

Performance characteristics of three handheld airway clearance devices: Quake, Acapella and Flutter

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Introduction

Handheld airway clearance devices are used by many patients as a supplement to or a replacement for methods such as CPT or The Vest (Hill-Rom, St. Paul, MN). When breathed through, the three handheld devices tested here, the Quake (Thayer Medical, Tucson, AZ), the Acapella (green) (DHD Healthcare, Wampsville, NY), and the Flutter (Axcan Scandipharm, Birmingham, AL), generate vibratory pressure waves in the airways of the patient to loosen mucus. In this study, these three devices were compared according to three key performance characteristics: vibration frequency (i.e. how many vibration pulses are delivered to the lungs per second), mean vibration pressure amplitude (i.e. the average strength of the vibration pulses) during exhalation, and mean vibration pressure amplitude during inhalation.

Devices Tested

Three of each of the three handheld devices (n=3) were tested (as shown in Figure 1). Each device was tested at three settings (detailed in Table 1), representing a wide range of performance characteristics.



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

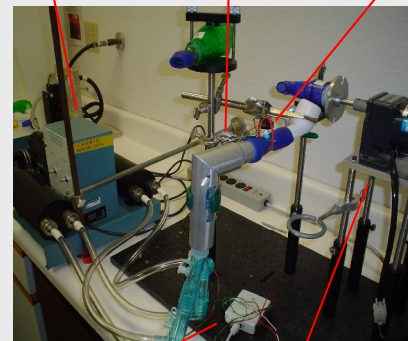
Device	Quake	Acapella	Flutter
Performance adjusted by:	Turning handle at different rates	Adjusting dial	Tilting device
Setting #1	30 RPM handle turn	Dial counterclockwise	Device horizontal
Setting #2	60 RPM handle turn	Dial at middle setting	Device tilted 20° back
Setting #3	120 RPM handle turn	Dial 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 1000 mL and 1500 mL at 12 breaths/minute and 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; $p \leq 0.05$ indicated a significant difference.

Breathing simulator USP throat model Pressure sensor



Data acquisition board Handle-turning motor (Quake only)

Figure 2. Pressure wave testing apparatus

Results

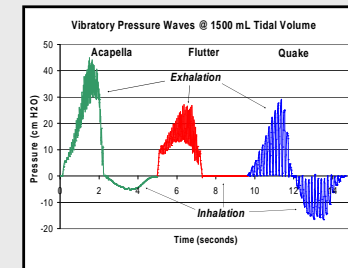
The results are summarized in Table 2. Of the three devices, the Quake had the widest vibration frequency range at the settings evaluated. At both the 1500 mL and 1000 mL tidal volumes, the best setting of the Quake generated vibrations with significantly larger amplitudes than the best settings of the 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 1500 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)	6.1 - 23.5	12.5 - 25.5	12.1 - 16.8
1500 mL Tidal Volume:			
Best Amplitude Setting	30 RPM	Middle	Horizontal
Best Mean Vibration Amplitude - Exhalation (cm H ₂ O)	14.1 (1.2)*	7.4 (0.7)	8.4 (0.3)
Best Mean Vibration Amplitude - Inhalation (cm H ₂ O)	9.3 (1.9)*	0	0
1000 mL Tidal Volume:			
Best Amplitude Setting	30 RPM	Middle	Horizontal
Best Mean Vibration Amplitude - Exhalation (cm H ₂ O)	7.8 (0.7)*	4.3 (0.2)	6.5 (0.3)
Best Mean Vibration Amplitude - Inhalation (cm H ₂ O)	5.8 (0.9)*	0	0

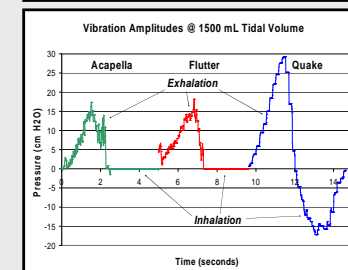
*Significantly higher than other devices, $p < 0.05$

Table 2. Results Summary



(a)

Figure 3. Representative pressure waves generated at 1500 mL breath volume. (a) Raw pressure waves. (b) Vibration amplitudes.



(b)

Conclusions

Under the conditions tested, the Quake generated significantly stronger pressure pulses than either the Acapella or Flutter. This should translate into more vigorous vibrations of the airways, which may lead to more effective loosening of mucus. Also, as the only device of the three to provide vibrations during inhalation as well as exhalation, the Quake most closely mimics the airway vibrations generated by CPT and The Vest.