The Effects of Caffeine Levels on Muscles Electrical Activity using Electromyography (EMG) Sensors- A Work In Progress

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Abstract and Background

Background: Electromyography (EMG) is the recording of electrical activity of muscles from muscle activation and neuron activity. EMG surface sensors are attached to the skin and muscles in the body emit electrical signals that are read by the sensor. EMG sensors can be used in a variety of different clinical approaches for diagnostic testing of neuromuscular diseases. Previous research has investigated neuromuscular groups and how energy drinks can affect motor tasks. We have investigated how caffeine interacts with the bicep brachii muscle groups in terms of the electrical signals emitted from the muscle group. **Methods**: For various caffeine contents (0mg, 50mg, 100mg, 150mg, and 200mg), electrical signals were measured using surface EMG sensors placed on the bicep brachii muscle group. Readings were gathered at both muscle relaxation and contraction**. Results:** When the muscles were relaxed there were some changes in voltage levels but there was not a correlation of higher the caffeine, the higher the voltage levels. In a few of the cases the initial voltage reading was higher than the final reading when 200 mg of caffeine was consumed. For muscle contraction, there was a correlation between the two, and all the 200 mg caffeine readings were higher than the initial recordings with no caffeine in the individual's system. **Conclusions:** Preliminary testing has only been performed thus far and more tests need to be done in the future to get conclusive results on the correlation between caffeine and electrical signals. From these preliminary tests it is shown that when muscles are at contraction there is a voltage increase particularly at 100mg of caffeine. This shows that caffeine contents may want to be limited especially when muscles are going to be under stress and contracting.

Introduction and Research Question

Individuals on the daily consume caffeine in the form of energy drinks. The majority of these individuals are not fully aware of what effect caffeine can have on their muscles. The news and other journal articles primarily focus on the effects that these drinks can have on your heart and your body but the effects that caffeine has on your muscles are extremely important too. Electromyography sensors are the driving tool in discovering these effects by reading the electrical signals that are produced by your muscles. We hypothesize that there will be a correlation between caffeine content and the muscle electrical activity. In order to investigate this correlation, a code has been developed in Arduino IDE that when working in conjunction with the attached sensors will read the voltage levels produced by the bicep brachii at different caffeine content levels.

With the question of how caffeine contents effect the electrical signals in your muscles a full study needed to be performed by measuring voltage levels at different caffeine levels for both relaxation and contraction of the muscles. By collecting data for this study initial conclusions can be made on what caffeine levels are safe to be consumed at different muscle contraction or relaxation times or determine there is no correlation between the two. In order to get conclusive results more testing will need to be done in the future in addition to this preliminary testing.

Methods

We began by developing a code written in Arduino IDE to collect voltage readings through an Arduino board that has EMG sensors attached [2]. The sensors are placed on the bicep brachii muscles which will emit electrical activity that the sensors will pick up on [1]. The sensors include three electrodes made of up a reference, middle, and end electrode that are placed precisely where the muscle will rise when contracted. These electrodes pick up on electrical signals that are then outputted as voltage readings through the Arduino IDE code in the form of Voltage vs. Time graphs[4,5]. Caffeine is then consumed at specific content levels and readings are gathered at both relaxation and contraction of the muscles[2].

In order to become comfortable with the sensors and electrode placement before adding caffeine, a variety of tests were performed to confirm that the readings gathered were accurate. The placement of the electrodes was very important because if they were placed in a slightly different position then the electrical signals recorded would be different as well. We recorded signals at both relaxation and contraction to see the correlation that these two had and ultimately use these results to compare the readings given when there was caffeine in the individuals system.

One challenge with the sensors is that noise will affect the readings given. Because of the noise the readings would vary from test to test but they were all within a certain range in this preliminary testing where the results could still be analyzed.

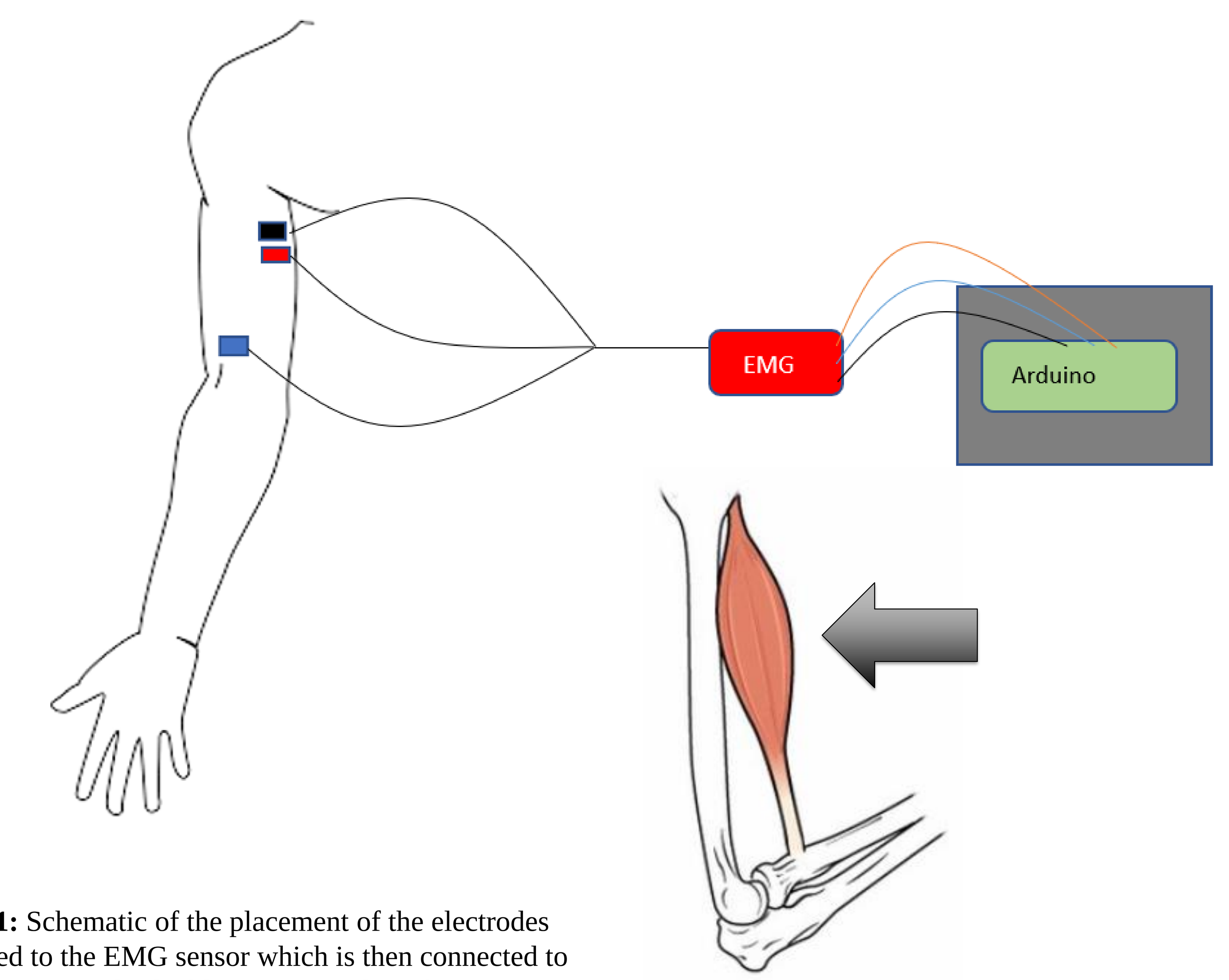

Figure 1: Schematic of the placement of the electrodes connected to the EMG sensor which is then connected to the Arduino Board. The blue sensor is the reference electrode, the red is the middle electrode, and the black is the end electrode.

Figure 2: Schematic of bicep muscle contraction. This is how contraction was done.

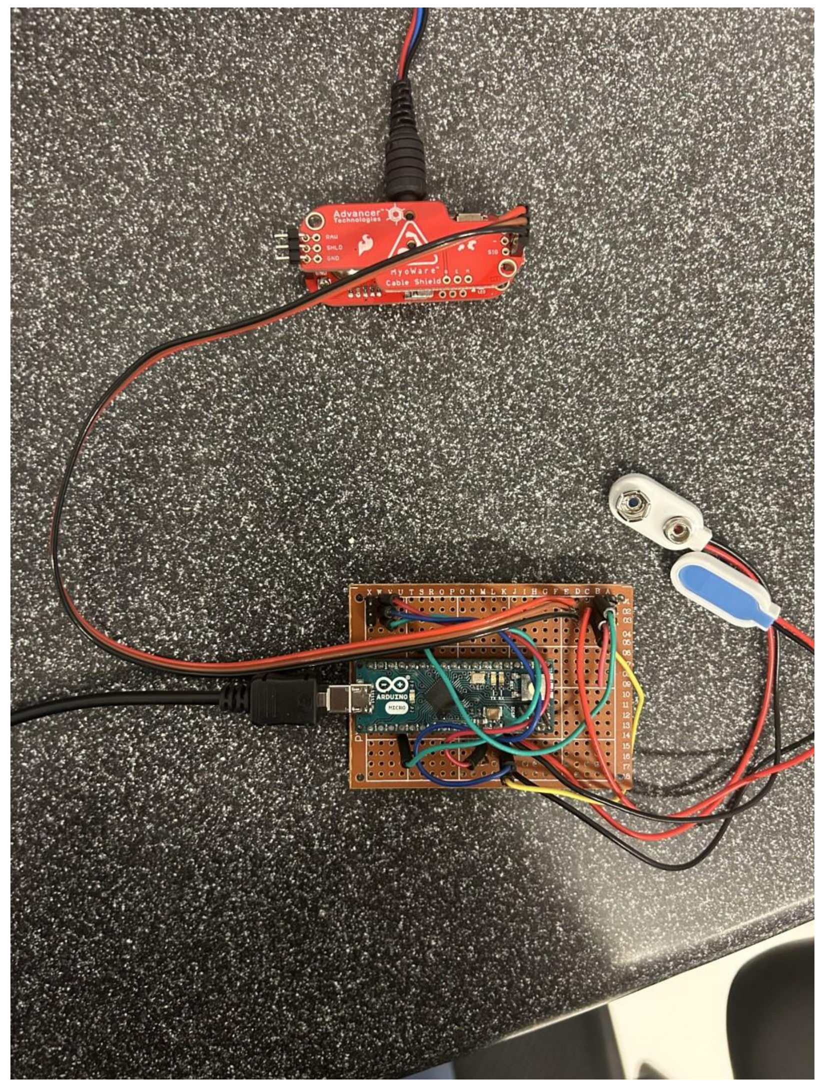

Figure 3: EMG sensor and Arduino Micro Board used to collect the data from the electrodes placed on the bicep brachii.

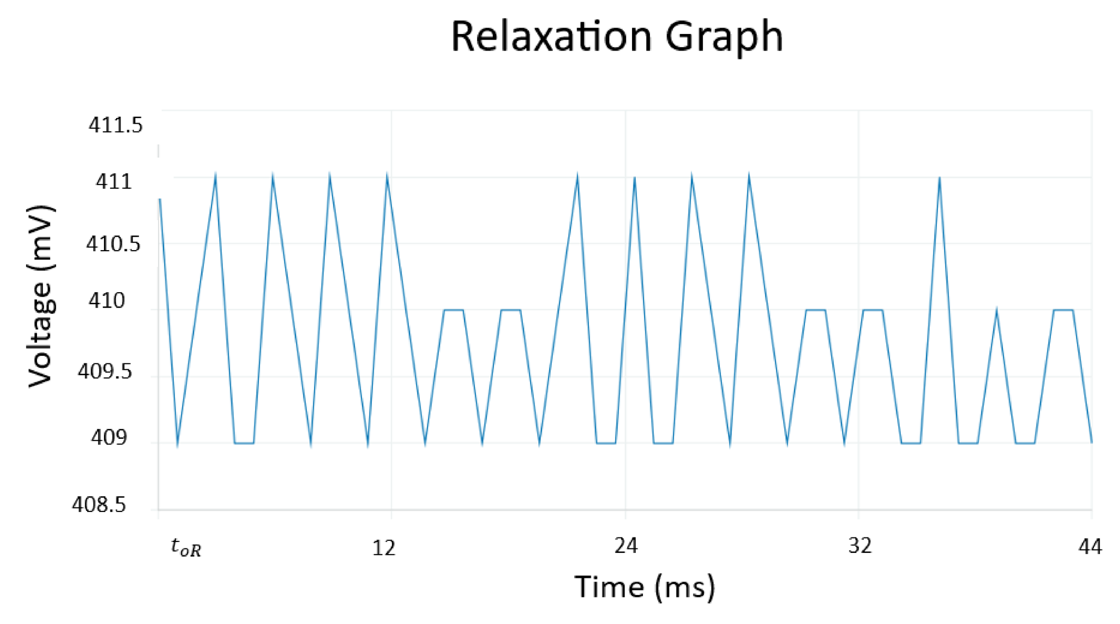

Figure 4: Graph capture produced by the Arduino IDE code of a Voltage vs Time graph. The bicep brachii muscle group was in full relaxation in this graph capture when 150mg of caffeine was consumed.Both t_{oR} and t_{oC} are arbitrary.

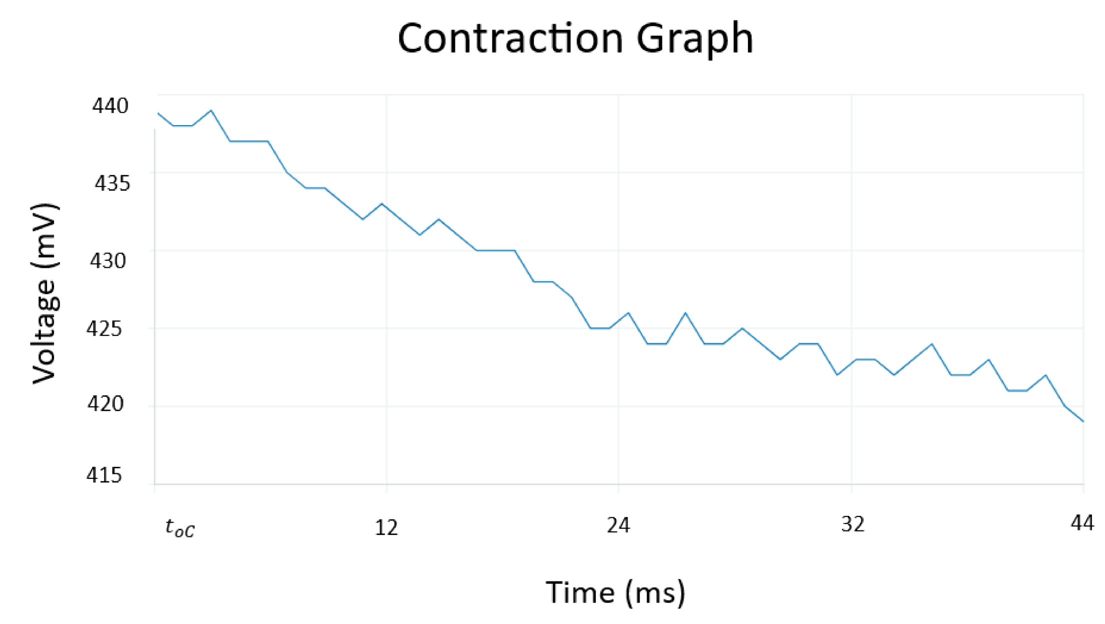

Figure 5: Graph capture produced by the Arduino IDE code of a Voltage vs Time graph. The bicep brachii muscle group was in contraction during this graph capture when 150mg of caffeine was consumed. Both t_{oR} and t_{oC} are arbitrary.

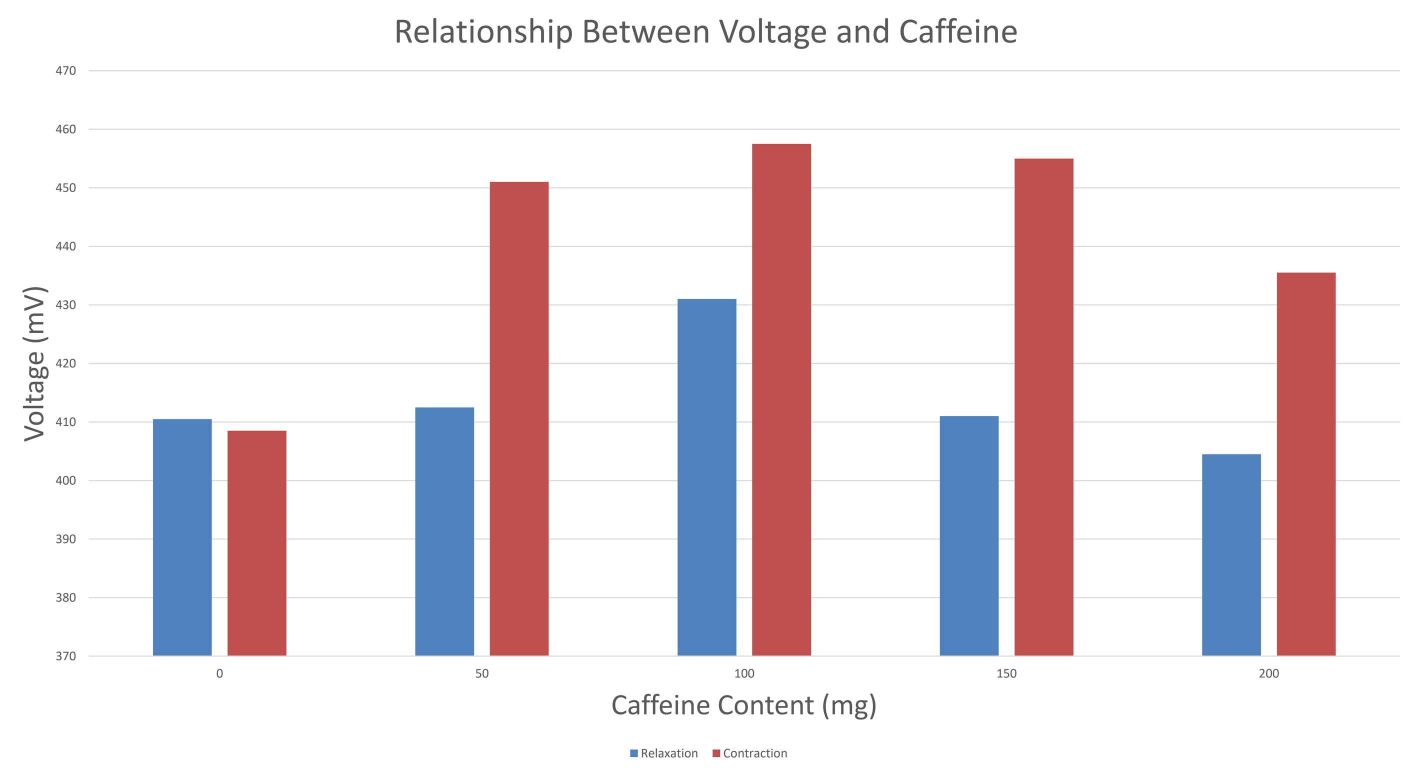

Figure 6: Bar graph created in EXCEL which shows the correlation of voltage levels as the caffeine consumption level increases. The bars show how relaxation and contraction are related to one another. Blue is contraction and red is relaxation.

Results and Conclusion

Preliminary Results

For each test that was performed, graph captures were taken twice for each caffeine consumption level. These values were then averaged, and bar graph was created to show the voltages reading for each caffeine level on one graph [6]. For relaxation, the initial reading was around 410mV. As caffeine was consumed, there was some increase in the voltage levels with it getting as high as 432mv when 100 mg was consumed but it did decrease after that. Further testing will need to be done to see what effect noise has on these readings, possibly causing come of the fluctuation. For muscle contraction, the same method was used of capturing two graphs for each caffeine consumption level and then averaging the two together and creating one bar graph with all the readings. The initial readings started around 410mV as well when there was no caffeine in the system. There was a steady increase in voltage levels as the caffeine content went up and then after 150mg there was a slight decrease. Voltage levels got as high as 458mV at 100mg of caffeine.

Conclusions

Based on the fact that voltage levels significantly increased at 100mg of caffeine for both relaxation and contraction, individuals should be mindful of the amount of caffeine they consume and 100mg should be a maximum point that individuals should go to. These are only preliminary results, so more testing will need to be performed in the future to draw conclusive conclusions.

Challenges

When recording data there were a few challenges that may have resulted in some of the fluctuations seen on the graphs. In future testing these challenges will be tested we will be looking for a resolution for them.

- Noise from the sensors being surface electrodes rather than implantation electrodes.
- Placement of electrodes varied from test to test slightly which may result in different values because they are picking up voltage outputs.
- A basic Arduino IDE code was implemented, so we plan on developing that code to create graphs that show more and possibly plot all the data we need rather than combining points and plotting it on our own.

Future Work

1. Perform more testing for both relaxation and contraction of the bicep brachii muscle group for the different caffeine content levels.
2. Develop a more sophisticated Arduino IDE code that will plot all the data together that is recorded from the Arduino.
3. Draw definite conclusions about what effect caffeine has on the muscles or if there shows to be no conclusive effect.
4. Work with smaller caffeine increments to see exactly where voltage changes are most prevalent to find the exact recommended caffeine cutoff.
5. Investigate further 150mg and 200mg caffeine points.

References and/or Acknowledgments

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