

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

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Chest 2007: American College of Chest Physicians, Chicago, Ill. October 20-25, 2007

Chest; October 2007, 132, 608a

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**® (Axcen 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	75 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**; $p \leq 0.05$ 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 **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 H ₂ O)	14.5 (1.6)*	6.4 (0.5)	9.0 (0.1)
Best Mean Vibration Amplitude - Inhalation (cm H ₂ O)	11.8 (1.4)*	0	0
500 mL Tidal Volume:			
Best Amplitude Setting	30 RPM	Middle	Horizontal
Best Mean Vibration Amplitude - Exhalation (cm H ₂ O)	9.1 (1.4)*	5.0 (0.3)	6.8 (0.2)
Best Mean Vibration Amplitude - Inhalation (cm H ₂ O)	7.7 (1.3)*	0	0

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

Table 2. **Results Summary**

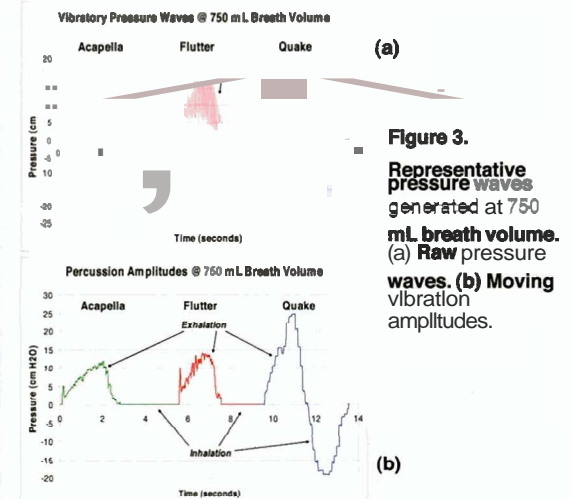


Figure 3. **Representative pressure waves** generated at **750 mL** breath volume. (a) **Raw** pressure waves. (b) **Moving** vibration amplitudes.

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**.