OSCILLATORY PRESSURE WAVE CHARACTERISTICS OF THE QUAKE, ACAPELLA AND FLUTTER DURING SIMULATED TIDAL BREATHING

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Introduction: For treatment of diseases requiring airway clearance, such as cystic fibrosis, chronic bronchitis and bronchiectasis, handheld oscillatory pressure devices are widely used in tandem with or in lieu of more stationary treatments such as chest physiotherapy (CPT) or The Vest (Hill-Rom, St. Paul, MN). Breathing through these handheld devices generates pressure waves, which vibrate the airways and help loosen pulmonary secretions. The magnitude of such airway vibrations depends largely on the amplitude of the waveform (i.e. the amount of pressure built up and quickly released during each cycle), and the frequency (i.e. how many oscillations occur per second). In this study, simulated tidal breathing (i.e. both exhalation and inhalation) was delivered through three handheld devices: the Quake (Thayer Medical, Tucson, AZ), the Acapella (green) (DHD Healthcare, Wampsville, NY), and the Flutter (Axcan Scandipharm, Birmingham, AL), and the pressure-wave characteristics of each were observed. Methods: Each of the three devices was evaluated at multiple device settings: the Quake at 30 RPM, 60 RPM, and 120 RPM of the rotating handle; the Acapella at the fully counterclockwise, midpoint, and fully clockwise positions of the adjustment dial; and the Flutter at 0° (horizontal), 20°, and 40° (with head tipped back). A Harvard Apparatus Dual Phase Control Respirator (Holliston, MA), modified to simulate tidal breathing (both exhalation and inhalation) of up to 1.5 L/min, was used to deliver tidal flows of 1.5 L/min, 1.25 L/min, and 1.0 L/min to each device at a breath rate of 12 breaths/min. To better simulate throat physiology, the simulated breaths were delivered through a USP throat model which was connected to the mouthpiece of each device. Both the exhalation and inhalation phases were flowed through the Acapella and Quake, but since the Flutter does not allow inhalation at many settings, only the exhalation phase was delivered to it. For each device setting-flow rate treatment, the pressure waves resulting from three complete tidal breaths were digitally acquired via Honeywell ASDX series pressure sensors (Freeport, IL). The mean pressure-wave amplitude and frequency for each treatment was calculated in Excel, and mean amplitude differences between treatments were considered significantly different at a p-value of 0.05. Results: At all three tidal volumes tested, the Quake rotated at 30 RPM provided the highest mean exhalation pressure amplitude: 14.4 cm H_2O at 1.5 L/min, 12.5 cm H_2O at 1.25 L/min, and 9.4 cm H_2O at 1.0 L/min. These values were significantly higher than the best performing Acapella and Flutter settings at each of the three tidal volumes. For the Acapella, the highest mean exhalation pressure amplitudes were observed at 1.5 L/min at the midpoint setting, and at 1.0 L/min and the clockwise setting (both 7.8 cm H_2O). The Flutter yielded its highest exhalation pressure amplitudes at the 0° (horizontal) setting, with a maximum of 6.7 cm H_2O at 1.5 L/min. Of the three devices, only the Quake provided oscillatory pressure upon inhalation, with the highest mean pressure amplitude of 9.2 cm H_2O observed using the Quake rotated at 30 RPM at a tidal volume of 1.5 L/min. Exhalation pressure wave frequencies for the three devices were similar, ranging from 6-24 pulses/second for the Quake, 11-22 pulses/second for the Acapella, and 14-24 pulses/second for the Flutter. The mean exhalation pressure wave amplitudes for the Flutter and Quake were consistent over all three breath cycles, with standard deviations from 1% to 4% of the mean for these devices at all settings. The Acapella was also consistent at the counterclockwise and midpoint settings, but became erratic at the clockwise setting, yielding standard deviations from 8% to 27%. Conclusions: Of the three devices tested, the Quake provided the highest mean pressure amplitudes at all tidal volumes simulated. In addition, the Quake was the only device that provided oscillatory pressures during the inhalation phase, as does The Vest. These findings suggest that, of the three devices tested, the Quake provides the strongest vibratory pulses throughout the entire breath cycle, which may translate into a better airway-clearance effect.