A NOVEL CPR FEEDBACK DEVICE

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Need Statement

There is a need for a comfortable, intuitive, and easy to read CPR compression evaluation and counter sensor module.
5 Aspects of CPR Quality

1. Compression fraction
2. Compression rate
3. Compression depth
4. Chest recoil
5. Ventilation
Cardiac Arrest Treatment and Mortality

In a manikin study, CPR compression quality dropped from 92.9% to 18% from first minute to fifth minute (1).

Less than 12% of people survive cardiac arrest when it occurs outside a hospital (2).

CPR quality is critical to survival
AHA Statements on CPR Feedback Devices

- 2010: “New CPR prompt and feedback devices may be useful for training rescuers and as part of an overall strategy to improve the quality of CPR in actual resuscitations.”

- 2015: “It may be reasonable to use audiovisual feedback devices during CPR for real-time optimization of CPR performance.”

Feedback devices provide crucial information during compressions
Current Feedback Devices

Zoll PocketCPR (3)
- $129
- Made of hard, bulky plastic

CPRmeter (4)
- $895
- 18% of healthcare providers find uncomfortable

Philips HeartStart MRx (5)
- $2,000 - $5,000 by model
- Confusing display module, attached to AED
## Design Parameters - Function

<table>
<thead>
<tr>
<th>Indicator of compression force</th>
<th>Bar of lights</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indicator for number of compressions completed</td>
<td>LCD display</td>
</tr>
<tr>
<td>Flexible and comfortable to use</td>
<td>Pliable main material</td>
</tr>
<tr>
<td>Sterilizable</td>
<td>Material can be cleaned</td>
</tr>
<tr>
<td>Electrically insulated</td>
<td>Material that has high resistivity</td>
</tr>
</tbody>
</table>
Final Design

- Pressure Sensor
- Soft Silicone Layers
- Light Bar
- Box to hold Electrical Components
### Our Feedback Indicator

<table>
<thead>
<tr>
<th>Load Range</th>
<th>Indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 lb &lt; Load &lt; 25 lb</td>
<td>🟢</td>
</tr>
<tr>
<td>26 lb &lt; Load &lt; 50 lb</td>
<td>🟢</td>
</tr>
<tr>
<td>51 lb &lt; Load &lt; 75 lb</td>
<td>🟢</td>
</tr>
<tr>
<td>76 lb &lt; Load &lt; 100 lb</td>
<td>🟢</td>
</tr>
<tr>
<td>101 lb &lt; Load &lt; 125 lb</td>
<td>🟢</td>
</tr>
<tr>
<td>126 lb &lt; Load &lt; 150 lb</td>
<td>🟢.green.red</td>
</tr>
<tr>
<td>151 lb &lt; Load</td>
<td>🟢.blue.green.red</td>
</tr>
<tr>
<td>Apply Breaths</td>
<td>🟢.blue.green.red</td>
</tr>
</tbody>
</table>
Device Set-Up

- Battery
- Signal Conditioning Board
- Microcontroller
- Pressure Sensor
- Light Module and Lights

IN CONTACT WITH PATIENT
NOT IN CONTACT WITH PATIENT
Testing and Calibration
Sensor Variance

Sensor tested under various conditions (tested for 0-5 lbs):

- Sensor by itself
- Sensor loaded on hard surface
- Sensor loaded on soft surface
- Sensor with heat

No significant change in output was found.
Calibration Methods

MTS Tensile Tester

- Apply a known load
- Measure digital output from Flexiforce/Tekscan board
- Adjust sensitivity/range of sensor accordingly using trimpot

Platin and Actuator

Adjustable Trimpot

Testing Set-Up
Calibration Results

MTS Calibration Curve

\[ R^2 = 0.9958 \]
Coding Methods

Similar to High Striker carnival game

- Each time a threshold was reached, an additional light turned on

```
if( sensorValue > 750 ) {
    // set pixel to red, delay(1000)
    strip.setPixelColor(5, 0, 255, 0);
    strip.show();
} else {
    // set pixel to off, delay(1000)
    strip.setPixelColor(5, 0, 0, 0);
    strip.show();
}

if( sensorValue > 900 ) {
    // set pixel to red, delay(1000)
    strip.setPixelColor(6, 255, 0, 0);
    strip.show();
} else {
    // set pixel to off, delay(1000)
    strip.setPixelColor(6, 0, 0, 0);
    strip.show();
}
```
Packaging and Assembly
Fabrication Methods

PDMS

- Molds for pouring PDMS into
- Two PDMS sheets cured
- Plasma treatment to bond sheets together
- Baked for 25 minutes at 70 °C
PDMS Testing

Tensile test between two layers of PDMS

Actuator pressing on Sensor

Set up for water proof testing

$y = 5.8994x - 42.755$

$R^2 = 0.9942$
First Prototype Review
Fabrication of Microprocessor Box

AutoCAD
• Created so features match dimensions of LCD screen and switch

3D Printer
• 3D printer maker bot used for fabrication
• Prints hard polymer
Second Prototype

- Created after BLS
  - Found 1st prototype to be too small
    - Could not see feedback
- New dimensions to include average size of human hand
Design Iterations
Feedback from Royal Oak Fire Department

Met with a total of 6 firefighters

- Thought that the device to be comfortable on their hands
- Thought that the feedback to be easy to understand
- Thought that the compression counter was useful
Future Work

- Further calibrations using an automatic CPR compression device
- Cheaper material selection for encasement
- Custom microprocessing and signal processing circuitry
- Applying for a design patent
References


QUESTIONS?
Objective:
Create a comfortable, intuitive, and easy to read CPR compression evaluation and counter sensor module.

Approach:
Identified a need, researched current devices and potential solutions, determined device design, identified suitable materials and equipment, and finally assembled final device.

Impact:
Could improve CPR feedback device compliance rates in the ambulatory and CPR training industries.

Progress and Results:
1. Tested and calibrated chosen sensor
2. Coded unique indicators of compressive force
3. Fabricated 3 functional devices
4. Received positive feedback from medical professionals regarding comfort
5. Further calibration with an automated CPR delivery device necessary