The Percussive Characteristics of the Acapella, Flutter and Quake During Low-Volume Tidal Breathing

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Introduction

Many airway-obstructed patients with small lung capacities use handheld percussive devices as part of their treatment regimens. When breathed through, the Acapella® (Blue; Smiths Medical), the Flutter® (Axcan Scandipharm), and the Quake® (Thayer Medical), generate pressure pulses in the airways of the patient to loosen mucus. In this study, we compared the strength of the pressure pulses (as measured by mean pressure-wave amplitude), and vibration frequencies generated by these devices during simulated low-volume tidal breathing.

Devices Tested

Three of each of the three handheld devices (n=3) were tested (as shown in Figure 1). Each device was evaluated at three settings (detailed in Table 1), representing a wide range of performance characteristics. The Acapella was tested at an exhalation time of 3 seconds, as per manufacturer's instructions. For the Flutter and Quake, exhalation times were not specified by the manufacturers; both were tested at 2-second exhalation times, which was identified as the most comfortable rate by several users.

Figure 1. Devices tested (n=3 for each)

Device	Quake	Acapella	Flutter
Performance adjusted by:	Turning handle at different rates	Adjusting dial	Tilting device
Setting #1	30 RPM handle turn	Dial counterclockwise	Device horizontal
Setting #2	60 RPM handle turn	Dial at middle setting	Device tilted 20° back
Setting #3	120 RPM handle turn	Dial fully clockwise	Device tilted 40° back

Table 1. Settings evaluated for each device

Materials and Methods

The devices were attached via a USP throat model and flexible tubing to a modified Harvard Apparatus (Holliston, MA) large animal ventilator simulating tidal breathing of 500 mL and 750 mL at 1:1 I:E. Resulting pressure waves were collected with Honeywell (Morris Township, NJ) ASDX series pressure sensors, and analyzed in Excel. Device performances were compared via two-tailed T-tests; p <= 0.05 indicated a significant difference.

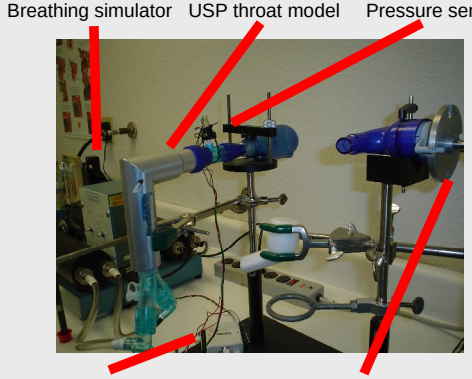

Figure 2. Pressure wave testing apparatus

Results

The results are summarized in Table 2. Of the three devices, the Quake had the widest vibration frequency range at the settings evaluated. At both the 750 mL and 500 mL breath volumes, the best setting of the Quake generated vibrations with significantly larger amplitudes than the best settings of the Acapella or Flutter. The Quake was the only device to generate vibrations during inhalation. Representative graphs of the pressure waves and vibration amplitudes generated by the three devices at 750 mL are shown in Figures 3a and 3b, respectively.

Results (continued)

Performance Characteristics (SDs in Parentheses)	Quake	Acapella	Flutter
Frequency Range: Min - Max (Vibrations/Second)	6 - 24	8 - 20	14 - 20
750 mL Tidal Volume:			
Best Amplitude Setting	30 RPM	Middle	Horizontal
Best Mean Vibration Amplitude - Exhalation (cm H2O)	14.5 (1.6)*	6.4 (0.5)	9.0 (0.1)
Best Mean Vibration Amplitude - Inhalation (cm H2O)	11.8 (1.4)*	0	0
500 mL Tidal Volume:			
Best Amplitude Setting	30 RPM	Middle	Horizontal
Best Mean Vibration Amplitude - Exhalation (cm H2O)	9.1 (1.4)*	5.0 (0.3)	6.8 (0.2)
Best Mean Vibration Amplitude - Inhalation (cm H2O)	7.7 (1.3)*	0	0

*Significantly higher than other devices; p < 0.05

Table 2. Results Summary

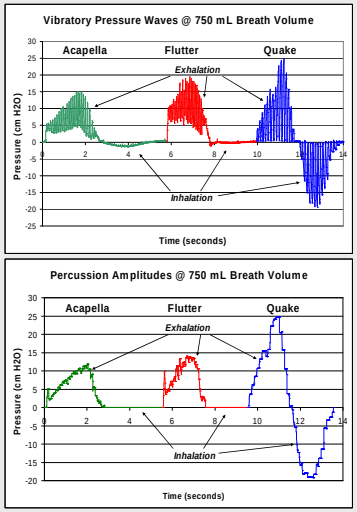

Figure 3. Representative pressure waves generated at 750 mL breath volume. (a) Raw pressure waves. (b) Moving vibration amplitudes.

Conclusions

Under the conditions evaluated, the Quake generated significantly stronger pressure pulses than both the Acapella and Flutter. This should translate into more vigorous airway percussion, and therefore more effective secretion loosening for patients with low tidal volumes. The Quake also demonstrated the widest range of vibration frequencies, which should allow the patient more control over the vibrations delivered to the airways.