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Effect of Respiratory Proprioceptive Neuromuscular Facilitation in Phase One Cardiac Rehabilitation – A Randomized Controlled Trial

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Abstract

Background: Patients undergoing coronary artery bypass graft (CABG) and valve replacement surgery often develop pulmonary complications in early post-operative period as results of decreased lung function and impaired cough reflex. The recent study aimed to determine and compare effectiveness of respiratory PNF to conventional physiotherapy in improving the pulmonary function and airway clearance in early period of CABG and valve replacement patients.

Methods: A Randomized control trial was conducted on 46 subjects with median sternotomy incision. Participants were assigned to either Group A (n=23) received phase one of cardiac rehabilitation or Group B (n=23) received phase one of cardiac rehabilitation and respiratory PNF. The sessions were carried for 30 min for five consecutive days twice a day. Outcome measure in the present study were peak flow meter, thoracic expansion, sputum volume, respiratory rate, heart rate and blood pressure. The outcome measures were evaluated on baseline and post 5 days of the intervention.

Results: within group analysis revealed that both the interventional and control groups improved significantly on all outcome measure with p-value less ($p<0.005$) than in all parameters expect for blood pressure, whereas a significant difference was seen in between group analysis in blood pressure (0.0500) and hear rate (0.0210).

Conclusion: the study concluded that phase one cardiac rehabilitation along with respiratory PNF are effective in improving the lung function, rate and depth of breathing, sputum clearance.

Keywords: phase one cardiac rehabilitation, respiratory PNF, CABG and valve replacement.

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Introduction

Due to a rise in the disease frequency, cardiovascular diseases have lately become more important in India. It is first among the top 5 causes of mortality of coronary vascular disease.[1]

CABG and valve surgery is carried through median sternotomy incision, which violates the chest wall. This has an impact on breathing pattern, due to which rate and depth of breathing is altered. Pain is experienced while breathing so individuals take shallow breaths that leads to less thoracic movement and causes decreased thoracic expansion of the chest.[2] After surgery patients commonly avoid coughing due to the prolonged effects of anesthesia and the absence of the cough reflex because of the pain at the incision site, which causes the cough to accumulate within the bronchial tree.

Cardiac rehabilitation increases exercise ability, quality of life, and mental health along with lowering mortality, morbidity, and unnecessary hospital admissions.[6] Following heart surgery, inpatient cardiac rehabilitation, also known as Phase I cardiac rehabilitation programs, is used to encourage early mobility and improve post-operative care.[5]

Breathing depth and rate can be changed by proprioceptive and tactile stimulation through neurophysiological facilitation. Stretching the intercostals is a productive treatment that enhances respiratory muscle activation and breathing rhythm, increases diaphragmatic excursion, chest expansion, and elevation of the chest wall. Anterior basal lift is procedure that aids increasing respiratory muscle activity and in turn increases intrathoracic lung capacity, which helps to increase flow rate percentage.[7,8] According to Rood, the diaphragm is activated through co-contraction of the abdomen this technique stretches the abdominal muscles, which excites the muscular spindle and caused its homogeneous extrafusal muscles to contract. Post operative pulmonary complications are most common problems encountered by physiotherapist in early phase of cardiac rehabilitation. The purpose of the research was to evaluate and compare effectiveness of respiratory PNF in phase one cardiac rehabilitation.

Method

Present study was conducted in Intensive Thoracic Unit of tertiary care hospital, in Belagavi city from January 2023 to July 2023. An ethical clearance from institution ethical committee was obtained and the study was registered under CTRI. A Randomized control trial was conducted on 46 subjects with median sternotomy incision. Participants were assigned to either Group A (n=23) received phase one of cardiac rehabilitation or Group B (n=23) received phase one of cardiac rehabilitation and respiratory PNF.An ethical clearance from institution ethical committee was obtained and the study was CTRI registered. Participants were screened for inclusion and exclusion criteria. Following the screening criteria eligible participants willing to participate in the study were provided with written inform consent. Simple random sampling was used to accomplish the randomization. The participants were randomly allotted in experimental and control group through envelop method. The study was a single blinded study. The statistician involved in the study was blinded to the intervention and control groups to ensure unbiased data analysis. Demographic data, pre and post assessment of the outcome measures were noted.

Participants:

Inclusion criteria: Participants age group between 20- 70 years of both the genders. Participants who are willing to participate. Participants referred to physiotherapy. Participants who underwent median sternotomy incision.

Exclusion criteria: Participants who are uncooperative. Participants with hemodynamic instability. Critically ill patient. Participants with cognitive inability to understand the procedure.

Intervention:

Similar post-operative medical treatment, nebulizer (budecort 0.5mg, duolin nebulizer solution), chest binder and incentive spirometer (800 cc/ sec) were administered to all the participants. Cardiac rehabilitation intervention with regards to the research, intervention study, started on POD2 for both the groups. The same therapist administered intervention in both the groups. Each participant was given a demonstration and detailed instructions about the intervention. Subjects were randomly allotted (envelop method) to Group A (control group) and Group B (experimental group). Intervention lasted for 20-30 minutes, twice a day for 5 days for both the groups.

Control group:

The treatment included standardized protocol of phase 1 cardiac rehabilitation.

Step 1: diaphragmatic breathing exercises. (5 repetitions, 3 sets), Active assisted ROM bilateral upper limb and lower limb (5repetitions, 3 sets) Ankle toe movements (5 repetitions, 3 sets), thoracic mobility exercises (5 repetitions, 3 sets)

Step 2: repeat step 1, sitting on the edge of the bed, active range of motion bilateral upper limb (shoulder abduction were limited to below 90 degree) and lower limb (5 repetitions, 4 sets)

Step 3: repeat step1, repeat step 2, supported room ambulation.

Step 4: repeat step1, repeat step 2, repeat step 3, trunk mobility exercises (5 repetitions, 3 sets), and unsupported ward ambulation (2 rounds)

Step 5: repeat step 4 and downstairs 2- flight (2 times/day), progression of ambulation[10]

Intervention group:

Similar intervention as above was followed along with phase 1 cardiac rehabilitation respiratory PNF was administered.

Inter costal stretch: subject positioning was standardized to supine flat, limbs in neutral position. The position of the therapist is behind the patient. First palpate the suprasternal notch. Then goes downward about 5cm. 2nd rib lies at the level of angle of Louis trace the finger laterally. The intercostal stretch technique was applied over 2nd- 6th rib bilaterally. The technique was given with the help of index finger. The direction of the pressure was downward towards the next rib. Technique was applied during expiration phase. It is applied for three breaths with 1-minute rest and three times repetition.[7]

Anterior Basal lifting: This procedure was performed by placing the hands under the posterior ribs of the supine patient and gently lifting the lower ribs upward. The lift is maintained and provides a maintained stretch and pressure posteriorly and stretch anteriorly as well. This technique was performed thrice and maintained for five breaths.[7,11]

Co contraction of abdomen: Provided by the therapist by pressing adequately pressure on the lower ribs and pelvis on the same side, so that the pressure is applied at the same angle. This technique will be performed thrice and maintained for five breaths.[11,12]

Outcome measures:

Peak expiratory flow meter:

the patient was seated in a chair or in fowler's position on bed. The patient was instructed to inhale as deeply as they could and blow into the mouthpiece as rapidly as possible. The method was carried out three times for accurate measurements, and the average of the three was calculated.[8,3]

Sphygmomanometer:

diamond mercurial blood pressure monitor was used to access the blood pressure. The patient was seated comfortably supine position.[11]

Respiratory rate:

the patient was in supine position, with the use of stopwatch the patient's respiratory rate was counted for one minute.[11]

Heart rate:

pulse oximeter was used to access the heart rate. The patient was in supine position resting comfortably.

Sputum volume:

Sputum was collected in a container with markings to indicate the volume of sputum produced during each intervention (for each session/day)[13]. On POD 6, it was reported how much sputum had been expectorated overall (in mL) from POD 2 to POD 6.[6]

Thoracic expansion measurements:

The participants were sitting comfortably in upright position and the readings were taken at three level that is at the axillary, nipple, and xiphisternum were marked. They were instructed to take a few regular breaths first and then asked for full exhalation, followed by a full inhalation and a short holding period. Using a measuring tape, the difference between the maximal inhalation and exhalation was recorded while holding breath at each of the three levels.[7,8,27]

Statistical analysis:

The various statistical measures such as mean, standard deviation, paired t test, Kolmogorov Smirnov test, Mann- Whitney U test was applied as required. Within group outcome measures like RR, HR blood pressure, thoracic expansion measurements, sputum volume and PEFR within group A and group B and between group A and group B was done using Kolmogorov Smirnov test, Mann-Whitney U test, dependent t test, independent t test.

Results

A total of 60 participants were screened for inclusion criteria, of this 10 did not meet the inclusion criteria, 4 declined to participate. 46 participants met the inclusion criteria and were randomly divide into experimental and control group. All participants baseline and post intervention i.e., on 5th day score of respiratory rates, heart rate, peak flow rate, thoracic expansion measurements, sputum volume and blood pressure were noted.

Table 1 shows the age, gender, and BMI of the subject in both the groups. There was no statistical difference in age and BMI. Males accounted for more than half of these patients. (56.52% in control and 78.26% in intervention group)

Although respiratory rate improved markedly in both the groups through the intervention, The difference in effect size between the two intervention was minimal (table 2) (figure 1). Group B was found to be more effective than group A. Heart rate improved markedly in the group through the intervention, The difference in effect size between the two intervention was minimal (table 3). Group B was found to be more effective than group A. As the table 4 suggest that systolic blood pressure has shown significant improvement from baseline to day 5 for both within and between group analysis. The difference in effect size was seen more in group B as compared to group A (table 4). There was no significant statistical difference seen in diastolic blood pressure in both the groups. (Table 5) sputum volume markedly improved in the group through the intervention (table 6) (figure 2), The difference in effect size between the two intervention was minimal. Group B was found to be more effective than group A. Peak expiratory flow rate markedly improved in the group through the intervention (table 7) (figure 3). The difference in effect size between the two intervention was minimal. Group A was more effective than group B. Thoracic expansion measurement markedly improved in the group through the intervention (table 8). The difference in effect size between the two intervention was minimal. There was significant difference in group B at t4 level.

Table 1: demographic data

Profile	group A	%	Group B.	%	p-value
Gender					
Male	13	56.52	18	78.26	0.1160
Female	10	43.48	5	21.74	
Age					
<= 40 yrs.	5	21.74	5	21.74	
41- 50 yrs.	2	8.70	7	30.43	0.2890
51- 60 yrs.	8	34.78	6	26.49	
< 61 yrs.	8	34.78	5	21.74	
Obesity					
Normal	3	13.04	5	21.74	
Over-weight	11	47.83	8	34.78	0.5990
Obese	9	39.13	10	43.48	
Total	23	100.00	23	100.00	

Table 2: Respiratory rate:

	Within group			Between group		
Group	Chang-es from	Mean ± SD	p-value	Effect size	Mean ± SD	p-val-ue
Group A	BL-Day 5	7.48 ± 2.27	0.0001*	0.8450	7.48 ± 2.50	0.3650
Group B	BL-Day 5	11.91 ± 4.20	0.0001*	0.8750	11.91 ± 2.90	0.6680

Table3: Heart rate:

	Within group			Between group		
Groups	Chang-es from	Mean ± SD	p-value	Effect size	Mean ± SD	p-value
Group A	BL-Day 5	8.96 ± 12.87	0.0002*	0.8450	8.96 ± 14.83	0.0020*
Group B	BL-Day 5	11.48 ± 5.43	0.0001*	0.8750	11.48 ± 5.62	0.4910

Table 4: Systolic blood pressure:

	Within group			Between group		
Groups	Changes from	Mean ± SD	p-value	Effect size	Mean ± SD	p-value
Group A	BL-Day 5	4.04 ± 8.21	0.0479*	0.2000	4.04 ± 7.81	0.0130*
Group B	BL-Day 5	8.78 ± 10.94	0.0078*	0.4340	8.78 ± 9.03	0.0500*

Table 5: Diastolic blood pressure:

	Within group			Between group		
Groups	Chang-es from	Mean ± SD	p-value	Effect size	Mean ± SD	p-val-ue
Group A	BL-Day 5	-0.39 ± 7.20	0.9375	0.0020	-0.39 ± 6.82	0.0870
Group B	BL-Day 5	0.43 ± 10.58	0.9039	0.0900	0.43 ± 15.21	0.7390

Table 6: Sputum volume:

	Within group			Between group		
Groups	**Changes from**	**Mean ± SD**	**p-value**	**Effect size**	**Mean ± SD**	**p-val-ue**
Group A	Pre-test to post-test	12.35 ± 4.73	0.0001*	0.8770	12.35 ± 4.63	0.4160
Group B	Pre-test to post-test	20.70 ± 4.29	0.0001*	0.9610	20.70 ± 4.62	0.7490

Table 7: Peak expiratory flow rate:

	Within group			Between group		
Groups	**Changes from**	**Mean ± SD**	**p-value**	**Effect size**	**Mean ± SD**	**p-value**
Group A	Pre-test to post-test	113.79 ± 25.92	0.0001*	0.9530	113.79 ± 31.03	0.5450
Group B	Pre-test to post-test	161.45 ± 68.95	0.0001*	0.8510	161.4 5± 84.04	0.1060

Table 8: Thoracic expansion measurement:

Measure-ments	Groups	Within group			Between group		
		Chang-es from	**Mean± SD**	**p-value**	**Effect size**	**Mean ± SD**	**p-value**
At axilla	Group A	Pre-test to post-test	0.48 ± 0.19	0.0001*	0.8690	0.48 ± 0.19	0.8650
	Group B	Pre-test to post-test	0.59 ± 0.25	0.0001*	0.8490	0.59 ± 0.25	0.8650
At t4 level	Group A	Pre-test to post-test	0.85 ±0.31	0.0001*	0.8880	0.85 ±0.31	0.1100
	Group B	Pre-test to post-test	1.19 ± 0.33	0.0001*	0.9320	1.19 ± 0.33	0.1450
At xiphoid process	Group A	Pre-test to post-test	0.83 ± 0.30	0.0001*	0.8890	0.83 ± 0.30	0.6650
	Group B	Pre-test to post-test	0.83 ± 0.48	0.0001*	0.7560	0.83 ± 0.48	0.7800

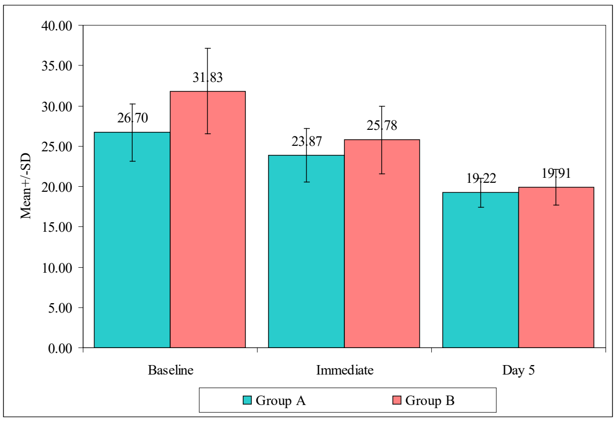

Figure 1: Comparison of Group A and Group B with RR scores at different treatment time points

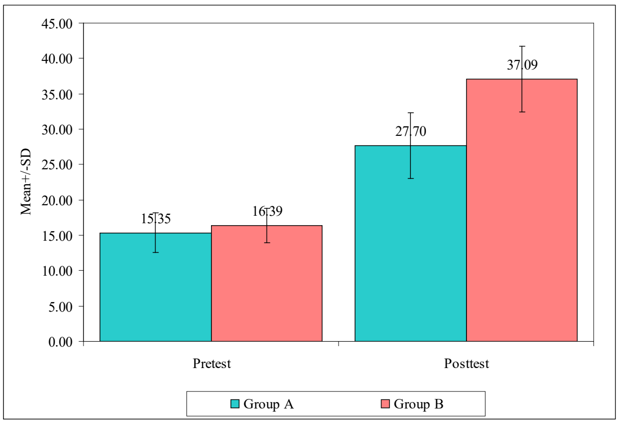

Figure 2: Comparison of Group A and Group B with SPUTUM VOLUME scores at different treatment time points

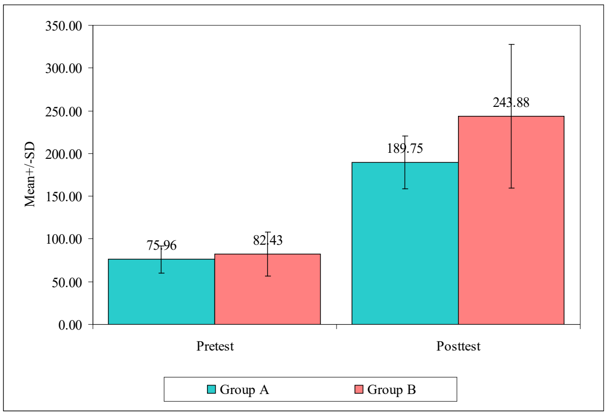

Figure 3: Comparison of Group A and Group B with PEAK FLOW TARE scores at different treatment time points

Discussion

The present study had focused to evaluate the comparative effectiveness of respiratory PNF with conventional cardiac rehabilitation on RR, HR, blood pressure, PEFR, thoracic expansion flow rate and sputum volume in phase one cardiac rehabilitation. This study is a single blinded randomized controlled trial. The total number of participant's recruited in the study were (n=46) in phase one cardiac rehabilitation with median sternotomy incision.

According to literature PNF procedures are applied to enhance pulmonary functioning and diaphragm muscle activity. Techniques are used to increase reaction and strengthen the muscles that control breathing. The direct application of these techniques, which are based on SHERRINGTON'S LAW OF SUCCESSIVE INDUCTION, stimulates the intrinsic muscles of respiration and increases the range of motion of the chest and diaphragm. This facilitates movement by inducing a stretch reflex and stimulating the intrinsic muscles of respiration.[13] A facilitator stimulus in the form of PNF respiration is generally established to induce responses to reflex respiratory movement approaches involve the use of external proprioceptive and tactile signals to produce reflex respiratory movement reactions that alters breathing frequency and depth. Abdominal co-contraction, intercostal stretch, and anterior stretch basal lift are some common PNF procedures.[17,18]

Chordiya SS et al research concluded that the values of pulmonary function and hemodynamic parameters were compared following traditional chest physiotherapy, and it was shown that PNF considerably improved the values of CPT pulmonary and hemodynamic parameters in mechanically ventilated patients[14]. The study statement by Kumar JA et al. our current research outcome by suggesting that phase one cardiac rehabilitation along with respiratory PNF shows enhancement in patient condition through decrease in RR, HR and Spo2.[15] During respiratory PNF, specific patterns of breathing and muscles contractions are employed to activate the muscle responsible for breathing, such as diaphragm, intercostal and accessory respiratory muscles. This activation leads to an increased awareness of breathing process, improving coordination and efficiency of breathing muscles. Therefore, in the recent study shows that post 5 days of intervention in post operated CABG and valve replacement patients there was significant difference in RR, heart rate. The study statement by Kumar JA et al. our current research outcome by suggesting that phase one cardiac rehabilitation along with respiratory PNF shows enhancement in patient condition through decrease in RR, HR and Spo2.[15]

The respiratory drive is controlled by input from sensory receptors in the airway, lungs, and respiratory muscles as well as central and peripheral chemoreceptors, the respiratory rate decreases when chest PNF is administered. The Golgi Tendon Organ (GTO), which is responsive to muscular stretch, regulates the contraction and relaxation of the respiratory muscles. This causes the muscle spindles to fire, which sends the signal to the central nervous system via the Alpha and Gamma motor neurons, which are directly in charge of starting the contraction of the muscle. IC Stretch causes the muscle fibers to contract and therefore resist the stretch because it enhances alpha motor neuron activity. The strength of the stretch reflex is controlled by gamma motor neurons, which innervate intrafusal muscle fibers of muscle spindles. Stretching the chest wall right before inhalation enhances gamma motor neuron discharge and improves alpha motor neuron activity.[7,8,16]

Thorat KD et al conducted a study on patients with spinal cord injury which was mainly based on pulmonary function and chest expansion[17]. it suggested that respiratory PNF enhanced pulmonary function and chest expansion in patients with spinal cord injury. In the present study significant difference was seen in thoracic expansion measurements at all three levels i.e., at axilla, at T4 level, at xiphoid process but effect size was more at t4 level in the experimental group. Respiratory PNF is a technique used to enhance respiratory muscle coordination and thoracic expansion. The mechanism of increase thoracic expansion after respiratory muscle PNF involves stimulating proprioceptive receptors in respiratory muscle which provides feedback to the central nervous system. The proprioceptive feedback from the activated respiratory muscles helps the CNS to fine-tune the timing and intensity of muscle contraction during breathing. This enhanced proprioceptive feedback for better synchronization of the respiratory muscles leading to a more effective and coordinated expansion of the chest during inspiration.

Mistry HM et al conducted a study and was based on RR, PEFR and chest expansion measurements in patient with chronic obstructive pulmonary disease[8]. The study concluded that respiratory PNF was effective in improving RR, PEFR, and chest expansion. In the present study it shows that post 5 days of intervention in CABG and valve replacement surgery it was effective in reducing RR, increasing PEFR and thoracic expansion measurements. Increase in PEFR after introducing respiratory PNF is due to the following: improving respiratory muscle strength, enhanced coordination i.e., effective breathing requires precise coordination between respiratory muscles, increased thoracic mobility, reduced airway resistance i.e., improved respiratory muscle strength and coordination along with increased thoracic mobility, can reduce this resistance. When the respiratory muscle work optimally, they can effectively overcome any resistance encountered in the airways, leading to smooth and increased peak expiratory flow rate.

Amin R et al conducted a study on patients undergoing CABG which was mainly based on pulmonary ventilation regimen to improve ventilation and avoid post operative complications in CABG patients,[10] similar observations were seen in the present study using incentive spirometry along with respiratory PNF and CRP enhances sputum clearance and improve pulmonary ventilation.

The primary muscle of breathing is diaphragm. Through its insertion at the lower ribs, the diaphragm exerts direct pressure on the rib cage, which the abdominal muscles then use to lower intrathoracic pressure. Effective coughing is influenced by the strength of the abdominal muscles. Individuals with weak abdominal muscles exhibit inefficient coughing, which can accumulate secretions and cause infections, which can impair pulmonary function.[16] This results in functional interruption of the diaphragm movement by reflex suppression of the phrenic nerve.[10,15,19,20]

In the present study CRP have significant effect on hemodynamic responses such as heart rate and blood pressure. Stable HR, SBP, and DBP readings during both PNF stimulations show that the procedures were properly tailored to the patients' needs. Aggressive stimulation may cause tachycardia, as well as discomfort and fatigue. The comparison between the control and interventional group showed significant improvement in heart rate and SBP and DBP post intervention in both the groups. O' Farrell et al found that low intensity exercise training significant improvement in SBP and DBP. The result of this study can be supported by Ghashghaei FE et al, which characterized that cardiac rehabilitation significantly improves functional capacity and some hemodynamic responses post CABG.[23,4] Therefore, the results of this study provide preliminary evidence where respiratory PNF along with cardiac rehabilitation was an effective treatment to improve chest expansion, peak expiratory flow rate, sputum volume and blood pressure and to lower the heart rate, respiratory rate in post operated CABG and valve replacement patients.

The current study had several limitations. Initially recruiting larger sample size was difficult due to post operative complications such as prolonged mechanical ventilation and oozing from suture site. Furthermore, patients with low-risk postoperative pulmonary complications were included in the study. Finally, the long-term effect of respiratory proprioceptive neuromuscular facilitation in phase one cardiac rehabilitation were not monitored. Further studies in patients with different risk and longer duration are suggested to be carried out.

The present study concludes that cardiac rehabilitation along with respiratory PNF was associated with enhanced respiratory muscle strength and function, effective in improving rate and depth of breathing, sputum volume and pulmonary function in post operated CABG and valve surgeries.

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Conflict of interest: There is no conflict of interest.

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