# Repeatability of AERO for Improved Lymphedema Assessment

Grace Krell[1], Stephanie George[1]
[1]East Carolina University, Greenville, NC

## Introduction

Lymphedema is swelling caused by a blockage in the lymphatic system, damage due to chemotherapy, or surgical removal of lymph vessels. The research team has previously developed AERO [1], an experimental device that assesses lymphedema. AERO works by administering an air puff to a patient through objective measurement, unlike individual and biased assessments clinicians.

## Objective

The purpose of this study was to assess the repeatability of AERO's automatic air pulse and quantify the pressure and flow output of the device. Results from this testing will prove if the AERO is a viable accurate device to administer these tests.

## The AERO Machine

- The AERO consists of: a nozzle that puffs compressed air which forms an indentation on the pressure pad or flowmeter, a pressure vessel, and a frame that maintains all the components in place. The unit is housed on a cart that holds all the components. The pressure vessel is hidden from view. This vessel was used to output pressure levels from 20psi to 80psi.
- Each test is initiated through a button that regulates the time that air is let out of the pressure tank.

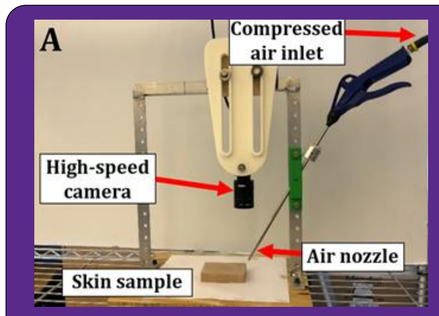


**Figure 2.** The AERO Machine

**Figure 3.** The AERO with Flowmeter

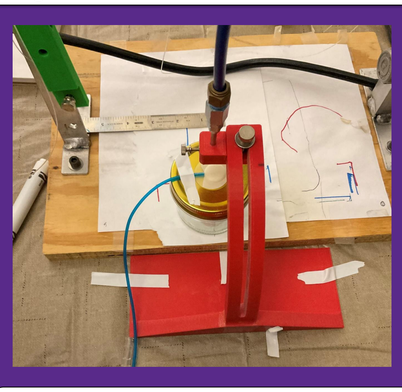

**Figure 4**. Arial View of Pressure Pad. Angle Markings are Visible

## Methods & Materials

•19 total tests were conducted using the AERO,
- The flowmeter and pressure pad testing method ensured that the nozzle was held the same distance away from the device each test.

Flowmeter:
- 7 tests
- 7 different pressure ranges, from 20psi to 80psi

Pressure Pad:
- 12 tests
- 4 angles and 3 pressures used, 20psi, 50psi, and 80psi.
- Data was collected and analyzed through the BIOPAC Student Lab Analysis Software.


**Figure 1.** A flowchart detailing each process within the testing procedure.

## Results

Flowmeter Testing:
- Peaks 3-5 were analyzed
- The standard deviation averaged 1.04142 L/s and ranged between 0.55 L/s to 1.65 L/s
- Each test occurred for 0.43 seconds

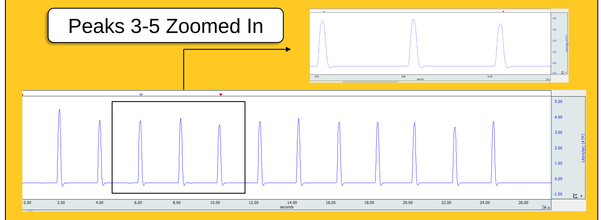


**Figure 5.** A view of the section of data selected from the Flowmeter 50psi test.

| Flowmeter Testing Trial Number | Pressure, psi | Standard Deviation, L/s |
|---|---|---|
| 1 | 20 | 0.54953 |
| 2 | 30 | 0.93994 |
| 3 | 40 | 0.84948 |
| 4 | 50 | 0.94707 |
| 5 | 60 | 1.41447 |
| 6 | 70 | 1.65149 |
| 7 | 80 | 0.93796 |

**Figure 6.** The average standard deviation for each flowmeter trial.

Pressure Pad Testing:
- Peaks 3-5 were analyzed
- The standard deviation averaged 0.268 psi and ranged between 0.082psi to 0.512psi
- Each test occurred for 0.43 seconds

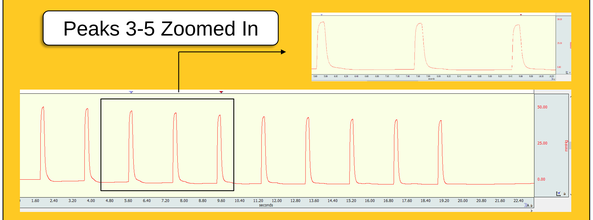


**Figure 7.** A view of the section of data selected from the pressure pad at angle 1 and 50psi.

| Pressure Pad Trial Number | Pressure, psi | Angle | Standard Deviation, psi |
|---|---|---|---|
| 3 | 20 | 1 | 0.000 |
| 6 | 20 | 2 | 0.000 |
| 9 | 20 | 3 | 0.000 |
| 12 | 20 | 4 | 0.000 |
| 2 | 50 | 1 | 0.000 |
| 5 | 50 | 2 | 0.000 |
| 8 | 50 | 3 | 0.000 |
| 11 | 50 | 4 | 0.000 |
| 1 | 80 | 1 | 0.000 |
| 4 | 80 | 2 | 0.000 |
| 7 | 80 | 3 | 0.000 |
| 10 | 80 | 4 | 0.000 |

**Figure 8.** The average standard deviation for each pressure pad trial.

## Discussion & Conclusion

- All 39 graphs have been created for this experiment.
- The maximum and minimum values for peaks 3-5 of every graph were determined along with the integral of each peak, average standard deviation, and the time for each peak to occur.
  - Since the AERO is controlled through a time sensitive button, all peaks occurred for 0.43 seconds as determined through the graphs analyzed.
- For the pressure pad testing, even through the angle was changing along with the pressure expelled by the AERO, the results across each angle remained consistent.
- When looking at a pattern in standard deviation, the standard deviation generally increased proportionally as the pressure increased, maintaining a value about 25% of the average height.
- The standard deviations are negligible, because the coefficient of variation for every measurement is less than one.
- Limitations of this test included the variations within the AERO setup, such as the pressure change when the compression tank was full, and the non-permanent fixture to hold the flowmeter.
- These results inspire confidence that changes in AERO measures are not due to variability of air pulse and support clinical translation
- In conclusion, the AERO machine provides a repeatable test that assures the same pressure and flow output with each puff of air.

## References & Acknowledgements

[1] Williams, K., et al., AERO: An Objective Peripheral Edema Measurement Device. presented at IEEE-EMBC 2018, p. 1-4

Thank you to Keith Williams and James Buck on their work towards the development of the AERO.
This Project has been funded through URCA, I-Corps, and Interdisciplinary Research Awards.