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Muscular Atrophy Detection (M.A.D) Sleeve Project Proposal

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Team 13

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# 1 Introduction

# 1.1 Objective

Muscular atrophy affects many people throughout the world. It is a disease that can be brought about from a lack of use of the affected muscle or neurogenic causes. When it comes to the case of atrophy from disuse, it is commonly seen in patients or elderly who are bedridden. In terms of neurogenic muscular atrophy, it is caused by injury or disease to the nerves that connect to the affected muscle tissue. Some of the more common diseases that cause this form of atrophy are ALS (Lou Gehrig Disease), Guillain-Barre Syndrome, and polio. [1] Regardless of cause, those that suffer from muscular atrophy experience a deterioration of muscle tissue causing a reduction of muscle strength and motor skills. [2]

Our goal is to develop a device that allows us to monitor the health of muscle tissue in an affordable and time efficient manner. For our project, we will focus on the upper arm and develop a sleeve with embedded sensors that use bioelectrical impedance to measure muscle density. This will allow the patient to monitor their muscle health over time in a quick and efficient manner. For the device to be considered a success, the data it collects needs to be comparable with the data obtained through conventional methods. We will set up an appointment with a professor doing research using conventional methods so that we may use both devices and compare data.

# 1.2 Background

Currently, the most common forms of detecting this disease are blood tests, CT scans, and MRI’s. [2][3] Blood tests can take long periods of time and can be invasive. CT scans can result in large doses of ionizing radiation. MRIs are very expensive. We must be able to make a device that is cost efficient and accurate, so that a physician would be able to properly monitor the patient while being less than $250 for each scan.

# 1.3 High Level Requirements

* Sensors must be able to safely and accurately measure muscle density
* Sensor data must be effectively transmitted and analyzed to display sensor outputs clearly
* Sensor setup should be cost effective

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# 2 Design

Our design consists of three modules that work together. These modules are the Power and Communication Unit (PCU), the Sensor Unit (SU), and the Computer Software Unit (CSU). The PCU will allow us to power our sensors and local data storage as well as allowing us to transmit our measured data to the CSU. In the CSU we will process this data and display it in a way convenient for the user. The SU will be used for gathering our data.



Figure 1: Block diagram for circuit

# 2.1 PCU

The Power and Communications Unit is comprised of three separate units. These units are the Communications Link, the Local Data Storage, and the Battery. This module is responsible for receiving and transferring data from the sensors to the computer and for supplying power to the device.

# 2.1.1 Communication Link

The communication link will be used to send data stored in local data storage to the computer data storage. It will do this based off of a trigger signal from the computer data storage. It will connect and send data via USB.

*Requirements: Link must be able to connect to computer and transmit necessary voltage data without corruption.*

# 2.1.2 Local Data Storage

The local data storage unit is a temporary storage unit for collecting sensor data. It will be powered by the battery and will send data to the communication link upon receiving a trigger signal from the link.

*Requirements: Storage must be able to hold necessary data while we are awaiting a successful link to the computer and must be able to transmit trigger signal and start collecting data*

# 2.1.3 Battery

The battery will be used to supply power to the communication link, local data storage unit, and sensors.

*Requirements: Battery must be able to power the link, local storage, and sensors with the voltages required for each device (to be determined).*

# 2.2 CSU

The Computer Software Unit will be comprised of 3 separate items: Computer Data Storage, Computer Data Analysis, and Display. These will all run in a linear fashion. This module will be used to analyze and display the sensor data and will also function as the starting point for the trigger to activate sensing.

# 2.2.1 Computer Data Storage

The computer data storage will act as the dump for the data. The data will be from the local storage and sent into a text file via the communication link. This file will stored into the computer awaiting parsing from the data analysis unit.

*Requirements: The storage must be able to hold all the relevant data for the analysis.*

# 2.2.2 Computer Data Analysis

Using software construction, the data analysis unit will parse the data from the storage unit and perform calculations on said data in order to properly analyze the muscle density. When it has properly parsed all of the data, it will delete the text file that was stored into the computer.

*Requirements: Analysis must be able to parse data from storage unit and compute data properly.*

# 2.2.3 Display

When the data is finished being analyzed, the computer will then display it on the screen in a format that will be easy to follow and readily organized.

*Requirements: Display must have correct information from analysis.*

# 2.3 SU

The Sensors Unit is comprised of two units. These units are the Sensors and the Switch. This module is responsible for the collection of data.

# 2.3.1 Sensors

The sensors are the main source of data collection for the M.A.D. Sleeve. They will measure the muscle density of the wearer via bioelectrical impedance. They will receive power from the battery, send their data to the local data storage unit, and operate based off of a trigger signal from the switch. They will be sets of surface EMG electrodes measured at 3 points on the arm. The setup will consist of an electrode that produces current located near the elbow and a ground electrode at the shoulder. In between there will be electrodes to measure the voltage at various points along the length of the arm.

*Requirements: Must be able to properly measure voltage/current data as necessary. Must transmit data to local storage.*

# 2.3.2 Switch

The switch is used to control the sensors. We will use it to prevent the sensors from operating continuously, which would be a drain on our battery, and will give our device time to transfer data between units. It will receive a trigger signal from the local data storage unit and transmit that trigger signal to the sensors.

*Requirements: Switch must be able to start sensing when trigger is sent.*

# 2.4 Risk Analysis

The sensors are currently the largest variable in the successful completion of the M.A.D sleeve. Sensors that measure bioelectrical impedance are not hard to find but they tend to be large (we are looking to fit many on a single arm) and expensive. Additionally, they generally require a 120V AC wall supply which doesn’t match our goals of the device being usable anywhere. While we could, for the sake of a proof-of-concept, use an external power supply, it would not be ideal.

In the event that an existing bioelectrical impedance sensor is not a viable option, we have a backup plan for replicating their function. We would be able to use two separate sets of stimulation electrodes, one for supplying current and one for reading voltage (the two standard functions of a bioelectrical impedance sensor). From this, we would be able to control the input current and read the voltage across various points of the arm and calculate the impedance from Ohm’s law.

Additionally, another less vital item of concern is how to place the sensors in the most effective positions. Regarding this, we would like to be able to differentiate between the different muscles of the upper arm (there are two in the bicep and three in the tricep) so as to produce the most accurate results. We would also like to place many sensors close together to obtain more data per unit of length but there may be a point where less sensors is acceptable for obtaining the data we hope to collect.

# 3 Safety and Ethics

The safety of our project has one major obstacle. The fact that we will be applying a current through the body may pose a risk to the patient should the current pass through the heart or if the current is too large. We must ensure that we have control over this current at all times throughout our sleeve. To help avoid this hazard, we will be applying the current to the right arm, grounding the shoulder, and grounding an area on the body to avoid current going to the heart. Additionally, we will be placing our battery in series with a very large resistor (>1[MOhm]) to limit current to the microamp range.

Ethically, we face no barriers outside of what we deal with in our obligation to safety. We must ensure that our device cannot be used to harm or maim a person, purposefully or accidentally. This corresponds to IEEE Code of Ethics (CoE) #9. [4] As this project pertains to biomedical engineering, we must also follow the Biomedical Engineering Society (BMES) Code of Ethics. We would want our device, in order for it to have practical use, to be able to have FDA certification under a 510k. This would run along with the BMES CoE for Research #1, “Comply fully with legal, ethical, institutional, governmental, and other applicable research guidelines…” [5]

We hope that during this semester we will be able to properly test this machine as much as possible. However, we are aware of the fact that this may not be completely feasible. As such, we fully and completely accept what this device will do, whether we intend for said use or not, complying with #1 in the IEEE CoE. [4]

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# References

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