exclusion criteria. Written informed consent was taken from the patients. Sample size calculation was done by using the free online calculator along with sealed envelope. Data on outcomes and standard deviation were taken from published literature. Sample size of 86 was calculated. Data were statistically analysed on 38 subjects. Willing participants were assigned to the groups by convenient sampling with random allocation. Group A were trained using flow IS device and Group B were trained using volume IS device, along with routine physiotherapy session. Patient’s basic demographic data, history of illness, surgery and treatment details were recorded. PEFR & SBC were taken before & after each treatment session, for both the groups from post-operative day 1 to day 5. There were 3 training session per day under supervision with flow and volume incentive spirometer. Each session had 3 sets of 5 repetitions, for 5 post-operative days. Subject were made to sit upright (long sitting) shoulder relaxed, holding the incentive spirometer in front at the level of the mouth piece. Patients were asked to normally exhale and place lips tightly around the mouthpiece.

To achieve a Slow Sustained Maximal Inspiration (SMI), inhale at a sufficient rate to raise the ball/piston and is repeted. Initially started with the base line of 200 cc on flow incentive spirometer and 250 ml on volume incentive spirometer, which was gradually increased according to the capacity of the patient able to raise the ball/piston. PEFR and SBC were recorded pre and post treatment session from day 1 to day 5. The pre and post readings of outcome measures for day 1 and Day 5, and the difference between day 1 and day 5 were statistically analysed to study the effectiveness of the intervention.

STATISTICAL ANALYSIS

The data was analysed using SPSS software version 16. Normality was tested using Shapiro Wilk test, and as the data was not normally distributed, non-parametric test was applied.

RESULT

The data was analysed using SPSS software version 16. Normality was tested using Shapiro Wilk test, and as the data was not normally distributed, non-parametric test was applied. Comparison of pre and post PEFR and SBC on day 1 and day 5 was done by using Wilcoxon signed Rank test for both group A and group B. Comparison between group A and group B for all parameters was done by Mann-Whitney U test. A total of 38 patients were included in the study; 19 patients were allocated to the Volume targeted Incentive Spirometry group and 19 patients to the Flow targeted Incentive Spirometry group. Baseline demographic characteristics for FIS and VIS group of the participant's age calculated by using Mann-Whitney test were 36.84 ± 9.28 and 40.78 ± 12.53. The gender calculated by using Chi Square test in the FIS group there were 11 (57.9%) male and 8 (42.1%) female and in VIS group were Male 7 (36.8%) and Female 12 (63.2%). There was no statistical difference between the Volume Incentive Spirometry and Flow Incentive Spirometry groups.

Group A = Flow incentive spirometer PEFR

Descriptive statistics of pre and post Peak Expiratory Flow Rate (PEFR) of day 1 and day 5 in flow incentive spirometer summarized in table 1. In FIS Group the mean and standard deviation of pre PEFR on day 1 is 105.26 ± 26.53 lit/min, which ranges from 80-170 and the median quartile value are 100. The mean and standard deviation of post PEFR on day 1 is 141.57 ± 37.60 lit/min, which ranges from 90-240 and the median quartile value are 130. The difference between pre and post PEFR on day 1 is 36.31 ± 21.65.

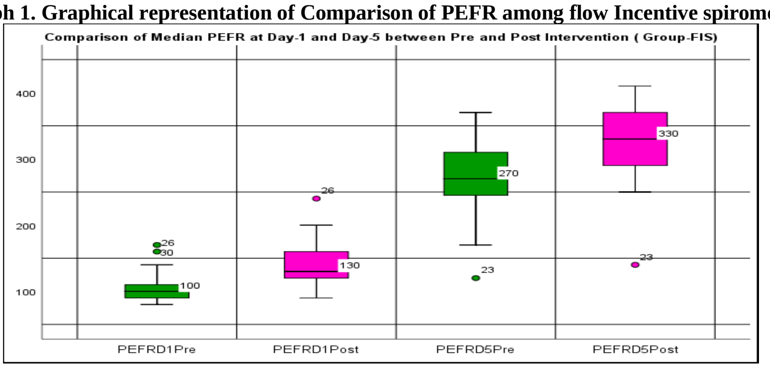
The mean and standard deviation of pre PEFR on day 5 is 267.89 ± 60.42 lit/min, which ranges from 120-370 and the median quartile value are 270. The mean and standard deviation of post PEFR on day 5 is 325.26 ± 66.36 lit/min, which ranges from 140-410 and median quartile value are 330. The difference between pre and post PEFR on day 1 is 57.36 ± 31.59.

Table 1: Descriptive statistics of pre and post PEFR of day 1 and day 5 in flow incentive spirometer.

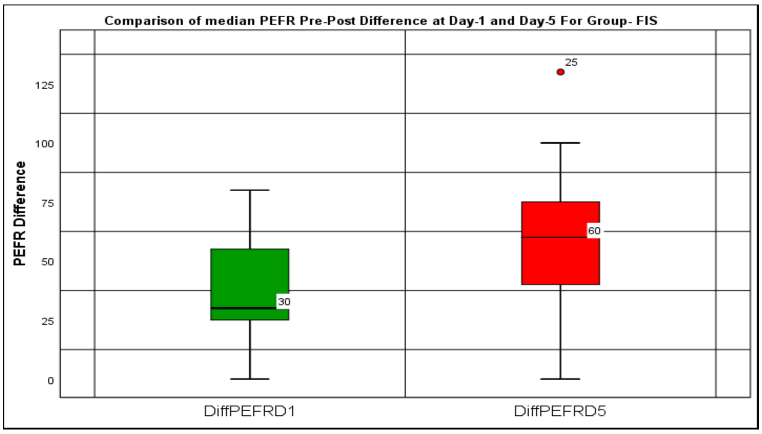
FIS Group	Parameter (L/Min)	Mean	SD	Percentiles (50%) Median	Range	Difference between pre and post PEFR	P Value	Significance
Day 1	Pre PEFR	105.26	26.53	100.00	80-170	36.31 ± 21.65	0.000	S
	Post PEFR	141.57	37.60	130.00	90-240			
Day 5	Pre PEFR	267.89	60.42	270.00	120-370	57.36 ± 31.59	0.000	S
	Post PEFR	325.26	66.36	330.00	140-410			

SD = Standard deviation, P = Probability, S = Significant

Graph 1. Graphical representation of Comparison of PEFR among flow Incentive spirometer.



Graph 2. Graphical representation of Comparison of difference between pre and post PEFR on day 1 and day 5 in flow incentive spirometer.



Inference: The calculated p value for PEFR on day 1and day 5 is P = 0.000 and P = 0.000 respectively, which is statistically significant. The difference of improvement in PEFR on day 1 was 30 and the difference of improvement in PEFR on day 5 was 60 suggesting improvements with FIS. There was significant improvement seen in of PEFR values in all 19 subjects on day 1 and day 5 suggesting improvement after intervention.

<u>Group A = Flow incentive spirometer SBC</u>

Descriptive statistics of pre and post single breath count of day 1 and day 5 in flow incentive spirometer summarized in table 2. In FIS Group the mean and standard deviation of pre SBC on day 1 is 2.47 ± 2.43 Count, which ranges from 0-7 and the median quartile value are 2. The mean and standard deviation of post SBC on day 1 is 4.26 ± 4.06 which ranges from 0-12 and the median quartile value are 5. The difference between pre and post SBC on day 1 is 1.78 ± 1.84.

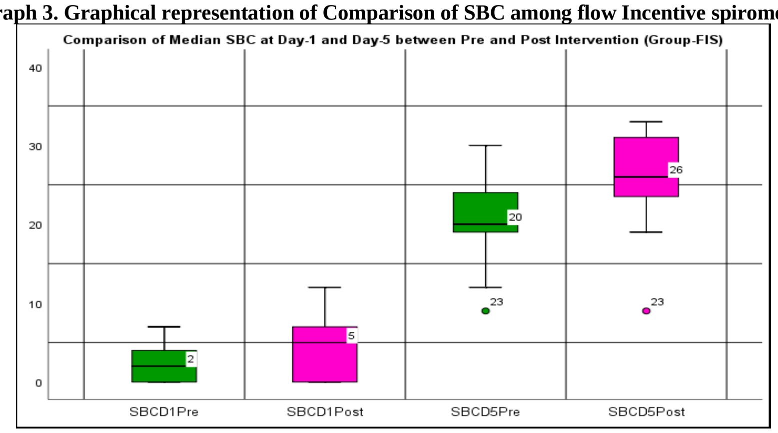
The mean and standard deviation of pre SBC on day 5 is 20.15 ± 5.27 Count which ranges from 9-30 and the median quartile value are 20. The mean and standard deviation of post SBC on day 5 is 25.94 ± 6.15 which ranges from 9-33 and the median quartile value are 26. The difference between pre and post SBC on day 5 is 5.78 ± 2.59.

Table 2: Descriptive statistics of pre and post SBC of day 1 and day 5 in flow incentive spirometer.

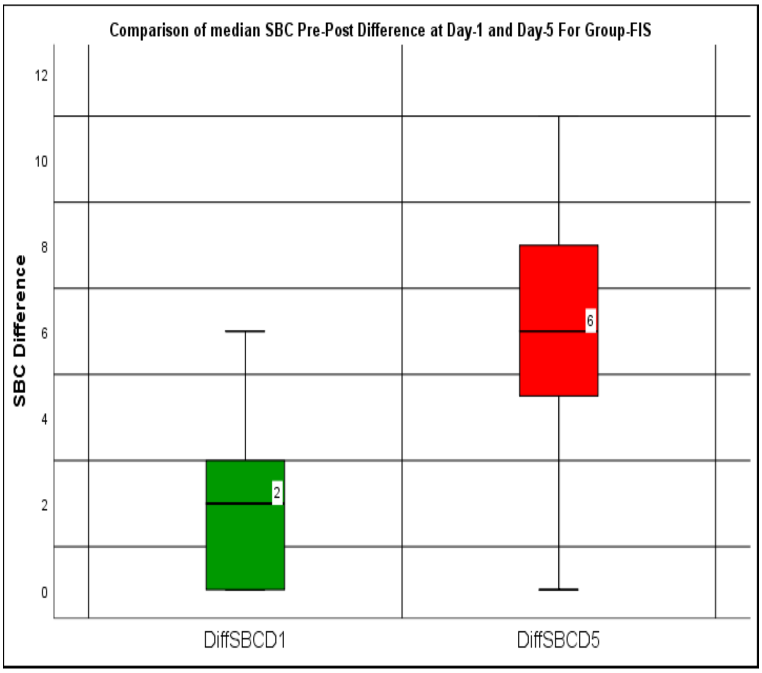
FIS Group	Parameter (L/Min)	Mean	SD	Percentile (50%) Median	Rang	Difference between pre and post SBC	P Value	Significance
Day 1	Pre SBC	2.47	2.43	2.00	0-7	1.78 ± 1.84	0.003	S
	Post SBC	4.26	4.06	5.00	0-12			
Day 5	Pre SBC	20.15	5.27	20.00	9-30	5.78 ± 2.59	0.000	S
	Post SBC	25.94	6.15	26.00	9-33			

FIS = Flow incentive spirometry, SBC = Single breath count, c = count, SD = Standard deviation, P = Probability

Graph 3. Graphical representation of Comparison of SBC among flow Incentive spirometer



Graph 4 Graphical representation of Comparison of difference between pre and post SBC on day 1 and day 5 in flow incentive spirometer.



Inference: The calculated p value for SBC on day 1and day 5 is P = 0.003 and P = 0.000 respectively, which is statistically significant. The difference of improvement in SBC on day 1 was 2 and the difference of improvement in PEFR on day 5 was 6 suggesting improvement with FIS. There was significant improvement seen in of SBC values in all 19 subjects on day 1 and day 5 suggesting improvement after intervention.

<u>Group B = Volume incentive spirometer</u>

<u>PEFR</u>

Descriptive statistics of pre and post Peak Expiratory Flow Rate (PEFR) of day 1 and day 5 in Volume incentive spirometer summarized in table 3. In VIS Group the mean and standard deviation of pre PEFR on day 1 is 94.21 ± 30.24 lit/min, which ranges from 60-160 and the median quartile value are 80. The mean and standard deviation of post PEFR on day 1 is 124.21 ± 35.94 lit/min, which ranges from 80-200 and the median quartile value are 110. The difference between pre and post PEFR on day 1 is 30.00 ± 18.85.

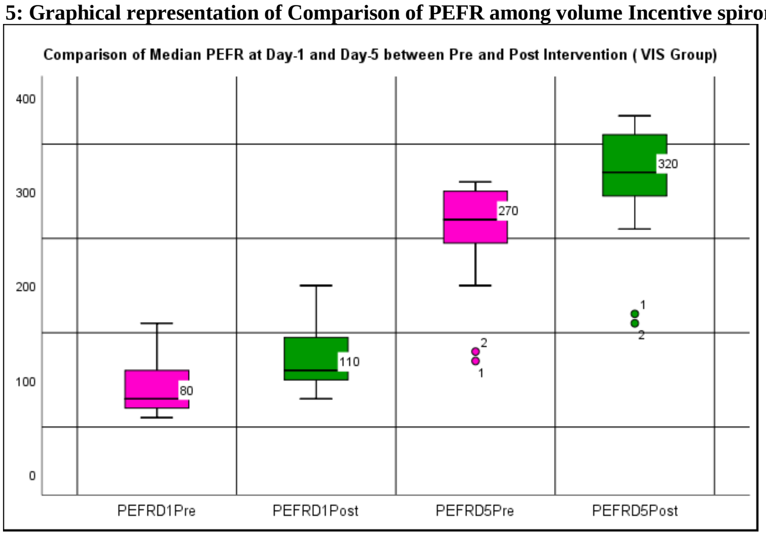
The mean and standard deviation of pre PEFR on day 5 is 257.89 ± 56.72 lit/min, which ranges from 120-310 and the median quartile value are 270. The mean and standard deviation of post PEFR on day 5 is 314.21 ± 63.36 lit/min, which ranges from 160-380 and the median quartile value are 320. The difference between pre and post PEFR on day 5 is 56.31 ± 14.98.

Table 3: Descriptive statistics of pre and post PEFR of day 1 and day 5 in Volume incentive spirometer.

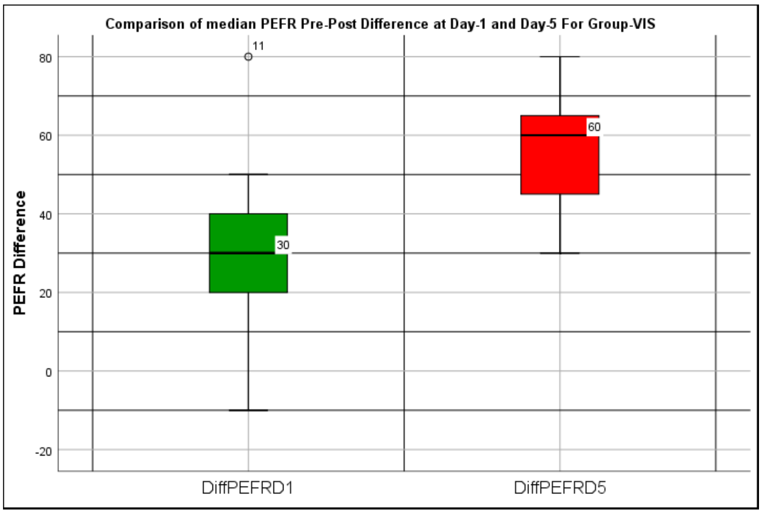
VIS Group	Parameter (L/Min)	Mean	SD	Percentiles (50%) Median	Rang	Difference between pre and post PEFR	P Value	Significance
Day 1	Pre PEFR	94.21	30.24	80.00	60-160	30.00 ± 18.85	0.000	S
	Post PEFR	124.21	35.94	110.00	80-200			
Day 5	Pre PEFR	257.89	56.72	270.00	120-310	56.31 ± 14.98	0.000	S
	Post PEFR	314.21	63.36	320.00	160-380			

PEFR = Peak expiratory flow rate, L/Min = Litter/minute, VIS = volume incentive spirometry, PEFR = Peak expiratory flow rate, SD = Standard deviation, P = Probability

Graph 5: Graphical representation of Comparison of PEFR among volume Incentive spirometer.



Graph 6. Graphical representation of Comparison of difference between pre and post PEFR on day 1 and day 5 in volume incentive spirometer.



Inference: The calculated p value for PEFR on day 1and day 5 is P = 0.000 and P = 0.000 respectively, which is statistically significant. The difference of improvement in PEFR on day 1 was 30 and the difference of improvement in PEFR on day 5 was 60 suggesting improvements with FIS. There was significant improvement seen in of PEFR values in all 19 subjects on day 1 and day 5 suggesting improvement after intervention.

Group B = Volume incentive spirometer SBC

Descriptive statistics of pre and post single breath count of day 1 and day 5 in flow incentive spirometer summarized in table 4. In VIS Group the mean and standard deviation of pre SBC on day 1 is 2.15 ± 2.25 Count, which ranges from 0-7 and the median quartile value are 0. The mean and standard deviation of post SBC on day 1 is 4.15 ± 3.80, which ranges from 0-10 and the median quartile value are 4. The difference pre and post PEFR on day 1 is 2.00 ± 1.91.

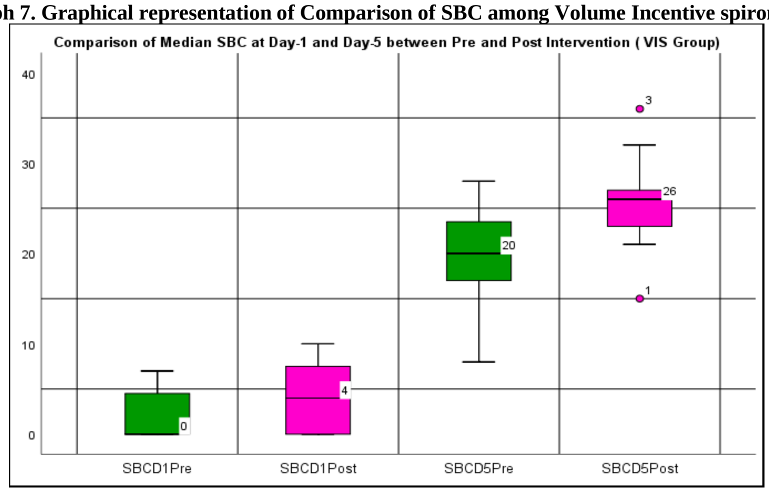
The mean and standard deviation of pre SBC on day 5 is 20.05 ± 4.66 Count, which ranges from 8-28 and the median quartile value are 20. The mean and standard deviation of post SBC on day 5 is 25.52 ± 4.59 Count, which ranges from 15-36 and the median quartile value are 26. The difference between pre and post SBC on day 5 is 5.47 ± 2.29.

Table 4: Descriptive statistics of pre and post SBC of day 1 and day 5 in Volume incentive spirometer.

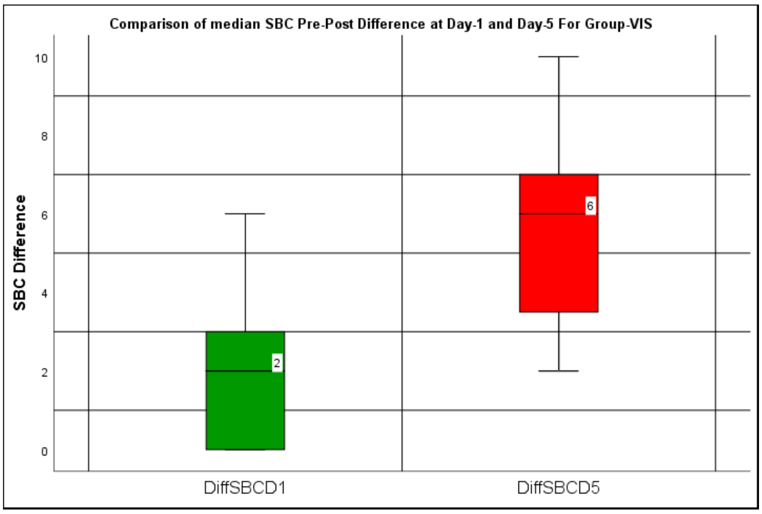
VIS Group	Parameter (L/Min)	Mean	SD	Percentiles (50 %) Median	Rang	Difference between pre and post SBC	P Value	Significance
Day 1	Pre SBC	2.15	2.52	.0000	0-7	2.00 ± 1.91	0.002	S
	Post SBC	4.15	3.80	4.0000	0-10			
Day 5	Pre SBC	20.05	4.66	20.0000	8-28	5.47 ± 2.29	0.000	S
	Post SBC	25.52	4.59	26.0000	15-36			

SD - Standard deviation, P – Probability

Graph 7. Graphical representation of Comparison of SBC among Volume Incentive spirometer



Graph 8. Graphical representation of Comparison of difference between pre and post SBC on day 1 and day 5 in volume incentive spirometer.



Inference: The calculated p value for SBC on day 1and day 5 is P = 0.002 and P = 0.000 respectively, which is statistically significant. The difference of improvement in SBC on day 1 was 2 count and the difference of improvement in PEFR on day 5 was 6 count suggesting improvement with FIS. There was significant improvement seen in of SBC values in all 19 subjects on day 1 and day 5 suggesting improvement after intervention.

COMPARISON OF OUTCOME MEASURES BETWEEN GROUP A AND GROUP B (FLOW INCENTIVE SPIROMETRY AND VOLUME INCENTIVE SPIROMETRY)

PEFR

Descriptive statistics of comparison of difference of mean PEFR and SBC between FIS and VIS on day 1 and day 5 is summarized in table 5. In FIS and VIS group the mean and standard deviation of

PEFR on day 1 is 36.31 ± 21.65 and 30.00 ±18.85 lit/min respectively. The median PEFR for day 1 value in both the groups is 30. Mann Whitney value for FIS and VIS is 120 and 130.00 respectively.

In the FIS and VIS group the mean and standard deviation of PEFR on day 5 is 57.36 ± 31.59 and 56.31 ± 14.98 lit/min respectively. The median PEFR for day 5 value for both the groups is 60. Mann Whitney value for FIS and VIS is 166 and 160.00 respectively.

SBC

In FIS and VIS group the mean and standard deviation of SBC on day 1 is 1.78 ± 1.84 and 2.00 ±1.91 Count respectively. The median SBC for day 1 value for both the groups is 2. Mann Whitney value for FIS and VIS is 166.50 and 179.50 respectively.

In the FIS and VIS group the mean and standard deviation of SBC on day 5 is 5.78 ± 2.59 and 5.47 ± 2.29 Count respectively. The median SBC for FIS and VIS for day 5 value is 4 and 6 respectively. Mann Whitney value for FIS and VIS is 170 and 162.50 respectively.

Table 5: Comparison of Difference of mean PEFR and SBC between FIS and VIS at day and 1 day 5.

		Mean of diff.	SD of diff.	Median of diff.	Man Whitney	P value	Significance
PEFR Day 1	FIS	36.31	21.65	30	120	0.343	NS
	VIS	30.00	18.85	30	130.50		
PEFR Day 5	FIS	57.36	31.59	60	166	0.976	NS
	VIS	56.31	14.98	60	160.00		
SBC Day 1	FIS	1.78	1.84	2.00	166.50	0.681	NS
	VIS	2.00	1.91	2.00	179.50		
SBC Day 5	FIS	5.78	2.59	4.00	170	0.723	NS
	VIS	5.47	2.29	6.00	162.50		

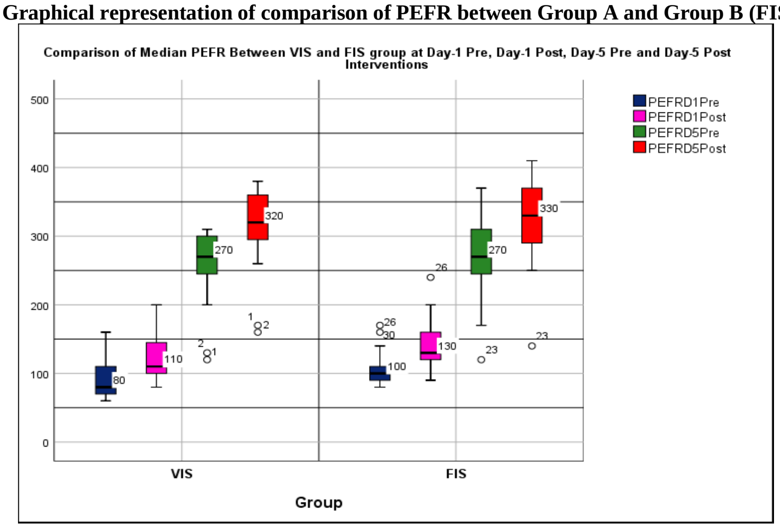
PEFR= Peak expiratory flow rate L/Min, SBC = single breath count, FIS = flow incentive spirometry, VIS = volume incentive spirometry, SD = standard deviation, P = Probability, NS = Non significant, diff = Difference

Inference: As the P value is 0.343, on day 1 the difference of PEFR between FIS and VIS is statistically not significant. On day 5 P value is 0.976, the difference of PEFR between FIS and VIS is statistically not significant.

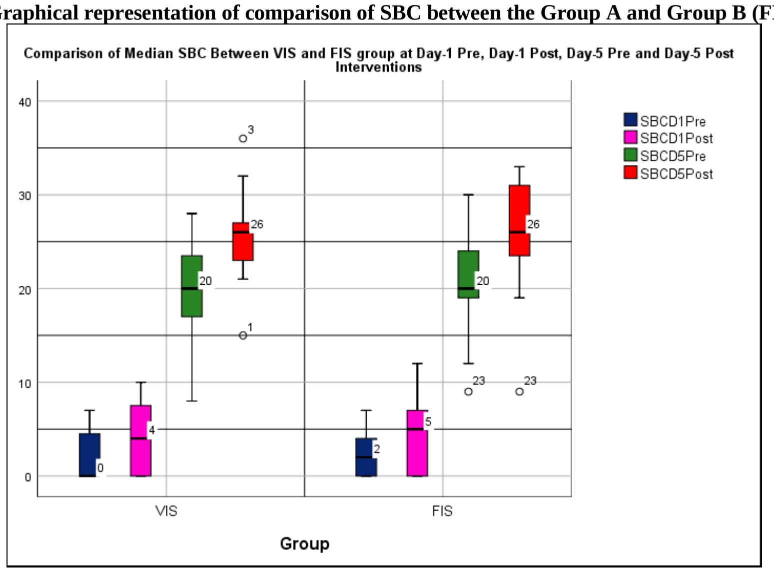
As the P value is 0.681, on day 1 the difference of SBC between FIS and VIS is statistically not significant. On day 5 P value is 0.723, the difference of SBC between FIS and VIS is statistically not significant.

All 38 subjects showed improvement in PEFR and SBC values on day 1 and day 5 in both the groups (FIS and VIS) which is clinically significant, though the calculated p value were not statistically significant.

Graph 9. Graphical representation of comparison of PEFR between Group A and Group B (FIS and VIS)



Graph 10. Graphical representation of comparison of SBC between the Group A and Group B (FIS and VIS)



DISCUSSION

The present interventional study which was conducted to determine the efficacy of Flow and Volume incentive spirometry on Peak expiratory flow rate and Single breath count in post sternotomy. Sternotomy surgery itself is the major factor that leads to, altered breathing pattern, inability to huff and cough effectively; surgical trauma contributes to change in pulmonary mechanism, regional hypoventilation, airway closure and also increases the length of ICU stay. These factors, associated with immobility, pain and fear, favour the adoption of a monotonous breathing pattern without periodic sighs promoting alveolar collapses. Therefore, it is crucial to deal with the post-operative pulmonary complications to avoid its deleterious effects. In this study 38 patients were recruited, and were equally and randomly assigned to 2 groups, group A, flow targeted incentive group and group B, volume targeted incentive spirometry group (Coach 2). Mean and standard deviation of age is 36.84 ± 9.28 and 40.78 ± 12.53 for flow incentive spirometry and volume incentive spirometry respectively.

The objectives of the study were to compare the effect of flow targeted with volume targeted spirometers on Peak expiratory flow rate and single breath count. Some studies have observed the differences in tidal volume and thoraco-abdominal motion when using flow targeted incentive spirometry and volume targeted incentive spirometry devices.[27] Flow-oriented devices impose more work of breathing and increase muscular activity of upper chest. Volume-oriented devices (coach 2) impose less work of breathing and improve diaphragmatic activity. In the current study, In FIS Group A the difference between mean and standard deviation of pre and post PEFR on day 1 was 36.31 ± 21.65 lit/min which improved on day 5 to 57.36 ± 31.59 lit/min suggesting improvement after flow incentive spirometry training, which was statistically significant with p=0.000 for both the days, day 1 and day 5. The difference between mean and standard deviation of pre and post SBC on day 1 was 1.78 ± 1.84 counts which improved on day 5 to 5.78 ± 2.59 count suggesting improvement after flow incentive spirometry training, suggesting it is statistically significant on day 1 p=0.003 and day 5 p=0.000. The findings indicate that the effect of flow incentive spirometry on PEFR and SBC is more on day 5 than day 1.

The exact mechanism of how the flow incentive spirometry works after sternotomy is not known, but some literature suggested that in flow incentive spirometry the patient aims to generate preset flow with full inspiration. A short, sharp inspiration can activate the flow-targeted incentive spirometry devices with a little increase in tidal volume.[23, 24] while using flow incentive spirometry, expansion of the upper chest or the basal area of the lung should be emphasized. Patients should also be able to inspire at high lung volume, expanding the upper chest. Benefits attributed to incentive spirometry include improvement in atelectasis, improved cough mechanism due to improved inspiratory capacity and diaphragm strengthening.[25] During spontaneous breathing, the lung moves with the chest wall because of drop in pleural pressure; thus the trans-pulmonary pressure gradient widens, causing the alveoli to expand, now the alveolar pressure become negative, a pressure gradient which is created between the airway opening and the alveoli, that is trans-respiratory pressure gradient causes gas to flow from the airway into the alveoli.[26]

In VIS Group B the difference between mean and standard deviation of pre and post PEFR on day 1 was 30.00 ± 18.85 lit/min which improved on day 5 to 56.31 ± 14.98 lit/min suggesting improvement after volume incentive spirometry training. The data suggested that difference between mean and standard deviation was statistically significant with both the days having same (p=0.000) on day 1 and day 5. The difference between mean and standard deviation of pre and post SBC on day 1 was 2.00 ± 1.91 counts which improved on day 5 to 5.47±2.29 count suggesting improvement after volume incentive spirometry training. The data suggested that difference between mean and standard deviation was statistically significant on day 1 p=0.002 and day 5 p=0.000. This finding suggested that volume incentive spirometry is more effective on PEFR and SBC on day 5 than day 1.

The mechanism of how the volume incentive spirometry works after sternotomy according to some literature suggested that Volume incentive spirometry device used to encourage to take maximal inhalation volume and help to maintain the patency of the smaller airways. Post-operative hypoxemia is reduced by using incentive spirometry which helps to provide low-level resistance training to the diaphragm and minimizes fatigue there by improving muscle strength and increasing lung volume.[27]

For volume, good strength is required which can be enhanced with device with a set target. Volume targeted device (Coach 2) need less work of breathing and improves diaphragmatic activity and help build endurance of respiratory muscle. Therefore to build strength, endurance and pressure the effort required is more. This may be difficult for post-operative patients to put more efforts (Thoracic and abdominal) due to post surgical pain. To clear the airway, cough should be effective therefore good flow should be generated and is most needed in post-operative conditions.

In post-operative conditions pain and apprehension, general anaesthesia, intubation triggers the production of secretions in upper and lower respiratory tract, altered breathing pattern (shallow/guarded) producing weak cough. Therefore flow targeted device should be used. Physical manoeuvres, incentive spirometry, deep breathing exercises and intermittent positive pressure breathing have been shown to prevent, pulmonary complications after surgery. Improvement in the respiratory muscle strength thus leads to better ventilation and appropriate clearance of tracheobronchial tree.

Comparing the outcome measures, group A and group B for day 1 and day 5 were not statistically significant. P value for outcome measures for group A and group B on day 1 is 0.343 and 0.681 respectively and P value for outcome measures for group A and group B on day 5 is 0.976 and 0.723 respectively. The p value is not statistically significant on comparing between the groups, but the improvement in PEFR and SBC from day 1 to day 5 is clinically significant, which indicates that both the devices contribute equally in improving the pulmonary status and avoiding post-operative complications.

Mang H, et al, in 1989, stated that after thoracic surgery, all lung volume and capacities decrease due to impairment of thorax and ribcage movement, changes in chest wall muscle tone, an increase tendency to lung recoil, and airway closure. At the end of each expiration few or some smallest airways collapse either partially or completely. This continues until normally a deep breathing is established. Hence incentive spirometry may help to overcome postoperative complications.[28]

Parreira VF et all stated that volume targeted incentive spirometry imposes less work of breathing and improve diaphragmatic activity compared with the flow targeted incentive spirometry. If using incentive spirometry post-operatively, volume targeted devices are more appropriate as they may impose less work of breathing, fatigue and pain.[29]

Kundra et al. carried out a comparative study on the effect of preoperative and postoperative incentive spirometry on the pulmonary function of 50 subjects who underwent laparoscopic surgery for cholecystectomy. The control group did incentive spirometry only in the postoperative phase. The study group carried out incentive spirometry before surgery, every 4 hours, with 15 repetitions in each session, for 1 week. Pulmonary function was noted before and post-surgery after 6hours, 24hours, and 48 hours and at the time of discharge. Use of incentive spirometry in preoperative period leads to greater improvement in lung functions then if given in the post-operative period. The authors concluded that use of volume incentive spirometry will result in active recruitment of diaphragm and other inspiratory muscles which may improve diaphragmatic excursion and pulmonary function is well-preserved with preoperative than postoperative incentive spirometry.[30]

Bartlett RH stated that post-operatively achieved functional requirements of re-expansion of lung, with breathing exercises which is characterized by a long, slow inspiration, with inspiratory holds. Incentive spirometry provides these components along with visual feedback, providing the subjects to measurable goal, to achieve appropriate volume and encourages good technique.[31, 32]

CONCLUSION

The present study concludes that flow targeted incentive spirometry and volume targeted incentive spirometry were equally effective in Improving peak expiratory flow rate and single breath count in post sternotomy for valve replacement.

Acknowledgement: None

Conflict of Interest: None

Source of Funding: None

Ethical Approval: Approved

REFERENCES

1. Dalton ML, Connally SR, Sealy WC. Julian's reintroduction of Milton's operation. Ann Thorac Surg 1992;53:532–3.
2. Kumar AS, Alaparthi GK, Augustine AJ, Pazhyaottayil ZC, Ramakrishna A, Krishnakumar SK. Comparison of flow and volume incentive spirometry on pulmonary function and exercise tolerance in open abdominal surgery: a randomized clinical trial. Journal of Clinical and Diagnostic Research: JCDR. 2016 Jan;10(1):KC01.
3. Pasquina P, Walder B. Prophylactic respiratory physiotherapy after cardiac surgery: systematic review. Bmj. 2003 Dec 11;327(7428):1379.
4. Tom J Overend et al. Effect of Incentive Spirometry on Post operative Pulmonary Complications: Systematic Review. Chest 2001;120;921-978
5. B. A. Zikaria, et at. Alteration of Ventilatory Function and Breathing Pattern Following Surgical Trauma. Annals of Surgery Jan 1972.
6. Henrik H Bendixen,el at. Pattern of ventilation in young adults. Journal of Applied Physiology March 1964 vol. 19 no.2195-198
7. Alexander JI, Spence AA, PARIKH R, Stuart B. The role of airway closure in postoperative hypoxaemia. BJA: British

Journal of Anaesthesia. 1973 Jan 1;45(1):34-40.

8. Berthoud MC, Reilly CS. Adverse effect of general anaesthetics. Drug Saf 1992 Nov-Dec; 7(6):434-59
9. Clarke RS. Adverse effects of intravenously administered drugs used in anaesthetic practice. Drugs. 1981 Jul;22(1):26-41.
10. Pasquina P, Walder B. Prophylactic respiratory physiotherapy after cardiac surgery: systematic review. Bmj. 2003 Dec 11;327(7428):1379.
11. Agostini P, Calvert R, Subramanian H, Naidu B. Is incentive spirometry effective following thoracic surgery?. Interactive cardiovascular and thoracic surgery. 2008 Apr 1;7(2):297-300.
12. Restrepo RD, Wettstein R, Wittnebel L, Tracy M. Incentive spirometry: 2011. Respiratory care. 2011 Oct 1;56(10):1600-4.
13. Jennifer A Pryor, Physiotherapy Technique In: Jennifer A Pryor, S Ammani Prasad, editors. Physiotherapy for respiratory and cardiac problems: adults and paediatrics 3 rd edition. Churchill Livingstone, an imprint Elsevier, Edinburg, 2004
14. Kumar AS, Alaparthi GK, Augustine AJ, Pazhyaottayil ZC, Ramakrishna A, Krishnakumar SK. Comparison of flow and volume incentive spirometry on pulmonary function and exercise tolerance in open abdominal surgery: a randomized clinical trial. Journal of clinical and diagnostic research: JCDR. 2016 Jan;10(1):KC01.
15. Weindler J, Kiefer RT. The efficacy of postoperative incentive spirometry is influenced by the device-specific imposed work of breathing. Chest. 2001 Jun 1;119(6):1858-64.
16. Alaparthi GK, Augustine AJ, Anand R, Mahale A. Comparison of diaphragmatic breathing exercise, volume and flow incentive spirometry, on diaphragm excursion and pulmonary function in patients undergoing laparoscopic surgery: a randomized controlled trial. Minimally invasive surgery. 2016;2016.
17. Manjunath CB, Kotinatot SC. Peak expiratory flow rate in healthy rural school going children (5-16 years) of Bellur region for construction of nomogram. Journal of clinical and diagnostic research: JCDR. 2013 Dec;7(12):2844.
18. Bongers T, O'driscoll BR. Effects of equipment and technique on peak flow measurements. BMC pulmonary medicine. 2006 Dec;6(1):1-6.
19. Bhandare SA, Rasal SS, Iyer SK. Correlation of peak expiratory flow rate and single breath count in normal adults. International Journal of Research in Medical Sciences. 2021 Jul;9(7):1960.
20. Bartfield JM, Ushkow BS, Rosen JM, Dylong K. Single breath counting in the assessment of pulmonary function. Annals of emergency medicine. 1994 Aug 1;24(2):256-9
21. Elsheikh B, Arnold WD, Gharibshahi S, Reynolds J, Freimer M, Kissel JT. Correlation of single-breath count test and neck flexor muscle strength with spirometry in myasthenia gravis. Muscle & nerve. 2016 Jan;53(1):134-6
22. Agostini P, Singh S. Incentive spirometry following thoracic surgery: what should we be doing?. Physiotherapy. 2009 Jun 1;95(2):76-82.
23. Restrepo RD, Wettstein R, Wittnebel L, Tracy M. Incentive spirometry: 2011. Respiratory care. 2011 Oct 1;56(10):1600-4.
24. Mier AN, Brophy CO, Estenne M, Moxham JO, Green M, De Troyer A. Action of abdominal muscles on rib cage in humans. Journal of Applied Physiology. 1985 May 1;58(5):1438-43.
25. American Association for Respiratory Care. AARC clinical practice guideline. Incentive spirometry. Respir Care. 1991;36:1402-5.
26. Weindler J, Kiefer RT. The efficacy of postoperative incentive spirometry is influenced by the device-specific imposed work of breathing. Chest. 2001 Jun 1;119(6):1858-64.
27. Mang H, Weindler J, Zapf CL. Postoperative Atemtherapie mit Incentive Spirometry [Postoperative respiratory therapy using incentive spirometry]. Anaesthesist. 1989 Apr;38(4):200-5. German. PMID: 2658675.
28. Minschaert M, Vincent JL, Ros AM, Kahn RJ. Influence of incentive spirometry on pulmonary volumes after laparotomy. Acta Anaesthesiologica Belgica. 1982 Jan 1;33(3):203-9.
29. Parreira VF, Tomich GM, Britto RR, Sampaio RF. Assessment of tidal volume and thoracoabdominal motion using volume and flow-oriented incentive spirometers in healthy subjects. Brazilian journal of

medical and biological research. 2005;38: 1105-12.
30. Kundra P, Vitheeswaran M, Nagappa M, Sistla S. Effect of preoperative and postoperative incentive spirometry on lung functions after laparoscopic cholecystectomy. Surgical Laparoscopy Endoscopy & Percutaneous Techniques. 2010 Jun 1;20(3):170-2.
31. Bartlett RH, Gazzaniga AB, Geraghty TR. Respiratory maneuvers to prevent postoperative pulmonary complications: a critical review. Jama. 1973 May 14; 224(7):1017-21.
32. Geete DB, Shetye JV, Sathe AM. Physiotherapy management of geriatric COVID-19 patients in an intensive care unit of a government tertiary care hospital: A case series. World Journal of Advanced Research and Reviews. 2020;8(3):007-13.

How to cite this article: Anil M. Sathe, Sushama A. Bhandare. Comparison of effect of flow and volume incentive spirometry on peak expiratory flow rate and single breath count in post sternotomy. *Int J Health Sci Res.* 2022; 12(8):167-180.
DOI: *https://doi.org/10.52403/ijhsr.20220824*

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