Pharmacophore

ISSN-2229-5402

Journal home page: http://www.pharmacophorejournal.com

REINFORCEMENT OF AIRWAY CLEARANCE BY QUAKE DEVICE TRAINING IN PATIENTS WITH CHRONIC BRONCHITIS

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ARTICLE INFO

Received:
03th Dec 2018
Received in revised form:
24th Apr 2019
Accepted:
28th Apr 2019
Available online:
28th Apr 2019

Keywords: Chronic Bronchitis, Quake Device, Posture Drainage.

ABSTRACT

Background: There are different airway clearance techniques (ACTs) that deals with lung drain of sputum which include percussion, vibration, deep breathing and huffing or coughing till the modalities that uses forced expiratory pressures which reinforce the drainage of sputum in an easy way. Aim: This study was directed to determine the effect of Quake device training on reinforcement of airway clearance in patients with chronic bronchitis. Subjects: Forty patients from both sexes (22 women and 18 men) were diagnosed clinically according to GOLD STANDRED 2016 have moderate (GOLD 2) COPD with age ranged from 40-50years enrolled in the study. They were chosen from outpatient clinic of chest department in Internal Affairs Police Hospitals. Methods: Patients were assigned into two groups equal in numbers. Group (A): Twenty patients (12 women, 8 men) received Quake device twice daily, 3 times/week for 8 weeks plus breathing exercises (diaphragmatic and localized breathing exercises), Group (B): Twenty patients (10 women, 10 men) received postural drainage technique twice daily that was carried out according to sputum anatomical presentation revealed in the chest radiograph (x-ray), 3 times/week for 8 weeks plus breathing exercises (diaphragmatic and localized breathing exercises). All participants were assessed by arterial blood gases analyzer to measure arterial blood gases (Pao2, Paco2, PH, Hco3), and used 30 ml medical graduated cup for sputum collection and assessment of its amount. Results: For group (A) results showed a statistical significant difference between pre and post-treatment mean values of blood gases with percentage of improvement in Pao2, Paco2, PH and Hco3 by about 23.27%, 12.89%, 3.87% and 35.3% respectively. For group (B) results showed a much lesser improvement in blood gases parameters as Pao2, Paco2, PH and Hco3 by about 14.25%, 6.18%, 2.4% and 16.74% respectively. Regarding the amount of sputum there was improvement in the amount of sputum that was ranged from half spoon to 5 ml for group (A) to nearly 1 spoon for group (B). Conclusion: It was concluded that Quake device boosted the airways to easily drain its secretions with positive impact on blood gases while posture drainage is likewise important with less positivity than Quake device.

To Cite This Article: Nesreen Ghareeb El Nahas, Abla Hamed, (2019), "Reinforcement of Airway Clearance by Quake Device Training in Patients with Chronic Bronchitis", ***Pharmacophore, 10(3),*** *21-27.*

Introduction

Chronic pulmonary disease (COPD) is a pattern of persistent respiratory symptoms that show characteristics of mucus hyper secretion in the airways due to hypertrophy of sub mucosal mucus-producing glands and goblet cells hyperplasia. The mucus hyper secretion leads to impaired gas exchange, reduction in mucociliary clearance, encouraging bacterial colonization and exacerbation of lung diseases [1].

The decline of functional capacity in patients with pulmonary dysfunction is related to its severity, which is defined as, decreased level of functional performance in people choose to engage in day-to-day basis [2].

Chronic bronchitis causes breathlessness and chest tightness which gives the patients the sensation of airway blockage because of the irritation that caused by swelling and inflammation in the airways and excess of mucus production [3].

Postural drainage is an airway clearance technique that is generally performed for three to five minutes on each lung segment (position related to anatomical presentation of each segment), during this time the patient being treated should take slow, deep breaths followed by vigorous coughing to boost airway clearance with the assistance of percussion or vibration as needed [4].

A large variety of physical therapy equipments have emerged for respiratory disorders and offered another options to traditional chest physiotherapy which characterized by less time, less effort and more independence to the patient with

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infectious pulmonary disease. These methods enhance mobilization and loosen of mucus from airways which reflected on improvement of lung ventilation, achievement of pulmonary functions improvement and gaining more independency [5].

The mechanics of positive expiratory pressure therapy acts through encouragement of airflow behind secretions. The oscillations induced vibrations works on walls of the airways moving secretions to lumen with reduction of sputum viscosity. Repeated oscillations accelerates expiratory airflow movement and enhance secretions to shifts from peripheral to central airways [6].

Quake device is a pipe-shaped device operating through manual rotating hand which creates oscillations on the bowl. Low-frequency oscillations and high expiratory pressure results from slow rotating handle. However, high-frequency oscillations and low expiratory pressure created from quick handle rotation. Oscillatory positive expiratory pressure OPEP increases airway clearance by about two-fold which considered a high benefit of it [7].

Quake device alters the rehology of mucus and increases the ciliary action through enhancement of epithelial cells located in cilia. The frequency of oscillation ranged from 6-24Hz which is closer to the ideal frequency needed for airway clearance from secretions. The normal frequency for ciliary action is (11-15Hz), if the oscillation is of similar frequency the resonance amplitude of ciliary beat is increased which in turn increases mucus transportation [8].

Subjects, Materials and Methods

Patients:

This study was directed to determine the effect of Quake device training on reinforcement of airway clearance in patients with chronic bronchitis. Forty patients from both sexes (22 women and 18 men) were diagnosed clinically according to GOLD STANDERD 2016 have moderate (GOLD 2) COPD and not suffered from any other respiratory disorders with age ranged from 40-50 years enrolled in the study for eight weeks. They were chosen from outpatient clinic of chest department in Internal Affairs Police Hospitals and were assigned into two groups equal in numbers. Group (A): Twenty patients (12 women, 8 men) received Quake device twice daily, 3 times/week for 8 weeks plus breathing exercises (diaphragmatic and localized breathing exercises) and Group (B): Twenty patients received (10 women, 10 men) received postural drainage technique twice daily, 3 times/week for 8 weeks plus breathing exercises (diaphragmatic and localized breathing exercises).

Materials for Evaluation:

Arterial blood gases analyzer (RADIOMETER-ABL800 FLEX): used to measure blood gases (PaO_2, $PaCO_2$, PH, HCO_3) through blood samples which were taken from each participant.

Plain X- ray (Samsung- Collimator-SDR-OGCL 60A apparatus): used for detection the location of sputum in which segment for all participants.

Thirty ml medical graduated cup: used for sputum collection after posture drainage and application of Quake device to assess the amount of sputum.

Materials for Treatment:

Quake device training used for group (A): It is used while patient in sitting position. Deep inhalation and full exhalation was done through mouthpiece which is firmly impeded to the patient lips. The patient instructed for taking deep inspiration followed by holding for 3-5 sec. Meanwhile, the handle rotated at a quiet and comfort rate which equal half to one rotation/sec. This mechanism allows control of oscillation which depends on hand-turned crank. Then, to achieve airway clearance they were instructed to exhale forcefully. Patients were instructed to stop any desire to cough during these cycles. This process repeated for 6 times and considered as a one set which is also repeated for 10 sets with rest period for 10 min. This process was applied three time /week for total period equal 8 weeks [9].

Postural drainage technique for group (B): According to sputum anatomical presentation reveled in the chest radiograph (x-ray) patient was carried out in either sitting or lying comfortable position in bed. Every drainage position was applied for 20 minutes. Percussion, vibration and shaking were used accompanied with postural drainage. Postural drainage was done twice daily 3times/week for 8 weeks [10].

All participants in both groups received traditional breathing exercise after each session in form of diaphragmatic and localized breathing exercises.

Statistical analysis:

The data was collected from patients and classified into pre and post treatment values. Data was statistically expressed in terms of mean± standard deviation (±S.D.). Paired (t) test was used to compare the results pre and post training in the same group. Unpaired (t) test was used to compare the result pre and post in the two groups. All statistical analyses were significant at 0.05 of probability ($p \leq 0.05$).

Results

A) Blood Gases

1- Results of Pao2 (mmHg) for both groups:

Pre and post treatment mean values of Pao2 for group (A):

The results of pre and post treatment mean values for PaO_2 were 50.7± 3.03 and 62.5 ± 3.55 mmHg respectively. The results showed statistical significant difference when p= 0.000 with mean difference = 11.8 and percentage of improvement= 23.27 % (Table (1), Figure (1)).

Pre and post treatment mean values of Pao2 for group (B):

The results of pre and post treatment mean values for PaO_2 were 49.8± 3.53 and 56.9 ± 3.96 mmHg respectively. The results showed statistical significant difference when p= 0.000 with mean difference = 7.1 and percentage of improvement= 14.25 % (Table (1), Figure (1)).

Table 1: Shows statistical analysis of pre and post treatment mean values of PaO_2 (mmHg) in group (A) and (B).

PaO_2 (mmHg)	Group (A)		Group (B)	
	Pre Treatment	Post Treatment	Pre Treatment	Post Treatment
Mean ± SD	50.7 ± 3.03	62.5 ± 3.55	49.8 ± 3.53	56.9 ± 3.96
MD	11.8		7.1	
% of improvement	↑23.27 %		↑14.25 %	
t-value	35		29.64	
p-value	0.000		0.000	
Level of Significant	S		S	

Pre: Before treatment program
Post: After eight weeks of treatment program
SD: Standard Deviation.
MD: Mean Difference.
% of improvement: Percentage of improvement.
t- value: Paired and Un-paired t- test value.
p- value: Probability value.
S: Significant. Level

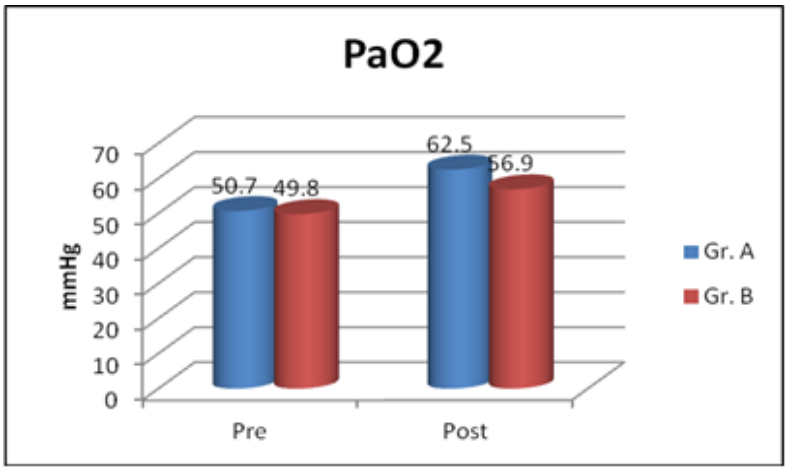

Figure 1: Pre and post treatment mean values of PaO_2 (mmHg) among both groups.

2- Results of $PaCO_2$ (mmHg) for both groups:

Pre and post treatment mean values of $PaCO_2$ for group (A):

The results of pre and post treatment mean values for $PaCO_2$ were 41.1± 2.27 and 35.8 ± 1.7 mmHg respectively. The results showed statistical significant difference when p= 0.000 with mean difference = 5.3 and percentage of improvement= 12.89 % (Table (2), Figure (2)).

Pre and post treatment mean values of Paco2 for group (B);

The results of pre and post treatment mean values for $PaCO_2$were 41.2± 2.26 and 38.65± 2.46 mmHg respectively. The results showed statistical significant difference when p= 0.000 with mean difference = 2.55 and percentage of improvement= 6.18 % (Table (2), Figure (2)).

Table 2: Shows statistical analysis of pre and post treatment mean values of $PaCO_2$ (mmHg) in group (A) and (B).

$PaCO_2$ (mmHg)	Group (A)		Group (B)	
	Pre Treatment	Post Treatment	Pre Treatment	Post Treatment
Mean ± SD	41.1 ± 2.27	35.8 ± 1.7	41.2 ± 2.26	38.65 ± 2.46
% of improvement	↑12.89 %		↑6.18 %	
t-value	25.65		13.81	
p-value	0.000		0.000	
Level of Significant	S		S	

Pre: Before treatment program
Post: After eight weeks of treatment program
SD: Standard Deviation.
MD: Mean Difference.
% of improvement: Percentage of improvement.
t- value: Paired and Un-paired t- test value.
p- value: Probability value.
S: Significant. Level

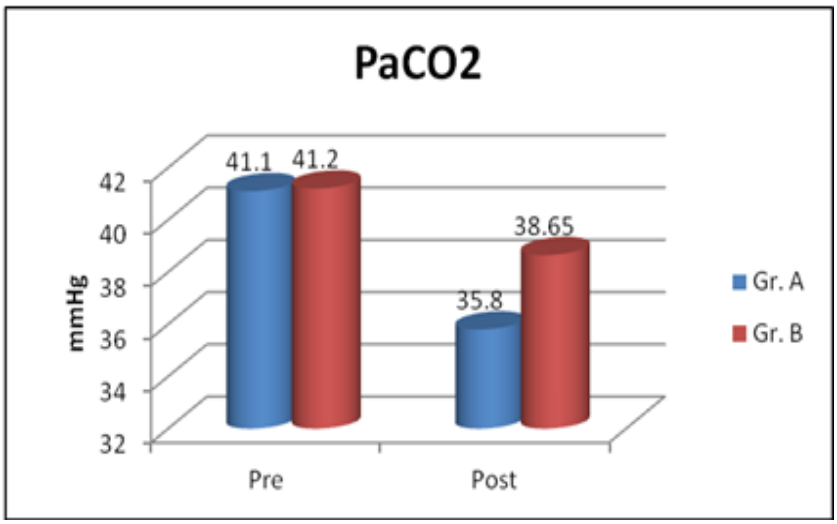

Figure 2: Pre and post treatment mean values of $PaCO_2$ (mmHg) among both groups.

3- Results of PH for both groups:

Pre and post treatment mean values of PH for group (A):

The results of pre and post treatment mean values of PH were 7.49± 0.1 and 7.2 ± 0.11 respectively. The results showed statistical significant difference when p= 0.000 with mean difference = 0.29 and percentage of improvement= 3.87 % (Table (3), Figure (3)).

Pre and post treatment mean values of PH for group (B):

The results of pre and post treatment mean values of PH were 7.5± 0.11 and 7.33 ± 0.09 respectively. The results showed statistical significant difference when p= 0.000 with mean difference = 0.18 and percentage of improvement= 2.4 % (Table (3), Figure (3)).

Table 3: Shows statistical analysis of pre and post treatment mean values of PH in group (A) and (B).

PH (mmHg)	Group (A)		Group (B)	
	Pre Treatment	Post Treatment	Pre Treatment	Post Treatment
Mean ± SD	7.49 ± 0.1	7.2 ± 0.11	7.5 ± 0.11	7.33 ± 0.09
MD	0.29		0.18	
% of improvement	↑3.87 %		↑2.4%	
t-value	10.07		9.64	
p-value	0.000		0.000	
Level of Significant	S		S	

Pre: Before treatment program
Post: After eight weeks of treatment program
SD: Standard Deviation.
MD: Mean Difference.
% of improvement: Percentage of improvement.
t- value: Paired and Un-paired t- test value.
p- value: Probability value.
S: Significant. Level

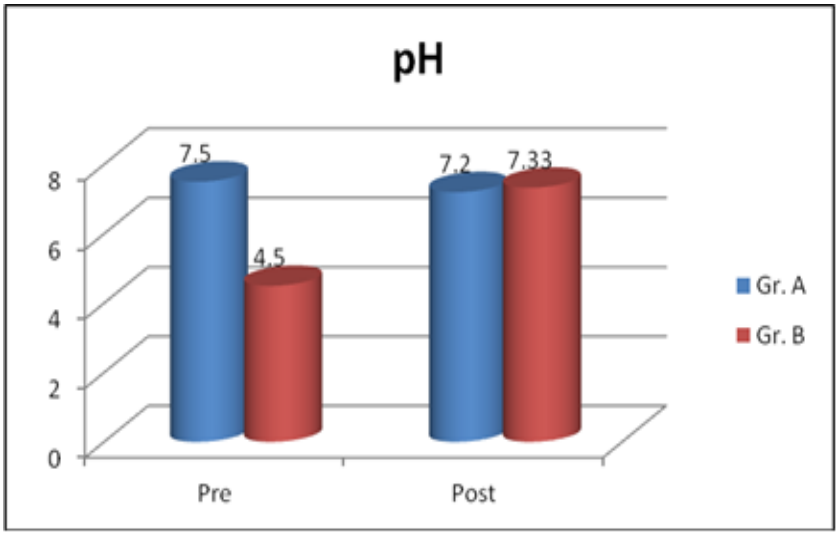

Figure 3: Pre and post treatment mean values of PH among both groups

4- Results of HCO_3 (mEq/L) for both groups:

Pre and post treatment mean values of HCO_3 for group (A):

The results of pre and post treatment mean values of HCO_3 were 32.57± 2.62 and 21.7± 3.3 mEq/L respectively. The results showed statistical significant difference when p= 0.000 with mean difference = 11.5 and percentage of improvement= 35.3 % (Table (4), Figure (4)).

Pre and post treatment mean values of Hco3 for group (B):

The results of pre and post treatment mean values of HCO_3 were 31.95± 3.04 and 26.6± 3.62 mEq/L respectively. The results showed statistical significant difference when p= 0.000 with mean difference = 5.35 and percentage of improvement= 16.74 % (Table (4), Figure (4)).

Table 4: Shows statistical analysis of pre and post treatment mean values of HCO_3 (mEq/L) in group (A) and (B).

Hco3 (mmHg)	Group (A)		Group (B)	
	Pre Treatment	Post Treatment	Pre Treatment	Post Treatment
Mean ± SD	32.57 ± 2.62	21.07 ± 3.3	31.59 ± 3.04	26.6 ± 3.62
MD	11.5		5.35	
% of improvement	↑35.3 %		↑16.74%	
t-value	19.26		17.99	
p-value	0.000		0.000	
Level of Significant	S		S	

Pre: Before treatment program
Post: After eight weeks of treatment program
SD: Standard Deviation.
MD: Mean Difference.
% of improvement: Percentage of improvement.
t- value: Paired and Un-paired t- test value.
p- value: Probability value.
S: Significant. Level

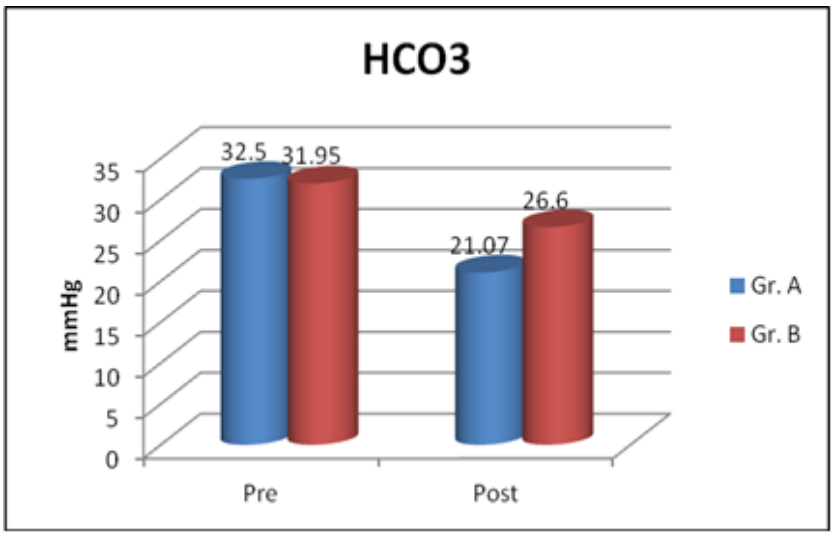

Figure 4: Pre and post treatment mean values of HCO_3 (mEq/L) among both groups.

B) Amount of Sputum

Regarding the amount of sputum, treatment procedures revealed that, there was an improvement in the amount of sputum clearance. It was observed that, the amount was ranged from half spoon to 5 ml for group (A) to nearly 1 spoon for group (B) with the emphasis of easy coughing and getting it out for Quake group.

Discussion

Respiratory dysfunctions which need bronchial drainage deals with traditional techniques of physical therapy in the form of mobilization and removal of airways secretions especially in chronic obstructive lung disease, suppurative lung disease and primary ciliary dyskinesia syndrome. Chest physiotherapy has another important role in improving pulmonary functions and preventing or reducing of respiratory complications in patients with chronic respiratory disorders [7].

The results of our study came in agreement with results achieved by Volosko et al, 2003 who stated that, the traditional respiratory treatment modalities as posture drainage has a beneficial effect in removing airway secretions without causing any harmful effect on oxygen saturation in patients with chronic bronchitis [11]. Other alternative valid techniques such as flutter and Acapella device (Positive expiratory pressure devices PEP) which allow patients to do their treatment independently should be considered very attractive and ranked as first choice of chest physiotherapy in management of chronic bronchitis exacerbation. Furthermore, flutter and Acapella have more positive effect than postural drainage in prolonging the secretion-removal effect, which leading to more homogeneous drainage of the bronchial tree.

The results of measured blood gases in our study which conducted with the easy way used in removing secretions coincided with the results achieved by Reilly et al., 2011 who declares that high oscillatory component devices have a great benefit in intra-or extra-thoracic oscillations and consequently a great benefit in bronchial hygiene [12]. The mechanism of these devices depends on; prolonged exhalation generates both oscillations of positive pressure in the airways and accelerations of expiratory airflow which result in improved clearance of sputum.

In accordance with results of our study, Fink and Mahlmeiter, 2002 mentioned that, the physiological effect of PEP oscillation summarized in helping the patient to inhale a volume greater than the tidal volume without reaching total lung capacity, followed by non-forced expiratory activity without surpassing functional residual capacity which delayed the patient fatigue or discomfort [13].

Hristara et al., 2008 supported the results achieved in our study, as he evaluated the impact of respiratory physical therapy devices including positive expiratory pressure, high frequency chest wall oscillation, oral high-frequency oscillation, incentive spirometer, flutter, Acapella and RC-Cornet R. and observed their efficiency in mucus evacuation [7]. Also he confirmed the results by pulmonary function tests.

Beside these effective results for alternative CPT devices a study done by El-Nahas et al 2011 who studied the effect of flutter device on the functional capacity of COPD patients in relation to oxygen saturation [14]; they declare that, the benefit of removal of secretions improves the ventilation perfusion ratio that was added to the results of improved pulmonary functions which also shares the view with the results in our study.

In clinical practice, the improving of airway clearance by positive expiratory pressure device has a great clinical and physiological importance that was discussed by Olsen et al., 2015 who described the aim, clinical trial and underlying physiology of PEP and concluded that, increasing lung volumes, decreasing hyperinflation or improving airway clearance are the most outcomes of using this device [15].

Our results also hold the same opinion that intra or extra- thoracic oscillations expressed as Quake (Intra-thoracic) or posture drainage (Extra-thoracic) are of great benefit of patients according to their indications and more important with their contraindications in choosing the suitable maneuver to apply with the patient as to ensure the patients compliance to treatment as well as his / her benefit.

This believe was supported by Linz and Wirth, 2012 who reported that intra- thoracic oscillations during obstructive apneas disturb ventricular repolarization that was in contrast to the benefits mentioned in the behalf of Intra-thoracic oscillations but it creates variable resistances within the airways and generating controlled oscillating positive pressure leading to mobilization of respiratory secretions [16]. When the frequency of oscillation approximates the resonance frequency of the pulmonary system, final bronchial pressure oscillations are amplified and result in vibrations of the airways, these vibrations leading to loosen of mucus in the airway walls.

Conclusion

It was concluded that management of removing secretions with Quake and posture drainage is likewise important by both methods with furthermore noticeable reinforcement in Quake training than in posture drainage with recommendation by measuring pulmonary functions test as another impact of Quake device.

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