International
Journal of Medical and Exercise Science
(Multidisciplinary, Peer Reviewed and Indexed Journal)

ORIGINAL ARTICLE

TO COMPARE THE EFFECT OF ACAPELLA AND DIAPHRAGMATIC BREATHING EXERCISE IN SMOKERS TO INCREASE IN VITAL CAPACITY

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ABSTRACT

Background of the study: Vital capacity is a fundamental concept of respiratory physiology, crucial for understanding the mechanics of breathing and the overall health of the respiratory system. Vital capacity represents key measurements that help assess lung function and provide valuable insights into an individual's respiratory health. Objective of the study is to compare and analyse the effects of acapella and diaphragmatic breathing exercise in smokers to increase in vital capacity. **Methods**: After receiving approval from the Institutions Review Board, this experimental study of a comparative type involving 40 participants was conducted for two months at the Faculty of Physiotherapy department, Dr. M.G.R Educational and Research Institute. Upon receiving participation consent, smokers were chosen for the study based on the inclusion and exclusion criteria. They were then divided into two groups using the random sampling technique. Each group had 20 participants, and for an 8-week period, 5 days per week, group A practised acapella exercises while group B practised breathing exercises. Spirometry was used to perform a lung function test before and after the intervention to determine vital capacity. **Result:** When comparing the Pretest and Post-test results between Group A and Group B on vital capacity and the FEV1/FVC ratio, it was found that Group A, which engaged in acapella exercises, improved more than Group B. **Conclusion:** This study concludes that compared to diaphragmatic breathing exercises, the Acapella device raised vital capacity in individuals with decreased vital capacity the best. It also improved lung function. Acapella devices can therefore be used as an adjuvant therapy for smokers who have compromised cardiopulmonary functions.

Keywords: Plantar fasciitis; Stretching exercise; Shockwave therapy; Laser therapy; Foot function index; Visual analogue scale.

Received on 18th August 2023, Revised on 26th August 2023, Accepted on 29th August 2023
DOI:10.36678/IJMAES. 2023.V09I03.005

INTRODUCTION

Smoking, a global health concern, is a leading cause of preventable deaths worldwide. It is well-established that smoking cigarettes exposes individuals to a cocktail of harmful chemicals and toxins, including nicotine, carbon monoxide, and tar[1]. These noxious substances wreak havoc on the respiratory system, leading to a myriad of health issues, with compromised lung function being a prominent consequence. Cigarette smoking remains a global health concern, with millions of individuals addicted to this habit despite its well-established association with various respiratory disorders, including chronic obstructive pulmonary disease (COPD), lung cancer, and emphysema[2]. Avoiding smoking is the only way to prevent pulmonary function impairment, but smokers fail to quit smoking[3]. In India 25.4% population is affected by chronic respiratory disease due to tobacco usage from year 1990-2016 [4].

The human respiratory system is an intricate network of organs and tissues designed to ensure the exchange of oxygen and carbon dioxide, a process vital for sustaining life. An essential component of this intricate mechanism is vital capacity (VC), a measure of the maximum volume of air a person can exhale after taking the deepest possible inhalation[5]. It is a critical parameter in assessing lung function and can provide valuable information about an individual's ability to move air in and out of their lungs. However, in individuals who smoke, the deleterious effects of tobacco on lung health are well-documented, leading to impaired respiratory function and a decreased vital capacity. Among the numerous adverse health effects of smoking, it profoundly impacts the respiratory system. The toxic substances in tobacco smoke can lead to inflammation, scarring, and reduced elasticity of lung tissue, ultimately reducing the vital capacity and compromising overall lung function[6].

Vital capacity, a critical measure of lung function, reflects the maximum volume of air a person can inhale or exhale. It is composed of various components, including tidal volume, inspiratory reserve volume, and expiratory reserve volume[7]. Tidal volume represents the amount of air moved in and out during normal breathing, while inspiratory and expiratory reserve volumes signify the maximum additional air that can be inhaled or exhaled after a normal breath[8]. Vital capacity is an essential parameter in assessing lung health, as it provides insights into an individual's respiratory capacity and their ability to respond to increased respiratory demands[9].

Second-hand smokers (SHS) are the most frequently impacted individuals in today's society. Worldwide, second-hand smoke contributes to more than 600,000 deaths annually, or more than 1% of all fatalities[10]. Children account for 165,000 of these deaths. The prevalence of SHS worldwide in 2004 was 40% in children, 33% in non-smoking males, and 35% in non-smoking females. Lung cancer, asthma, ischemic heart disease, and lower respiratory infections are among the illnesses that are affected by this and cause mortality[11].

In the case of smokers, the harmful chemicals in tobacco smoke can damage lung tissue, leading to inflammation, mucus production, and structural changes that diminish vital capacity[12]. Consequently, individuals who smoke may experience shortness of breath, reduced exercise tolerance, and an overall decreased quality of life.

Diaphragmatic breathing is a technique that focuses on engaging the diaphragm, the primary muscle responsible for respiration. In diaphragmatic breathing, individuals are trained to breathe deeply, allowing the diaphragm to contract more fully during inhalation and relax during exhalation[13]. This technique enhances the efficiency of breathing, maximizes oxygen intake, and can lead to improvements in lung function[14]. For smokers, diaphragmatic breathing exercises may offer a natural and non-invasive approach to counteract the adverse effects of smoking on lung capacity.

Acapella therapy is a relatively recent addition to the arsenal of respiratory therapy techniques. It involves the use of a handheld device that generates positive expiratory pressure during exhalation. This positive pressure helps to mobilize mucus in the airways, facilitating its clearance and improving lung function[15]. Acapella therapy has gained recognition as an effective intervention for individuals with conditions like cystic fibrosis, bronchiectasis, and COPD[16].

The Acapella a mechanical oscillatory device consists of a one-way valve system that allows patients to exhale against resistance, promoting lung recruitment and enhanced airway clearance[17]. This therapy is particularly advantageous for smokers, as it can assist in clearing the accumulated mucus and potentially aid in restoring vital capacity. However, the comparative effectiveness of Acapella therapy in increasing vital capacity among smokers remains an area that warrants further investigation.

Spirometry is a non-invasive pulmonary function test that measures the volume and flow of air during inhalation and exhalation[18]. It provides valuable insights into lung health by quantifying various respiratory parameters, including forced vital capacity (FVC), forced expiratory volume in one second (FEV1), and the FEV1/FVC ratio[19]. These parameters serve as critical indicators of lung function and are instrumental in diagnosing and managing a wide range of respiratory conditions, from asthma and chronic obstructive pulmonary disease (COPD) to interstitial lung diseases and restrictive lung disorders[20].

This study helps to advance our understanding of effective interventions for smokers looking to improve their lung health. By comparing two distinct approaches—Acapella therapy and diaphragmatic breathing exercises—we can offer evidence-based recommendations to guide healthcare providers and individuals in choosing the most appropriate intervention for their specific needs.

METHODS

After receiving approval from the institution's review board, this experimental study was carried out for a period of two months at the department of physiotherapy at Dr. MGR Educational and Research Institute University.40 subjects between the ages of 20 and 40 were enrolled in the study after the participants gave their informed consent after being told of the technique and the need for the investigation. The study only included male patients who had smoked for five to ten years and had regular episodes of coughing, wheezing, difficulty breathing, and a decrease in VC. The study excluded participants with any form of infectious pulmonary disease, respiratory tiredness, psychiatric or neurological issues, cardiac issues, or restrictive lung disorders. They were grouped into two groups

using the random sampling technique. Each group had 20 participants. For an 8-week period, five days a week, the subjects in group A practiced acapella exercises while the subjects in group B practiced breathing exercises.

Materials Used: Couch, Chair, Stop watch, Foot stool, Acapella, Pillows.

General procedure of Pulmonary Function Test (Spirometer):

During the test, the patient was seated. A clip was placed on the patient's nose to keep the nostrils closed. The subject was then instructed to take a deep breath and exhale as forcefully as possible for several seconds into the tube. Ensuring that the subject's lips created a seal around the tube to prevent air leakage was essential. The test was repeated at least three times to ensure relatively consistent results. In cases where there was significant variation among the three outcomes, the test was repeated. The final result was determined by selecting the highest value among the three closely matched test results. The entire process typically took less than 15 minutes.

Interventions:

Acapella exercise:

The patient was seated comfortably, and a mouthpiece connected to the Acapella device was provided. Patients were then guided to hold the Acapella device with the mouthpiece comfortably placed in their mouths. As the exercise commenced, patients were instructed to take deep breaths, filling their lungs to their maximum capacity and hold for three seconds. Following inhalation, they exhaled as forcefully as possible while maintaining a tight arch in their cheeks through the Acapella device. This process was designed to generate positive expiratory pressure (PEP) as patients exhaled against the resistance offered by the device. The duration of the exhale was typically advised to be up to three to four times as long as the inhale. The patient repeated the whole process for ten to twenty PEP breaths, followed up with three to four "huff" coughs under the guidance of a physiotherapist.

Fig-1 Acapella Device

Diaphragmatic breathing exercise:

Patients were first positioned in a comfortable and relaxed posture, often in a seated or supine lying position. Patients were then encouraged to place one hand on their chest and the other on their abdomen to enhance awareness of their breathing patterns. They were instructed to take a slow and deep breath through their nose, allowing their abdomen to rise while keeping their chest relatively still. This signified the diaphragmatic inhalation phase. Patients held

their breath for a brief moment and then exhaled slowly and fully through pursed lips, with a focus on abdominal contraction during exhalation. The diaphragmatic breathing cycle was repeated for 3-4 times a day with 10 repetitions, typically under the guidance of a physiotherapist. Patients were encouraged to maintain a relaxed and consistent rhythm throughout the exercise, ensuring that their chest remained relatively still while their abdomen expanded during inhalation and contracted during exhalation. Later the patients were progressed to power breathing exercises. During power breathing exercises, individuals engage their diaphragm and accessory respiratory muscles to generate forceful breaths, expanding their lung volume to its maximum capacity along with weight lifts.

Fig 2: Inhaling

Fig 3: Exhaling

Fig4: Inhaling (Purse Lip)

Fig5: Exhaling (Purse Lip)

Fig 6: Exhaling (Power Breathing)

Fig 7: Inhaling (Power Breathing

Data Analysis

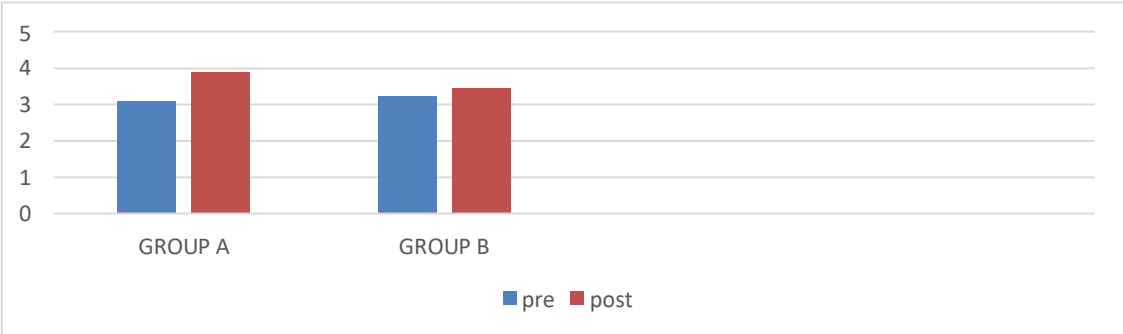
The Statistical Package of Social Science (SPSS) version 24 was used to evaluate each parameter. In order to identify statistical differences between the groups, the paired t-test was used, and the independent t-test (Student t-Test) was used to identify statistical differences within the groups.

VITAL CAPACITY	#GROUP – A		#GROUP – B		t – TEST	df	SIGNIFICANCE
	MEAN	S.D	MEAN	S.D			
Pre-Test	3.0900	.453	3.2350	.459	-1.005	38	.161
POST TEST	3.8950	.371	3.4500	.425	3.530	38	<.001

(*- P > 0.05), (***- P ≤ 0.001)

Table-1 Comparison of Vital Capacity Between Group – A And Group – B

In Pre and Post Test The Mean, Standard Deviation (S.D.), t-test, degree of Freedom (df), and p-value between (Group A) and (Group B) in the pretest and posttest Weeks are shown in the above table. This table demonstrates that there is no statistically significant difference between Group A and Group B's pretest data (*P > 0.05). This table displays the statistically significant posttest difference between Groups A and B at (***- P ≤ 0.001)



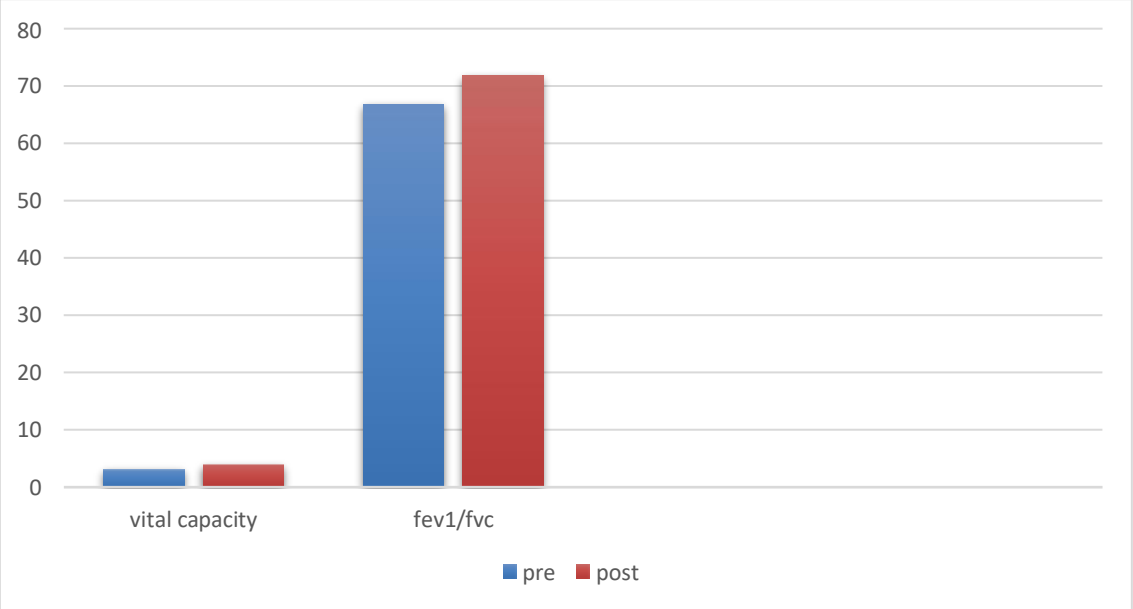
Graph – I Comparison of Vital Capacity Between Group – A and Group – B in Pre and Post Test

VARIABLE	Pre-Test		Post Test		t – TEST	Df	SIGNIFICANCE
	MEAN	S.D	MEAN	S.D			
VITAL CAPACITY	3.0900	.453	3.8950	.371	-15.174	19	<.001
FEVI/FVC	66.8000	3.66	71.7500	3.63	-29.160	19	<.001

Table-3 Comparison of Dependent Variables in Group – A In Pre and Post Test

The Mean, Standard Deviation (S.D), t-Value, and p-value between the pre- and post-tests for GROUP A are shown in the above table.

Within GROUP A, there is a statistically significant difference between the pre- and post-test values (***≤P 0.001)



Graph -3 Comparison of Dependent Variables in Group A Pre and Post Test

RESULT

On comparing the mean values of Group, A and Group B on Vital Capacity (VC), it shows significant increase in the post test mean value in both groups, but Group A (Acapella device) shows mean value (3.8950) which has the higher mean value is effective than Group B (Diaphragmatic breathing exercise) showing (3.4500) at P ≤ 0.001. Hence null hypothesis is rejected.

On comparing the mean values of Group, A and Group B on Fev1/FVC ratio), it shows significant increase in the post test mean values in both groups, but Group A (Acapella device) shows mean value (71.7500) which has the higher mean value is effective than Group B (Diaphragmatic breathing exercise) showing (68.6000) at P ≤ 0.001. Hence null hypothesis is rejected.

On comparing Pretest and posttest within Group A and Group B on vital capacity and Fev1/FVC ratio showed highly significant difference in mean values at p ≤ 0.001.

DISCUSSION

Cigarette smoking doesn't only affect active smokers but also non-smokers exposed to cigarette smoke in places like homes, restaurants, schools, and theatres[21]. Evidence suggests that cigarette smoking alters cardio-respiratory status and immunological responses, primarily due to reduced oxygen-carrying capacity in the body. This leads to higher anaerobic metabolism and damages the blood vessel walls, making them more rigid, as proposed by Flouris AD et al[22].

This study aimed to compare and analyze the effects of Acapella and diaphragmatic breathing exercises on smokers aged 20 to 40 in terms of their vital capacity. Sri Vastava R, et al., suggested that smokers with chronotropic incompetence face an increased risk of death and coronary disease, with heart rate being a crucial predictor of all-cause mortality[23].

Before the exercise program, both groups had reduced cardiopulmonary function, consistent with the findings of Julia R Sengbusch et al., who stated that smoking significantly worsens cardiorespiratory functions during moderate to severe exercises, likely due to reduced oxygen-carrying capacity in the body[24]. Cigarette smoking affects respiratory muscles by influencing the vascular system with free radicals, reducing blood supply to respiratory muscles, and adversely affecting respiratory functions[25].

Comparing the pre- and post-test values, Group A, which used the Acapella device (as shown in Table 3), showed a significant improvement in FEV1 and FVC ratios compared to Group B. The greater improvement in vital capacity in Group A suggests that Acapella exercises have a pronounced impact on increasing lung volume. This is particularly significant for smokers, as tobacco smoke can lead to reduced lung capacity due to airway obstruction and inflammation. During Acapella exercises, the increased pressure is transmitted to the airways, creating back pressure that prevents premature airway closure and reduces gas trapping. This promotes collateral ventilation, allowing pressure to build up distal to the obstruction[26]. Our findings was similar to Sachin Chaudhary et al who stated that acapella exercises promote collateral ventilation, a phenomenon where alveolar structures are ventilated through channels that bypass normal airways[27]. This prolongs expiratory flow and prevents airways from collapsing. Collateral ventilation keeps the airway open and maintains

ideal airflow, which enhances lung function. Apart from this Myung Hun Jang et al has also proved that regular use of the Acapella device can strengthen respiratory muscles, including the diaphragm[28]. Hence, the Acapella device appears to facilitate the restoration of vital capacity in smokers and their general lung health.

On comparing the pre- and post-test values for Group B, which performed diaphragmatic breathing exercises (as shown in Table 4), there was a significant improvement in FEV1 and FVC. During deep diaphragmatic breathing, the diaphragm contracts and flattens, creating a vacuum effect that draws air into the lungs. This results in deeper inhalations and improved ventilation of the lower regions of the lungs[29]. Deep breaths facilitated by diaphragmatic exercises lead to better lung expansion. Thus, promoting improved oxygenation of the blood, which is essential for overall bodily function and energy production[30].

In summary, the findings of this study suggest that acapella exercises, with the ability to enhance vital capacity, improve the FEV1/FVC ratio, and address airflow obstruction, may be a more beneficial strategy for improving respiratory functions among smokers compared to diaphragmatic breathing exercises alone. However, it's important to acknowledge that both interventions have their merits, and the choice of therapy should be tailored to individual patient characteristics and preferences.

Ethical Clearance: Ethical clearance has obtained from Faculty of Physiotherapy, Dr. MGR. Educational and Research Institute, Chennai, Tamil Nadu, Reference number: No: D-27/PHYSIO/IRB/2020-2021, Dated: 07/01/2021.

Conflict of interest: There was no conflict of interest to conduct and publish this study.

Fund for the study: It was a self-financed study.

CONCLUSION

This study concludes that Acapella device was best in increasing vital capacity in patients with decreased in vital capacity; it also increased the function of the lungs when compared to diaphragmatic breathing exercise. Further research is needed to corroborate these findings and explore the long-term effects and broader clinical implications of Acapella therapy in the context of smoking cessation and respiratory health management.

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Citation:
Tharani. G, **Kamatchi. K, Yuvarani. G, Ranjith Kumar (2023).** To Compare the Effect of Acapella and Diaphragmatic Breathing Exercise in Smokers to Increase in Vital Capacity, ijmaes; 9(3); 1607-1617