Section: Physiotherapy

Original Research Article

THE EFFECT OF ACAPELLA ON DYNAMIC HYPERINFLATION AND EXERCISE CAPACITY IN COPD PATIENTS DURING THE SIX-MINUTE WALK TEST, A CROSS SECTIONAL STUDY

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Received *: 05/01/2025*
Received in revised form *: 02/03/2025*
Accepted *: 18/03/2025*

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DOI: 10.70034/ijmedph.2025.2.161

Source of Support: Nil,
Conflict of Interest: None declared

Int J Med Pub Health
2025; 15 (2); 893-896

ABSTRAC

Background: This study investigates the impact of the Acapella device on dynamic hyperinflation and exercise capacity in patients with moderate to severe chronic obstructive pulmonary disease (COPD) during the six-minute walk test (6MWT). The results indicate that the use of Acapella significantly improves inspiratory capacity, oxygen saturation, and distance walked, while reducing heart rate and maintaining FEV1, FVC, and FEV1% values.

Materials and Methods: The use of Acapella during the 6MWT resulted in significant improvements in Inspiratory Capacity (1.70±0.48 L vs. 0.975±0.21 L, $p<0.0125$), SpO2 (97.29±0.93% vs. 91.82±2.46%, $p<0.0125$), and distance walked (242.41±4.534 m vs. 233.12±4.401 m, $p<0.05$) when they were compared post 6MWT vs pre 6MWT. Heart rate decreased significantly with Acapella (83.52±7.86 bpm vs. 92.02±8.14 bpm, $p<0.0125$). FEV1, FVC, and FEV1% values were maintained with Acapella use.

Results: The Acapella is a safe and effective device for improving inspiratory capacity, reducing dynamic hyperinflation, and enhancing exercise capacity in COPD patients during the 6MWT. Further studies with larger sample sizes, longer durations of various other exercise tests and long-term follow-up are recommended to validate these findings.

Conclusion: Thus, we see that there has been an eventual increase in overweight, obesity and overnutrition among both genders over the years.

Keywords: 6MWT, Acapella, Inspiratory Capacity, FEV1, FEV1%, Dynamic Hyperinflation.

INTRODUCTION

Chronic Obstructive Pulmonary Disease (COPD) is a significant cause of chronic morbidity and mortality worldwide, ranking as the 4th leading cause of death globally.[1] The Global Burden of Disease study in 1990 estimated the worldwide prevalence of COPD to be 9.34 per 1000 men and 7.33 per 1000 women.2 In India, the prevalence is reported to be 4.1% with a male to female ratio of 1.56:1.3 COPD is characterized by chronic airflow obstruction that is persistent and largely irreversible, involving chronic bronchitis and emphysema.[1,4] It is associated with an abnormal inflammatory response to harmful particles or gases, particularly tobacco smoke and polluted air.[1,4] Structural changes in the lungs, such as airway remodeling, obstruction, destruction of alveolar septa, and decreased pulmonary elastic recoil, lead to air trapping, difficulty in air removal, airflow limitation, and pulmonary hyperinflation.[5,6] In COPD patients, a rapid and shallow breathing pattern leads to dynamic hyperinflation due to expiratory flow limitation. While at rest, these patients can maintain stable End Expiratory Lung Volume

(EELV) and Inspiratory Capacity (IC). However, during exercise, the increased ventilatory demand exacerbates expiratory flow limitation, resulting in increased EELV and reduced IC, which are major factors contributing to dyspnea.[7] Lung hyperinflation, caused by increased lung compliance and irreversible changes from emphysema, further increases the load on inspiratory muscles and leads to neuro-ventilatory dissociation.[4,5,8,9] This exacerbates dyspnea, causing exercise intolerance, limited physical activity, and a poor quality of life.[7] In COPD patients, exercise intolerance and dyspnea are primarily due to airway obstruction and peripheral muscular dysfunction. Rehabilitation programs that include exercise training can reduce dyspnea and improve exercise tolerance.[5,7,8] Dynamic Hyperinflation (DH) can be assessed after a six-minute walk test (6MWT) and is related to hyperinflation at rest.[9] Strategies to manage DH include increasing expiratory time by slowing the respiratory rate using low-level Positive Expiratory Pressure (PEP).[6] Pursed lips breathing, which creates a low-level PEP, is often used by COPD patients to prolong expiration and lower respiratory rate.[10] PEP therapy, developed in the 1970s, offers independence to patients as it is easy to use and does not require an assistant.[10] Positive expiratory pressure (PEP) devices help more air enter peripheral airways through collateral channels, pushing secretions towards larger airways for easier expulsion and preventing alveolar collapse.[12] Patients inhale to full capacity and then exhale slowly through a mouthpiece with a fixed orifice resistor, creating an expiratory pressure resistance between 10-20 cm H2O.[10] Vander Schans et al. (1994) found that using a PEP device at 5 cm H2O reduced minute ventilation and respiratory rate during exercise but increased dyspnea and CO2 retention, suggesting higher pressure might be more effective.[6,7] The Acapella device, similar to the Flutter, generates oscillating PEP using a counterweighted plug and magnet but is not dependent on gravity as in the case of the Flutter device.[10] A positive expiratory pressure (PEP) combined with high-frequency oscillation (HFO) can be produced by Acapella like devices that produce oscillatory positive pressures during expiration. These devices produce short and successive interruptions of the air flow, promoting vibrations during expiration.[11] Exhaled gas passes through a cone, which is intermittently occluded by a plug attached to a lever, producing air flow oscillations. A knob located at the distal end of the device adjusts the proximity of the magnet and counterweighted plug, thereby adjusting the frequency, amplitude, and mean pressure.[12] Teresa A Volsko et al (2003) suggested that the Acapella has pressure-flow characteristics similar to the Flutter, Acapella may offer advantages to some patients by virtue of its ability to generate OPEP at any angle (e.g. with the patient supine) and at very low expiratory flows (eg, in children with severe obstructive lung disease).[12] Tadsawiya Padkao et al (2010) suggested that the conical-PEP device decreases lung hyperinflation and inspiratory capacity increased 200 ml and slow vital capacity increased 200 ml,[7] Antonello Nicolini et al (2013) suggested that the distance covered during 6MWT improved in the PEP group more than in the control group. The PEP group showed an increase in meters walked versus the control group, and the duration of exercise had also increased. It was also suggested that the PEP devices enhance exercise capacity in COPD patients by using only a low positive expiratory pressure (5 cm H20).[4] Previous studies have demonstrated the effect of different exercises on dynamic hyperinflation with the use of various PEP devices. However there is a lack of knowledge regarding the use of Acapella on dynamic hyperinflation and exercise capacity. The present study aims to investigate the effect of Acapella on dynamic hyperinflation and exercise capacity during 6MWT in patients with moderate to severe COPD.

MATERIALS AND METHODS

Study Design

A repeated measure pretest and posttest design was employed.

Sampling

Convenient sampling method was used to select 34 outpatients with moderate to severe COPD.

Inclusion Criteria

The patients included were clinically diagnosed moderate to severe COPD (FEV1 < 70%), with all genders included, clinically stable and free from exacerbations for more than 4 weeks, who were not dependent on oxygen support, with a reasonable ability to comprehend instructions and those who had no change in medication a week prior to the test.

Exclusion Criteria

Those individuals who were unable to perform 6MWT, had cardiac arrhythmias or heart block, had uncontrolled hypertension/diabetes and had musculoskeletal, neurological, psychological, or cognitive disorders were excluded from participating in the research.

Instrumentation

Instruments used include a) Acapella: a vibratory PEP system b) Standard spirometer (COSMED Quark) c) Fingertip oximeter and d) a Sphygmomanometer.

Procedure

Patients underwent baseline measurements of inspiratory capacity, FEV_1, FVC, FEV_1%, blood pressure, oxygen saturation, and heart rate. They performed a 6MWT without Acapella, followed by a 6MWT with Acapella after a washout period. Parameters were reassessed post-test.

RESULTS

Inspiratory Capacity (IC)

A statistically significant improvement was found in the inspiratory capacity after 6MWT with Acapella.

At rest IC was 1.28+0.27L, after 6MWT without Acapella it was 0.975+0.21L and after 6MWT with Acapella, IC was 1.70+0.48L. IC half an hour after the 6MWT with Acapella was 2.22+0.51L ($p<0.0125$)

FEV_1

A Statistically Significant Difference is shown between pre FEV1 (0.88±0.33) and FEV1 after 6MWT without Acapella (0.73±0.28) ($P<0.0125$). There was no significant difference in FEV, after 6MWT with Acapella (0.86±0.29) and pre FEV1. However, FEV1 significantly increased when 6MWT was done with (0.86+0.29) an Acapella device when compared to the 6MWT without (0.73+0.28) Acapella. A significant increase was seen in FEV1, calculated half hour after 6MWT with Acapella (0.92+0.32) when compared to that, calculated immediately after 6MWT with (0.86+0.29) and without (0.73+0.28) Acapella both.

FVC

A statistically significant difference in between pre FVC (1.46+0.55) and FVC after 6MWT without Acapella (1.30+0.52)($p<0.0125$) was noted. However, the difference between pre-FVC and FVC immediately (1.40+0.46) as well as half hour after (1.47+0.55) 6MWT with Acapella was not significant.($p > 0.0125$)

FEV_1%

A significant difference was noted between Pre FEV1% (60.54+3.43) and after 6MWT without Acapella (55.86+4.07) ($p < 0.0125$). There was a significant increase in FEV1% immediately (62.12+3.45) as well as half hour after (63.05+3.80) 6MWT with Acapella when compared to that of 6MWT without Acapella (55.86+4.07) and pre test (60.54+3.43) ($p<0.0125$).

Oxygen Saturation (SpO2)

There was a significant decrease in the SpO2 after 6MWT without Acapella (91.82+2.46) when compared to the pre test SpO2. And, there was a significant increase in SpO2 after 6MWT with Acapella (97.29+0.93)($p<0.0125$) when compared to that after 6MWT without Acapella and Pre test SpO2.

Heart Rate

A significant increase in heart rate (92.02+8.14) was noted with 6MWT without Acapella when compared to the resting heart rate(pre 6MWT)(85.44+8.12)($p<0.0125$). However the mean heart rate after 6MWT with Acapella (83.52+7.86) was comparable to the pretest heart rate (85.44+8.12) as there was no significant difference between the two, $p>0.0125$.

Distance Walked

Paired t-test was used to analyse the distance walked during 6MWT without and with Acapella. A significant increase in the distance walked during 6MWT with Acapella (242.41+4.534) was noted when compared to that of 6MWT without Acapella (233.12+4.401), $p<0.05$.

DISCUSSIONS

Expiratory flow limitation, which is the primary pathophysiological hallmark of chronic obstructive pulmonary disease, is caused by reduced lung elastic recoil and increased airway resistance. Forced expiration associated with increased ventilatory demands during exercise can induce premature airway closure leading to air trapping and dynamic hyperinflation.[4] One of the various explored strategies to manage dynamic hyperinflation is to increase expiratory time as a result of slowing the respiratory rate by using low-level positive expiratory pressure.[4] Positive expiratory pressure devices can prolong expiratory time and decrease respiratory rae, thereby reducing airway closure and dynamic hyperinflation. Acapella devices proved to be acceptable by patients in general and no adverse effects were reported. The use of Acapella can be suggested as a novel strategy for minimizing dynamic hyperinflation. It is a simple and a cheap device and does not require a power supply and is also safe to use. Acapella could prove to be an economical and non-invasive tool for enhancing the exercise capacity in COPD patients.

The data obtained supports the hypothesis that Acapella produces a significant effect in patients with moderate to severe COPD. In the present study it was found that the Acapella, a PEP device, enhances inspiratory capacity by reducing dynamic hyperinflation during 6MWT in patients with moderate to severe COPD. The principle of Acapella is to increase the expiratory flow and decrease the pulmonary hyperinflation during exercise. It was also found that the distance walked and the oxygen saturation had increased and the heart rate had decreased with the use of Acapella. FEV1, FVC and FEV1% values after the 6MWT with Acapella (both immediately and half hour after) were comparable to the pre-test (resting) values.

In the current study the inspiratory capacity had increased after 6MWT with Acapella which suggests that the Acapella has an effect on exercise induced hyperinflation as it provides positive pressure during exhalation phase of breathing that generates a net increase in intraluminal pressure thereby increasing transpulmonary pressure gradient. It results in the shift of the equal pressure point proximally which in turn results in less collapsibility of the alveoli and reduces the gas trapping during exhalation.

Hyperinflation of lung is an elevation of the resting functional residual capacity (FRC) or end expiratory lung volume (EELV). When the patients blow through the Acapella it improves the lung emptying with each exhalation by generating a back pressure which inhibits the premature closure of bronchioles which leads to a reduction in FRC, owing to which a steady rise of IC was possible.

Another probable mechanism of improving inspiratory capacity was building of equilibrium between outward recoiling of chest wall and inward

recoiling of lungs. This deflation of lungs to the resting volume with Acapella reduces the elastic loading on inspiratory muscles.

In the current study it was found that the inspiratory capacity had reduced after 6MWT without Acapella, which is in accordance with Padkao et al (2013)'s study.

In our study Spirometry tests of FEV1, FVC and FEV1% showed a non-significant difference between pre values and post values after 6MWT with Acapella. Also, no significant difference was found even after half an hour (P-value>0.0125). These results are similar to those obtained by Sridhar S.A et al (2012).

FEV1, FVC and FEV1% had reduced after 6MWT without Acapella in our study which contradicted with the result obtained by Sridhar S.A et al in 2012 (they concluded that there was no significant change in both FEV1 and FEV1% in the control group during 6MWT without PEP. In the current study the probable reason for reduction in FEV1, FVC and FEV1% was due to increased breathing frequency which may have limited the time for exhalation and lead to premature closing of airways.

We found a statistically significant improvement in Oxygen saturation after 6MWT with Acapella ($p<0.0125$). Our result is in accordance with Antonello et al (2013) who observed an increase in oxygen saturation in COPD patients after 6MWT with PEP.

We observed a reduction in Heart rate after 6MWT with Acapella. Antonello Nicoline et al (2013) obtained similar results.

To add on, the distance walked by the patients increased with the use of Acapella. The results are in accordance with Nicolini et al (2013) who suggested that the use of PEP devices increased the distance walked in COPD patients.

Limitations

While the results are encouraging, there are some limitations in this study including a small sample size and although there were improvements noted in the parameters observed in our study, the duration of improvements, whether they were sustained or not, was not studied.

CONCLUSION

This study observes that the Acapella is a safe and effective device for use during 6MWT in moderate to severe COPD patients and it reduces dynamic hyperinflation, enhances inspiratory capacity, and improves exercise capacity. Further studies with larger sample sizes, variable exercises and long-term effects are recommended.

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