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Measured Expiratory Resistance of the Blue and Green Acapella Devices as Setting is Increased From 1–5; Amplitude 20, 30, 40

Amanda Wroblewski

College of Health Sciences, Boise State University

Scott Hawkins

College of Health Sciences, Boise State University

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Abstract

Background: After reviewing the literature on both high flow and low flow Acapella devices, it was determined that most researchers evaluated only three frequency dial settings. Due to this gap, we chose to determine the expiratory resistance at each frequency dial setting for both high flow and low flow Acapella devices, as patient effort (amplitude) is increased on an electronic lung simulator. Hypothesis: 1) As the frequency dial setting is increased on the Acapella, the expiratory resistance will increase, and 2) as the patient effort (amplitude) is increased, the expiratory resistance will increase.

Methods: Each Acapella device was attached, separately, via a female-to-female adapter to the Hans Rudolph 1101 Electronic Lung Simulator. HR 1101 settings: Resistance 5 cm H₂O/L/sec, Compliance 50 mL/cm H₂O, Respiratory Rate 20/minute, Amplitude 10, 20, 30 and 40 cm H₂O (to simulate patient effort), Percent Inhale 30 %, Targeted Volume 3000 mL, Load Effort Normal. Initially, amplitude was set at 10 cm H₂O and the Acapella was set at the lowest setting. After allowing for stabilization, Peak Pressure and Peak Expiratory Flowrates were recorded for 20 consecutive breaths. The Acapella dial was then increased to the next setting; pressure and flowrates were recorded again as previously described. This process was continued until reaching the highest Acapella setting. Next, data was gathered at amplitudes of 20, 30 and 40 cm H₂O, following the same procedure as stated for amplitude of 10 cm H₂O. Resistance was calculated as $(P1-P2)/Flow$. P1 = averaged peak pressure for 20 breaths; P2 = 0 (ambient pressure); Flow = averaged Peak Expiratory Flowrate for 20 breaths.

Results: The expiratory resistance increased as the frequency dial setting was increased and the expiratory resistance increased as amplitude increased. At an amplitude of 20 cm H₂O, the expiratory resistance increased from 25.83 to 47.02 cm H₂O/L/sec on the blue Acapella and from 12.56 to 38.24 cm H₂O/L/sec on the green Acapella device as the frequency dial setting was increased from 1-5 (Figure 1).

Conclusion: The expiratory resistance increased as the frequency dial setting increased from 1 to 5 on both Acapella devices. The expiratory resistance increased as the amplitude increased at 10, 20, 30 and 40 cm H₂O, on both devices, confirming our hypothesis.

Keywords

expiratory resistance, Acapella devices

Disciplines

Respiratory System

Measured Expiratory Resistance of the Blue and Green Acapella Devices as Setting is Increased from 1-5; Amplitude 20, 30, 40 cm H₂O

Amanda Wroblewski, Scott Hawkins and Lonny Ashworth MEd RRT FAARC.
Boise State University, Boise, Idaho

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Conclusion: The expiratory resistance increased as the frequency dial setting increased from 1 to 5 on both Acapella devices. The expiratory resistance increased as the amplitude increased at 10, 20, 30 and 40 cm H₂O, on both devices, confirming our hypothesis.

Results: The calculated expiratory resistance, as the dial setting was increased, is as follows:

Green 1 device

Amplitude 10 cm H₂O: the range was 9.71-103.33 cm H₂O/L/sec

Amplitude 20 cm H₂O: the range was 12.56-38.24 cm H₂O/L/sec

Amplitude 30 cm H₂O: the range was 15.87-25.48 cm H₂O/L/sec

Amplitude 40 cm H₂O: the range was 18.27-26.62 cm H₂O/L/sec

Green 2 device

Amplitude 10 cm H₂O: the range was 11.81-127.11 cm H₂O/L/sec

Amplitude 20 cm H₂O: the range was 12.42-31.78 cm H₂O/L/sec

Amplitude 30 cm H₂O: the range was 15.19-25.74 cm H₂O/L/sec

Amplitude 40 cm H₂O: the range was 17.5-29.84 cm H₂O/L/sec

Blue 1 device

Amplitude 10 cm H₂O: the range was 22.87-103.43 cm H₂O/L/sec

Amplitude 20 cm H₂O: the range was 25.83-47.02 cm H₂O/L/sec

Amplitude 30 cm H₂O: the range was 33.8-39.58 cm H₂O/L/sec

Amplitude 40 cm H₂O: the range was 38.42-44.17 cm H₂O/L/sec

Blue 2 device

Amplitude 10 cm H₂O: the range was 17.79-90.70 cm H₂O/L/sec

Amplitude 20 cm H₂O: the range was 22.55-68.48 cm H₂O/L/sec

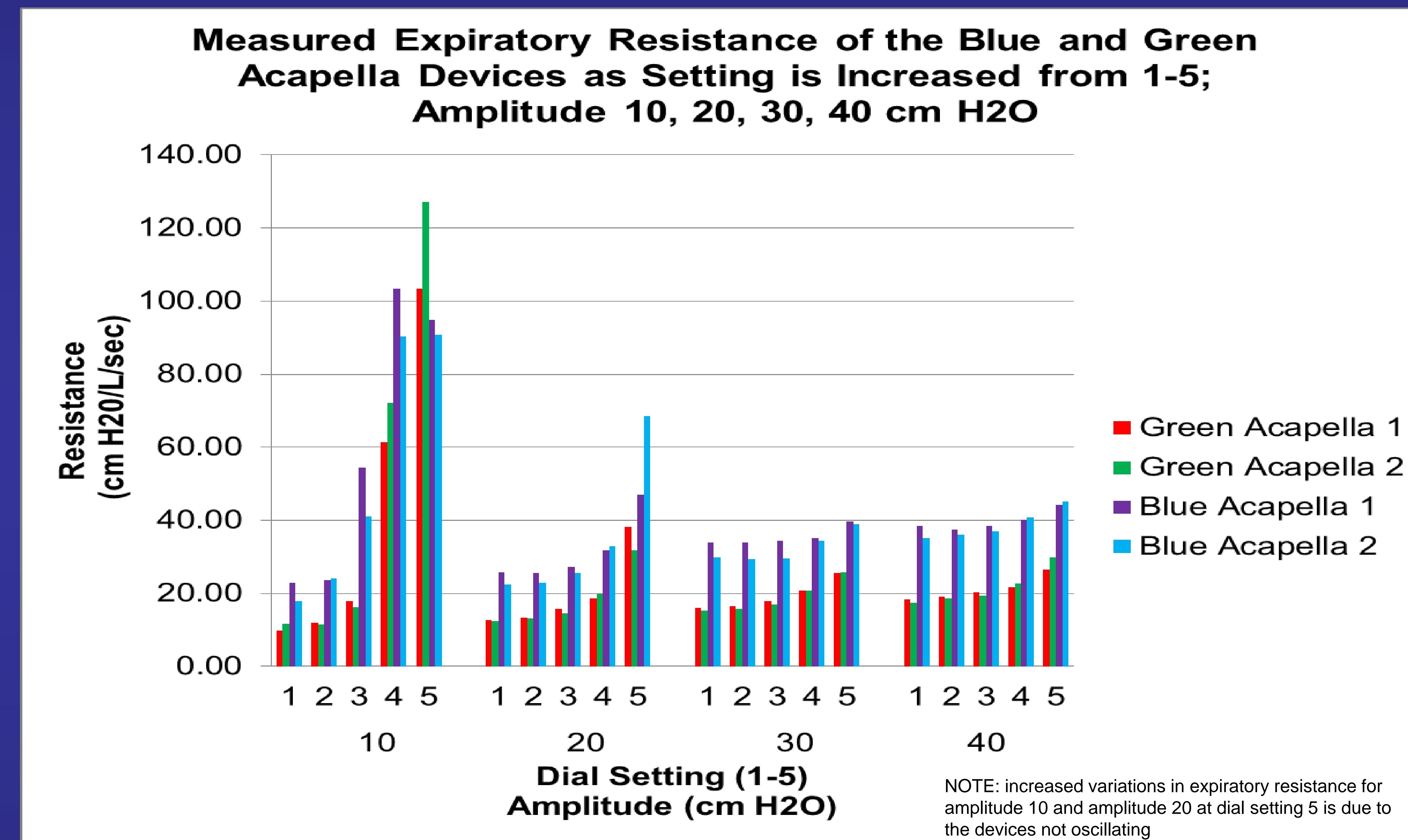
Amplitude 30 cm H₂O: the range was 29.95-38.81 cm H₂O/L/sec

Amplitude 40 cm H₂O: the range was 35.04-45.13 cm H₂O/L/sec

See Table for all the results. As the frequency dial setting was increased from 1 to 5 on each Acapella device, the expiratory resistance increased. Also, the expiratory resistance increased when the amplitude increased from 10, 20, 30 and 40 cm H₂O, on each device at every frequency dial setting.

Special thanks to Saint Alphonsus Regional Medical Center for the donation of the Acapella devices

Background: The Acapella (DHD Healthcare, Wampsville, New York) provides a combination of high-frequency oscillations and PEP therapy to facilitate secretion removal. The resistance of the Acapella can be adjusted by turning the dial at the distal end of the device to one of the five settings, altering the frequency of vibratory pressure waves. After reviewing the literature on both high flow and low flow Acapella devices, it was determined that most researchers evaluated only three frequency dial settings. This left a wide range of gaps for clinicians to consider when providing Acapella therapy, leaving the question as to whether or not the other settings have any clinical significance. Is there a difference between the lowest frequency dial setting and the second lowest frequency dial setting, or should we just be using the lowest, middle and highest settings as these values have been shown to provide adequate secretion removal? Due to this gap, we chose to determine the expiratory resistance at each frequency dial setting for both high flow and low flow Acapella devices, as patient's expiratory effort (amplitude) is increased on an electronic lung simulator. Hypothesis: 1) as the frequency dial setting is increased on the Acapella, the expiratory resistance will increase, and 2) as the patient's expiratory effort (amplitude) is increased, the expiratory resistance will increase.



Amplitude	Dial Setting	Green Acapella 1	Green Acapella 2	Blue Acapella 1	Blue Acapella 2
10	1	9.71	11.81	22.87	17.79
	2	11.88	11.41	23.55	24.20
	3	17.96	16.24	54.49	41.09
	4	61.41	72.20	103.43	90.35
	5	103.33	127.11	94.88	90.70
20	1	12.56	12.42	25.83	22.55
	2	13.33	13.15	25.55	22.82
	3	15.78	14.52	27.12	25.63
	4	18.73	19.79	31.73	32.88
	5	38.24	31.78	47.02	68.48
30	1	15.87	15.19	33.80	29.95
	2	16.40	15.77	33.85	29.42
	3	17.96	16.95	34.50	29.57
	4	20.72	20.70	35.03	34.43
	5	25.48	25.74	39.58	38.81
40	1	18.27	17.50	38.42	35.04
	2	19.01	18.71	37.57	35.95
	3	20.41	19.31	38.49	37.06
	4	21.64	22.75	40.06	40.93
	5	26.62	29.84	44.17	45.13

Methods: Each Acapella device was attached, separately, via a female-to-female adapter to the Hans Rudolph 1101 Electronic Lung Simulator. HR 1101 settings: Resistance 5 cm H₂O/L/sec, Compliance 50 mL/cm H₂O, Respiratory Rate 20 breaths/minute, Amplitude 10, 20, 30 and 40 cm H₂O (to simulate patient effort), Percent Inhale 30%, Targeted Volume 3000 mL, Load Effort Normal. The HR 1101 has an active inspiration and an active expiration; therefore, as we increased amplitude, expiratory effort increased.

Initially, amplitude was set at 10 cm H₂O and the Acapella was set at the lowest setting. After allowing for stabilization, Peak Pressure and Peak Expiratory Flowrates were recorded for 20 consecutive breaths. The Acapella dial was then increased to the next setting; pressures and flowrates were recorded again as previously described. This process was continued until reaching the highest Acapella setting. Next, data were gathered at amplitudes of 20, 30 and 40 cm H₂O, following the same procedure as stated for amplitude of 10 cm H₂O. Resistance was calculated as (P1-P2)/Flow. P1 = averaged Peak Pressure for 20 breaths; P2 = 0 (ambient pressure); Flow = averaged Peak Expiratory Flowrate for 20 breaths in L/second. Data were gathered at 100 Hz (cycles/sec).

The Green 1 device and Blue 1 device had been used previously in the laboratory. The Green 2 device and Blue 2 device were freshly opened and only used for this research project. This demonstrated the variations in the devices as they are used over time.

Discussion: The purpose of this study was to evaluate the effect of frequency dial setting and patient expiratory effort on expiratory resistance. As noted in the results, as the frequency dial setting was increased, expiratory resistance increased and as patient expiratory effort increased, the expiratory resistance increased.

While performing this study, it was noted that at an Amplitude of 10 cm H₂O (patient expiratory effort), the Acapella devices would not oscillate and resulted in an extremely high expiratory resistance (see table for exact values). It is possible that a patient's disease state may result in an increased airway resistance and may also affect the performance of this device, potentially reducing their expiratory flow rate and reducing the oscillations within the device. Patients with high airway resistance may not be able to simply increase their expiratory effort due to muscle fatigue or muscle weakness. Further research would need to investigate this concept and include assessing patient's airway resistance, as this could affect their expiratory flowrate and the expiratory resistance of the device. The reason we used four devices is that the green 1 device and blue 1 device were used to help us gain our baseline values and critique the study along the way. Therefore these two specific devices show a varying expiratory resistance as they are used over time. Compared to the green 2 device and blue 2 device that were freshly opened solely for this study and were only used for the study. By comparing all four devices we are showing there is a variation with the Acapella over time with use.