CALIFORNIA STATE SCIENCE FAIR
2015 PROJECT SUMMARY

Name(s)

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Project Number

35327

Project Title

A Wearable Device for Heart Rate and Blood Oxygen Saturation Tracking and Health Management

Abstract

Objectives/Goals

The goal of this project was to build a wearable device that could measure heartrate (BPM) and blood oxygen saturation (SpO2) during various types of exercise and could be used to monitor health.I hypothesized that if I used such a device, I would be able to measure BPM to near EKG levels.

Methods/Materials

I used an Arduino board, a phototransistor, red and infrared LEDs for the pulse oximeter and photoplethysmograph, generic electronic components to amplify the signal from the LEDs, glove, hard drive case, and Sugru Self-Setting Rubber for finger cuff. Arduino and Processing sketches from the internet were modified to calculate the BPM and the ratio R=(ACrmsRed/DCrmsRed)/(ACrmsIR/DCrmsIR) for SpO2. A Nonin OEM III Kit was used to calibrate BPM and SpO2 at rest, and verified for accuracy of measurements during a treadmill workout. An empirically derived equation 118 - 20*R was estimated to match the sensor SpO2 data. BPM and SpO2 were measured for four subjects (12 to 83 years), during, before, and after exercise for 1) normal walking and 2) a treadmill (speeds 2.8, 3.2 and 3.6mph).

Results

Subjects 2 and 3 were tested at >85% of age-adjusted peak BPM (for a mile at 3.2 and 3.6 mph respectively) for 7-11 days. Subjects 1, 2, and 4 recovered to resting rate within 20 minutes, while Subject 3 took much longer, sometimes >1 hour. SpO2 mostly stayed within 90 to 100%, considered as normal. Unlike expectations before the study, peak BPM for all subjects. deviated less than 15%. BPM reduction after 2 minutes was >22 for Subjects 2 and 3 indicating no cardiovascular issues.

Conclusions/Discussion

My hypothesis was supported because the device was able to accurately monitor BPM and SpO2 during exercise, contrary to the initial assumption that accelerometer based error correction would be needed. Also, there was excellent correlation between the heart rate data from the wearable device and the Nonin OEM Kit, providing an R^2 fit of 0.96 from 77 to 147 BPM. The finger cuff helped limit relative movement between finger and sensor, producing accurate results even during exercise, and the device was simple to manufacture. This study could be extended to test cardiovascular patients with support from a cardiologist to do detailed comparison of BPM and EKG. Device improvements could be non-invasive blood glucometer, sweat analysis sensor and a thermometer; a mobile app to allow long-distance monitoring for physicians.

Summary Statement

A prototype wearable device for mobile health management by measuring heart rate and blood oxygen saturation and extendable to glucose and other biomarkers.

Help Received

My parents guided in coding and soldering portions of the device. Thanks to Steve Carey from Nonin-Medical Inc. for providing the device free of cost for use in testing.

Preliminary