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Design Testing

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Background

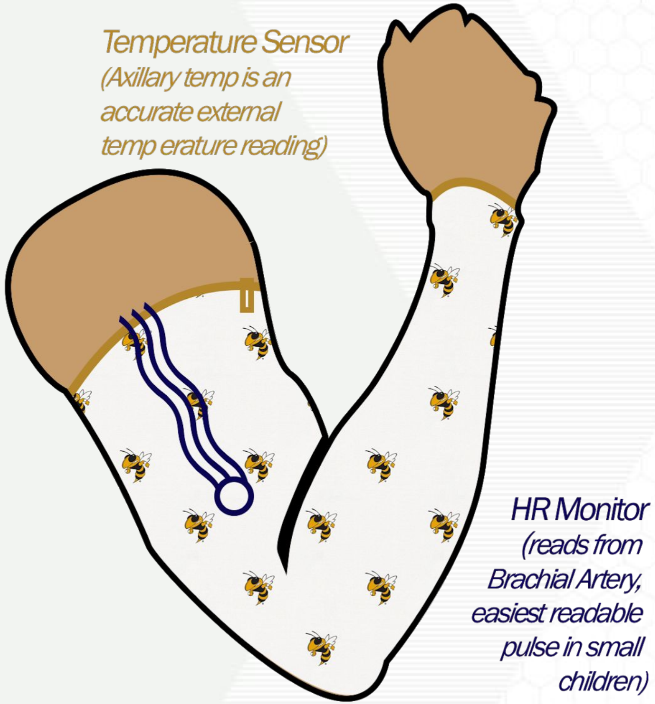

Figure 1: Idealized final design

A febrile seizure is a type of generalized tonic-clonic seizure that is accompanied by high temperature.

- Febrile seizures affect **2-4%** of children in the United States
- Affects children between age **6 months and 5 years**
  - Peak age between **12 and 18 months**

Current Medical devices test:

- **changes in body temperature**
- muscle convulsions
- heart rate
- **heart rate variability (HRV)**

Conceptual Model

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- **Microcontroller:**
  - Elegoo Uno R3
- **Sensors:**
  - Pulse Sensor Amped (PPG sensor)
    - Measures the **changes in light absorption** from the skin to detect blood flow rate.
  - TMP36 Analog Temperature Sensor
    - Detects the **axillary** temperature
- **Sampling Rate**
  - 100 Hz using a 10 bit Analog/Digital converter
- **Processor/Support**
  - Matlab
  - Arduino Support Package

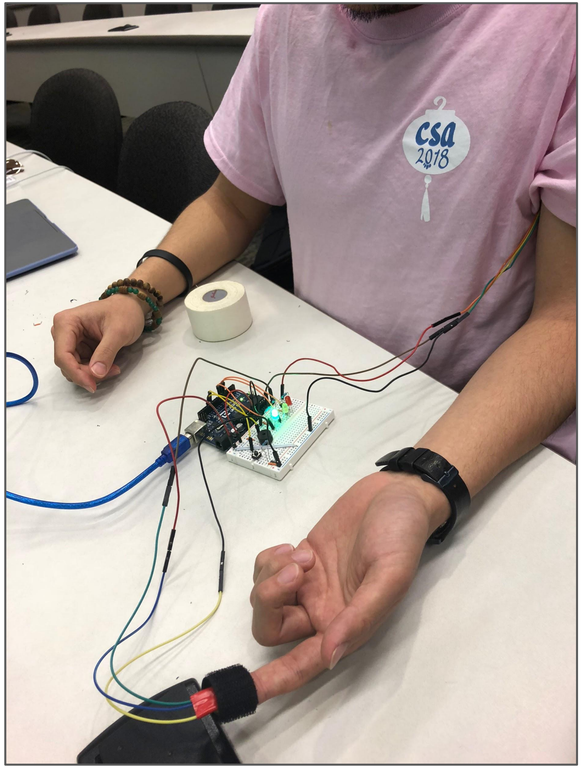

Figure 2: Device in application.

Decision Making Process

Experiment	Pros	Cons
Heart Rate vs. Heart Rate Variability	- Confirm the hypothesis that HRV is a more reliable method than HR for determining seizure onset	- Not using seizure data from our chosen population to test LF/HF ratio
Fluctuation of LF/HF Ratio	- Tests a limit of our device and would allow us to determine a condition under which the device fails	- Lack of data and research that suggests LF/HF ratios will fluctuate on the cusp of seizure/non-seizure threshold

Decision Making Process

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Experiment	Test Type	Pros	Cons
Heart Rate vs. Heart Rate Variability	ANOVA	- Compares both the mean and variation of two or more populations	- Requires two or more independent samples receiving different treatments
	Unpaired t-test	- Tests the means of two independent random samples	- Inappropriate for experiment in which treatment is applied - Requires two independent samples - Cannot control for effects of the environment
	Paired t-test	- Tests the means on before and after observations on same subjects - Eliminates the risk that participants in each group vary significantly from each other	- Inappropriate for experiments with independent samples

Experimental Design

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Motivation

- We aim to show that voluntary physical activity can generate a 10% or more increase in heart rate in 2 minutes but not change the LF/HF ratio significantly.

Dependent Variable

- Heart rate and LF/HF ratio

Independent Variable

- Physical activity

Confounding Variable

- Health condition of the test subject

Figure 3: Collecting heart rate data

Experimental Design

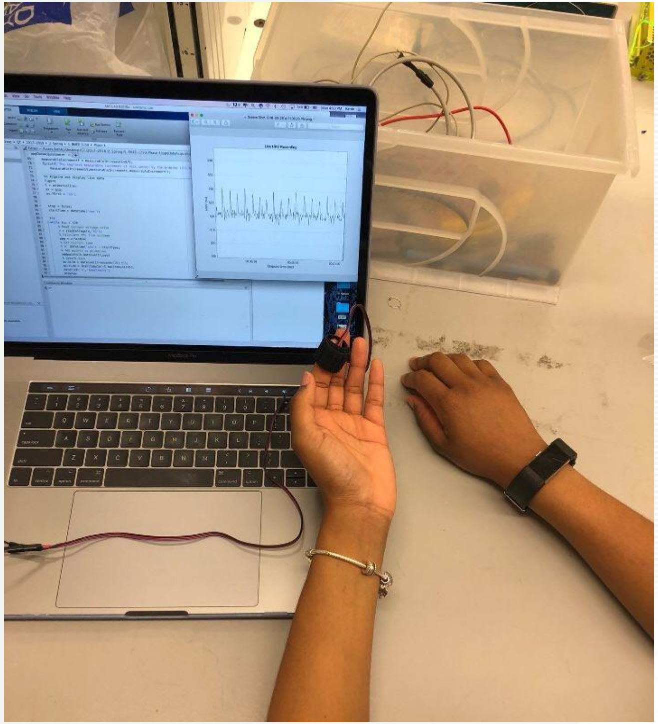

Figure 4: Post-run HRV data collection

Design

- Convenience sample of 10 students ages 18-23
- Measure the LF/HF ratio and HR before running on treadmill (2 minutes)
- Have subjects run on a treadmill at a speed of 5 mph for 2 minutes
- Measure HR during running period
- Measure the LF/HF ratio and HR after running (2 minutes)
- Perform paired t-tests on pre and post run measurements.

Assumptions:

- Participants do not have pre-existing heart conditions
- FitBit Technology is a reliable way to measure HR

Hypotheses

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Heart Rate

H_0: Null Hypothesis $\mu_1 = \mu_2$

- There is no significant difference between the means of pre and post run HR

H_1: Alternative Hypothesis $\mu_1 < \mu_2$

- The mean of post run HR is greater than the mean of prerun HR

LF/HF

H_0: Null Hypothesis $\mu_1 = \mu_2$

- There is no significant difference between the means of pre and post run LF/HF ratio.

H_1: Alternative Hypothesis $\mu_1 \neq \mu_2$

- There is a significant difference between the means of pre and post run LF/HF ratio.

Data Analysis

Feature	Pre-run	Post-run	% Change	P value
Mean Heart-rate (beats/min)	70.9	97.0	36.8	**<0.0001**
Mean LF/HF ratio	0.57	0.56	-1.22	**0.9104**

Statistical test for HR

- One-tailed Paired t-test

Decision

- Reject null hypothesis
- There is a significant increase in the mean from pre-run to post-run HR.

Statistical test for LF/HF ratio

- Two-tailed Paired t-test

Decision

- Fail to reject null hypothesis
- There is no significant difference in the means of pre and post run LF/HF ratio

Data Analysis

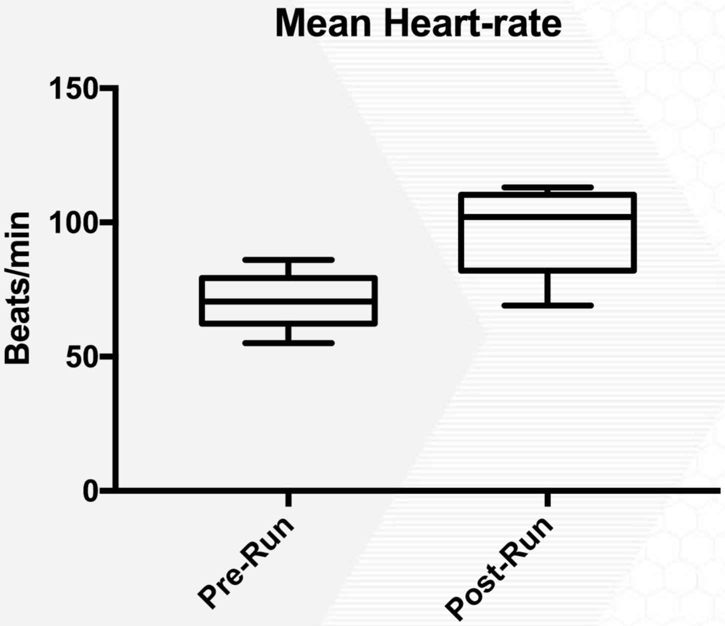

Figure 5: Comparison between mean HR prerun and mean HR postrun

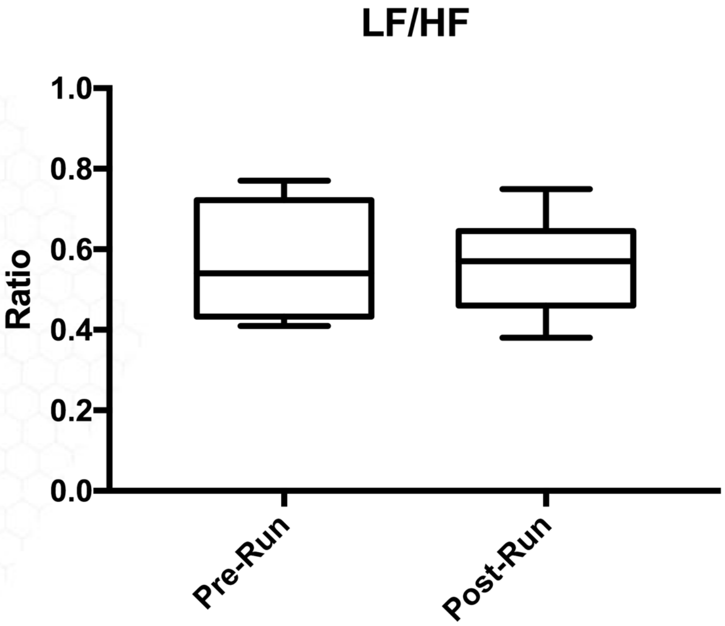

Figure 6: Comparison between mean LF/HF ratio prerun and mean LF/HF ratio postrun.

Insights Gained

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Lessons Learned

- Sample size is relevant in a meaningful statistical analysis
- What a t-test is and why it is insightful
- LF/HF ratio is a reliable method for detecting seizure onset

Future Steps

- Optimize post-run data collection process
- Test on a random sample with target population (1.5 - 3 year olds)
- Measuring the brachial pulse, instead of using the finger
- Materials for and creation of the sleeve itself
- Incorporating the electronics into the sleeve

Citations

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Determining Sample Size

Calculating Effect Size

- Resting Heart Rate for a 20 year old = 60-100 bpm
- Active (50-85%) Heart Rate for a 20 year old = 100-170 bpm
- Mean of difference = 135 - 80 = 55
- Standard Deviation of difference ~ (20 + 35)/2 = 27.5
- Effect Size = 2

Calculating Sample Size

- Tail(s) = One
- Parent distribution is normal
- Effect Size = 2
- α err prob = 0.05
- Power (1- β err prob) = 0.95
- Sample Size = 5