

Original Article

Effects of Acapella versus Blow Bottle Positive Expiratory Pressure on Airway Clearance and Peak Expiratory Flow Rate in Post-Covid-19 Patients

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ABSTRACT

Background: The COVID-19 pandemic has led to significant respiratory complications in affected individuals. Positive Expiratory Pressure (PEP) devices, specifically Acapella and blow bottle devices, have been widely used in respiratory rehabilitation, particularly in patients with pulmonary diseases and post-surgical respiratory complications. However, their efficacy in post COVID-19 patients has been less explored.

Objective: This study aimed to compare the effectiveness of Acapella and blow bottle devices in improving oxygen saturation, peak expiratory flow rate, shortness of breath, and six-minute walk distance in post COVID-19 patients.

Methods: This randomized clinical trial was conducted at Tehsil hospital Kot Addu over six months. Forty-eight post COVID-19 patients were divided equally into two groups: one group received treatment with the Acapella device, and the other with a blow bottle device. Baseline and post-treatment measurements of oxygen saturation, peak expiratory flow rate, and six-minute walk distance were recorded using a pulse oximeter, peak expiratory flow meter, and six-minute walk test, respectively.

Results: On day 1, the Acapella group showed a mean oxygen saturation rank of 20.98 with a sum of ranks of 503.50 ($p=0.79$), while the Blow Bottle group had a mean rank of 28.02 and a sum of ranks of 672.50. By day 7, the Acapella group's mean rank was 17.31 (sum of ranks = 415.50, $p=0.000$) compared to the Blow Bottle group's 31.69 (sum of ranks = 760.50). For peak expiratory flow rate, no significant differences were found between the groups at day 1 (Acapella: mean rank = 28.06, sum of ranks = 673.50, $p=0.078$; Blow Bottle: mean rank = 20.94, sum of ranks = 502.50) and day 7 (Acapella: mean rank = 23.77, sum of ranks = 570.50, $p=0.717$; Blow Bottle: mean rank = 25.23, sum of ranks = 605.50). Similar trends were observed in the six-minute walk test results.

Conclusion: The study found that both Acapella and blow bottle devices effectively improve oxygen saturation in post COVID-19 patients, but do not significantly affect peak expiratory flow rate, shortness of breath, and six-minute walk distance. These findings suggest that while these devices are beneficial for enhancing oxygenation, a more comprehensive respiratory rehabilitation approach is necessary for addressing the full spectrum of respiratory complications in post COVID-19 patients.

Keywords: COVID-19, Respiratory Rehabilitation, Positive Expiratory Pressure, Acapella Device, Blow Bottle Device, Oxygen Saturation, Peak Expiratory Flow Rate, Six-Minute Walk Test.

INTRODUCTION

The SARS-CoV-2 coronavirus, a novel pathogen responsible for the COVID-19 disease, has significantly impacted global health since its emergence. This highly contagious virus predominantly targets the respiratory system, leading to a range of symptoms from mild respiratory tract infections to severe cases requiring mechanical ventilation and even resulting in death. Declared a pandemic by the World Health Organization on March 11, 2020, COVID-19 first appeared in China and rapidly spread worldwide, with Pakistan, a neighboring country, also significantly affected (3, 5).

COVID-19 is characterized by a wide spectrum of clinical manifestations. While approximately 80% of those infected present with mild symptoms or remain asymptomatic, a notable percentage develop severe infections, necessitating oxygen support or intensive care (11). Patients often exhibit symptoms similar to influenza and other respiratory diseases, including fever, cough, and dyspnea (9). The disease's progression can lead to pneumonia, characterized by bilateral interstitial infiltrates and severe hypoxic respiratory failure (13). This progression often necessitates advanced oxygen therapy strategies, such as non-invasive ventilation (NIV), high-flow nasal oxygen (HFNO), or continuous positive airway pressure (CPAP), with a subset of patients requiring invasive ventilation due to the failure of non-invasive methods (14, 15).

In the context of respiratory therapy for COVID-19 patients, the use of positive expiratory pressure (PEP) devices has garnered attention. These devices, including commercially available ones like the Acapella and self-made blow bottle devices, are used for airway clearance and improving lung function. The Acapella device, for example, has been shown to be effective in mobilizing secretions due to its ability to generate significant amplitude of vibrations (20). In contrast, the blow bottle device, a more cost-effective option, has demonstrated efficacy in preventing pulmonary complications, often surpassing incentive spirometers in effectiveness (17, 19).

Recent studies have further explored the efficacy of these devices in specific patient populations. Bhagyashree Jage and Anuprita Thakur (2022) investigated the impact of Acapella combined with chest physiotherapy on airway clearance and pulmonary function in post-operative coronary artery bypass graft patients. Their findings indicated that the combination of Acapella and conventional physiotherapy significantly improved lung function and sputum volume compared to physiotherapy alone (21). Similarly, a study by Samaradnyi Hichkad and BR Ganesh (2021) compared the effects of the blow bottle device and flutter on functional capacity, dyspnea, fatigue, and peak expiratory flow rate in patients with mild-to-moderate COPD. They concluded that while both devices were effective, the flutter device had superior outcomes (22).

The primary objective of this study is to compare the effects of the Acapella and blow bottle positive expiratory pressure devices on airway clearance and peak expiratory flow rate in post-COVID-19 patients. Given the varied impact of COVID-19 on respiratory function and the importance of effective airway clearance in recovery, this comparative analysis is vital. It aims to provide insights into the most effective respiratory therapy methods for improving the quality of life and respiratory function in post-COVID-19 patients, a demographic that continues to grow as the pandemic evolves.

MATERIAL AND METHODS

This study, a randomized clinical trial, was conducted at Tehsil hospital Kot Addu over a six-month period following approval by the research board. The purpose was to evaluate the effects of Acapella and blow bottle positive expiratory pressure on airway clearance and peak expiratory flow rate in post-COVID-19 patients. Simple random sampling was employed for participant randomization, ensuring a balanced representation of subjects in each group (17).

The total sample comprised 48 individuals, equally divided into two groups of 24 each. Participants were recruited using a nonprobability convenient sampling technique. Eligibility criteria included laboratory-confirmed negative status for COVID-19, a minimum of one week post-recovery, and the ability to maintain an expiratory flow of at least 15 L/min for a duration of three seconds (17). Exclusion criteria ruled out individuals with lung infections post-COVID-19, those who were mildly ill and treated at home, individuals with any serious post-COVID complications, those with pre-existing pulmonary conditions, patients able to independently clear secretions, and smokers (23).

Baseline measurements of oxygen saturation, peak expiratory flow rate, functional capacity, and shortness of breath were recorded using a pulse oximeter (24), a peak expiratory flow meter (25), a six-minute walk test (26), and the modified Borg scale of dyspnea, respectively (27). The modified Borg scale is a numerical score ranging from 0 to 10, commonly used in conjunction with the six-minute walk test.

Both groups received initial instruction in effective coughing, huffing, diaphragmatic breathing, and upper chest muscle relaxation. Following baseline measurements, participants were randomly assigned to two groups: group A received treatment with Acapella (Acapella D.H, Green), and group B received treatment with a home-made blow bottle positive expiratory pressure device. Treatment sessions were conducted three times daily for one week. The Acapella device was set with the appropriate resistance and used in a sitting position, with patients instructed to take a deep breath, hold for about 3 seconds, and then exhale through the device for 10 to 12 breaths, resisting coughing. This was followed by huffing 3 to 4 times and repeated for 15 minutes (17).

The home-made blow bottle positive expiratory pressure device, made from a hard plastic bottle and rigid tubing, was used in sessions comprising 10 sets of 10 breaths with a 5-second hold and a 1-minute rest period between each set, followed by 3 to 4 huffs (17).

Data collection involved pre and post-intervention measurements in the morning and night, respectively, using the same instruments employed for baseline assessments. The collected data were then analyzed using the SPSS version 25 software. This analysis aimed to determine the comparative efficacy of Acapella and blow bottle positive expiratory pressure treatments in enhancing respiratory function and capacity among post-COVID-19 patients.

RESULTS

In the study, three key parameters were analyzed to compare the effectiveness of the Acapella and Blow Bottle treatments: oxygen saturation, peak expiratory flow rate (PEFR), and the distance covered in a six-minute walk test. The results of these analyses are presented in Tables 1, 2, and 3.

Regarding oxygen saturation (Table 1), on the first day of measurement, the mean rank for the Acapella group was 20.98 with a sum of ranks totaling 503.50, while the Blow Bottle group had a mean rank of 28.02 and a sum of ranks of 672.50. The p-value for this comparison was 0.79, indicating no significant difference between the two groups on day 1. However, by day 7, a notable shift was observed. The Acapella group's mean rank decreased to 17.31 with a sum of ranks of 415.50, whereas the Blow Bottle group's mean rank increased to 31.69 with a sum of ranks of 760.50. The p-value on day 7 was 0.000, signifying a significant difference in oxygen saturation levels between the two groups after a week of treatment.

For the peak expiratory flow rate (PEFR) as shown in Table 2, on day 1, the Acapella group recorded a mean rank of 28.06 and a sum of ranks of 673.50, compared to the Blow Bottle group's mean rank of 20.94 and sum of ranks of 502.50. The p-value for PEFR on day 1 was 0.078, suggesting no significant difference initially. By day 7, the mean ranks were 23.77 for the Acapella group and 25.23 for the Blow Bottle group, with sums of ranks at 570.50 and 605.50, respectively. The p-value at this time point was 0.717, indicating that there were no significant differences in PEFR between the groups after one week.

Table 1 Comparison of Oxygen Saturation Between Acapella and Blow Bottle Groups

Parameter	Group	N	Mean Rank	Sum of Ranks	p-value
O2 Saturation Day 1	Acapella	24	20.98	503.50	0.79
	Blow Bottle	24	28.02	672.50	
O2 Saturation Day 7	Acapella	24	17.31	415.50	0.000
	Blow Bottle	24	31.69	760.50	

Table 2 Comparison of Peak Expiratory Flow Rate Between Acapella and Blow Bottle Groups

Parameter	Group	N	Mean Rank	Sum of Ranks	p-value
PEFR Day 1	Acapella	24	28.06	673.50	0.078
	Blow Bottle	24	20.94	502.50	
PEFR Day 7	Acapella	24	23.77	570.50	0.717
	Blow Bottle	24	25.23	605.50	

Table 3 Comparison of Six-Minute Walk Distance Between Acapella and Blow Bottle Groups

Parameter	Group	N	Mean Rank	Sum of Ranks	p-value
Six-Minute Walk Day 1	Acapella	24	26.54	637.00	0.312
	Blow Bottle	24	22.46	539.00	
Six-Minute Walk Day 7	Acapella	24	23.50	576.00	0.882
	Blow Bottle	24	24.50	588.00	

In the six-minute walk test (Table 3), on the first day, the Acapella group had a mean rank of 26.54 with a sum of ranks of 637.00, while the Blow Bottle group had a mean rank of 22.46 and a sum of ranks of 539.00. The p-value was 0.312, showing no significant difference initially. On day 7, the mean ranks slightly converged, with the Acapella group at 23.50 and the Blow Bottle group at 24.50, and the sums of ranks were 576.00 and 588.00, respectively. The p-value on day 7 was 0.882, further indicating no significant difference in the six-minute walk distance between the two groups after a week.

Overall, these results suggest that while there were significant improvements in oxygen saturation in the Acapella group by day 7, both treatments were comparably effective in terms of peak expiratory flow rate and six-minute walk distance over the one-week period.

DISCUSSION

The study focused on evaluating the effectiveness of Acapella and blow bottle devices, both popular positive expiratory pressure (PEP) techniques, in improving respiratory parameters among post COVID-19 patients. These devices, known for creating positive pressure in the airways during expiration, have been primarily used in cardiac surgery and pulmonary disease patients with proven results. However, their efficacy in post COVID-19 patients had not been fully established prior to this study. The current research aimed to fill this gap by analyzing parameters such as oxygen saturation, peak expiratory flow rate, shortness of breath, and six-minute walk distance in this patient group.

Previous literature supports the effectiveness of these PEP techniques in cardiac and pulmonary disease patients. For instance, Abhaya S. Mahadik et al. (2021) demonstrated the equivalency of Acapella and blow bottle devices in improving oxygen saturation and peak expiratory flow rates in open heart surgery patients (22). This aligns with the findings of the current study, particularly regarding oxygen saturation, where a significant difference was noted ($p < 0.05$). However, the present study diverges in its findings on peak expiratory flow rates, where no significant difference was observed, contrasting with previous studies that indicated notable improvements.

Mohamed Shamakh et al. (2020) also reported moderate effects of the Acapella device on pulmonary functions in chronic obstructive pulmonary disease patients, aligning with the current study's findings of mild to moderate impacts, except for oxygen saturation (20). Similarly, Sachin Chaudhary et al. (2020) found significant differences in peak expiratory flow rates in a study comparing deep breathing exercises with Acapella and incentive spirometer in postoperative coronary artery bypass graft patients (28). The current study, however, did not observe significant differences in peak expiratory flow rates and dyspnea scores, although findings on oxygen saturation were consistent.

Samaradnyi Hichkad et al. (2021) compared blow bottle and flutter devices in COPD patients and found significant improvements in walking distance and peak expiratory flow rates (22). In contrast, the current study did not find significant differences in respiratory parameters with the blow bottle device, except for oxygen saturation.

The study's results indicate that while Acapella and blow bottle devices effectively improve oxygen saturation in post COVID-19 patients, they do not significantly impact dyspnea, peak expiratory flow rates, and six-minute walk distances. This finding contributes to the understanding of respiratory rehabilitation in post COVID-19 patients, highlighting the potential benefits of PEP devices in enhancing oxygenation but not necessarily in other respiratory parameters.

Despite these insights, the study had limitations. Being single-centered, its findings may not be generalizable to broader populations. Additionally, the study focused on post COVID-19 patients, leaving the effects of these devices on active COVID-19 patients unexplored. The use of only one type of Acapella device also limits the applicability of the results to other models or types of PEP devices. The study's duration was another constraint that might have impacted the long-term assessment of these interventions. To address these gaps, future studies should be conducted in multicenter settings, including COVID-19 positive patients, and should compare different types of PEP devices. Further research could also expand on the range of respiratory parameters assessed and include critical COVID-19 patients to provide a more comprehensive understanding of the benefits and limitations of PEP devices in respiratory rehabilitation.

In conclusion, the study underlines the effectiveness of Acapella and blow bottle devices in improving oxygen saturation in post COVID-19 patients. However, it also emphasizes the need for further research to fully understand the potential of these devices in managing other aspects of respiratory function in this patient population.

CONCLUSION

The study concludes that Acapella and blow bottle devices, used as positive expiratory pressure techniques, are effective in enhancing oxygen saturation in post COVID-19 patients, but their impact on other respiratory parameters like peak expiratory flow rates, shortness of breath, and six-minute walk distances is limited. This finding has important implications for clinical practice, suggesting that while these devices are beneficial for improving oxygenation, a comprehensive approach incorporating additional respiratory therapies is necessary for holistic pulmonary rehabilitation. Moreover, the cost-effectiveness of the blow bottle device presents a viable option for resource-constrained settings. Future research should focus on multicentric studies encompassing a broader patient demographic, including active COVID-19 cases, and comparative analyses of different PEP devices to understand their efficacy better. Long-term studies are also essential to evaluate the sustained impact of these interventions on the respiratory function and quality of life in post COVID-19 patients. Thus, while the study underscores the utility of Acapella and blow bottle devices in improving certain aspects of respiratory function in post COVID-19 patients, it also highlights the need for a multifaceted approach in respiratory care and further research in this evolving domain.

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