BioMEchanics Foot Insole - Project Description

Group 2: Mina Buchanan, Andi Garcia-Ortiz, Georgy Koromyslov, Matthew DeVaughn

BIOENGINEERS

For anyone who walks, runs, or participates in a sport relying on foot movement, proper foot form is essential to keep free of injury. Feet are the contact point between the body and ground, and improper form during movement can cause injuries in the lower extremities that can radiate up throughout the body. In this capstone project, we set out to create a device to measure the force distribution from a person's foot and interpret the data to screen for foot form issues. The main foot form issues we set out to identify are heel striking, oversupination, and overpronation. All feet are biomechanically a little different and may naturally differ in foot form, but a significant presence of any of these three foot form issues can lead to injury.

Our device concept is a foam insert that can slide into any shoe under the regular insole. This foam insert has eight force-sensing resistors around key areas of the foot and measures the force applied by the foot to the ground over the course of an activity. The resistors are wired into a battery box clipped onto the shoelaces that contains an arduino microcontroller, which stores and converts the raw data into foot form insights.

To start our project, first we obtained an arduino microcontroller and connected our force sensing resistors (FSRs) to measure force applied over a period of time. The force sensing resistors and uploaded arduino code convert differences in current caused by varying resistances to the amount of force applied to the sensor. We successfully recorded force applied in Newtons over a period of time.

Next, we wanted to validate that the values of newtons recorded matched the actual pressure applied to the sensor. The FSRs we purchased claimed to be accurate from "100 g to 10 kg for over 1 million uses." We applied pressure to our FSRs while placing them on top of a scale. We recorded the value seen on the scale, and plotted it against the value recorded by the sensor. From this experiment, we were able to verify that the force reported by the arduino was accurate and scaled appropriately with increasing pressure. Although the FSRs aren't as precise as other forms of force measurement, they are simple, long-lasting, and thin enough to slip into a shoe.

We created a code in MATLAB to analyze force data after measurement. In our product concept, the data is relayed using a bluetooth chip from the arduino board to our phone app for analysis. The eight FSRs are grouped into 5 different sensor groups to compare between each other for foot form identification. For example, if there is significantly more force applied to the outside of the foot, the data is flagged for potential oversupination. This data would be presented to our user on the app interface after an activity.

We also performed a comfortability survey to determine the ideal thickness of our foam insole. Three different foam thicknesses were presented to participants, and we asked them to rank the foam in terms of comfortability and provide comments. We determined that the most comfortable product would consist of 2 layers of 2 mm foam sandwiching the FSRs. This is the model available for viewing today at the EXPO.

Thank you for stopping by our EXPO capstone project!

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GRADE SCHOOL STUDENTS

How many of you love to play sports? Do your feet ever hurt after playing, but you can never figure out why? You might be using bad foot form when exercising. When you have bad foot form it can cause you to get hurt easier and stay hurt for longer. Bad foot form can cause injuries in not only your feet, but also your knees and hips. We designed the BioMEchanics Foot Insole to help you figure out if you have bad foot form while exercising.

The foot form issues we are looking at are over pronation, supination, and heel striking. Pronation is when your feet lean inward when landing, and supination is when your feet lean outward. Heel striking is when you land only on the back part of your foot.

We designed a thin foam insert that fits comfortably under any shoe insole. The insert has eight force-sensing resistors (FSR) that can see where you are landing your feet while exercising. The sensors send the information to a small computer programmed device that is clipped to the top of your shoe laces. A computer program then calculates how much force you are putting on each part of your foot and identifies if you have bad foot form. The data is then transmitted to an app on your smartphone with bluetooth.

We did a lot of experiments to make sure our project would be comfortable and give correct force readings. First we tested our sensors to make sure that they were sensitive enough to pick up both small and large changes in force over time. To do this we applied several different pressures to our sensors and recorded how accurate the computer readings were. From this experiment, we were able to determine that the force reported by our sensors were accurate.

Next, we made a computer code that could detect our three foot form issues. We used a computer program called MATLAB to write our code. We grouped the eight FSRs into five different sensor groups and compared them to each other to find foot form issues. For example, if there was a lot more force applied to the outside of the foot, the data was flagged for possible oversupination.

Finally, we made sure the insert was comfortable so it was not noticeable during activity. We created a survey and asked people to rank three different foam thicknesses on how comfortable they were while in their shoes. The survey results told us that two layers of 2 mm thick foam was the most comfortable. This is the foam insert we have with us today!

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PUBLIC ADULTS SUMMARY

As we get older, our bodies tend to break down and we lose the ability to do a lot of the activities we used to love. What if this doesn't have to be the case. If there was a way to gauge how certain activities affect the body and how to improve it, that would be beneficial to everyone. Most common injuries start from the ground up. If there are issues in the foot, it will affect the knee and then the hip and can progress even farther. This is why we have designed a device to put in your shoe, so that the way somebody steps can be measured and critiqued in order to deliver the best results to prevent any further injury.

For those of you unaware of certain common foot problems, the main three that we will be tackling with this product are pronation, supination, and heel striking. Pronation is when the foot and the leg tend to rotate inward and put pressure on the interior of the ankle, and supination is when the foot leans more outwards during stepping. Heel striking is more unique because it has more to do with the order in which you step as opposed to the ankle rotating. In heel striking, the heel is the first part of the foot to connect with the ground during a stride which can put too much stress on your knee due to shock absorption that occurs when heel striding.

We have aimed to attack these issues by adding force sensors on top of a thin 2 millimeter layer of foam insole to be inserted underneath the insole already within the shoe. These force sensors will record the force applied onto each while striding in order to see how your steps are spaced out and if they show signs of pronation, supination, or heel striking. The data is stored within a computer chip that will be within a plastic container that can be clipped onto the top of the shoe laces. This data will also be delivered to an app that will interpret your personal results and provide instructions on how to walk better to prevent injury.

There were three methods we used to test how effective our product was going to be, and to make sure we met certain requirements. First, we played around with our force sensors to figure out exactly how they worked and measure how accurate they were, so that we could meet our desired goal for the product. The main goal of this was to find how accurate the sensors truly are.

Second, we created a coding system in an application called MATLAB that could discover the foot form issues we are looking to fix. This was done by grouping the sensors so that if one area experienced more pressure, it would be flagged for one of the issues.

Finally, we had people try different thicknesses of foam and fill out a survey on which is the most comfortable because if the product feels weird, nobody is going to want to use it while they are working out. After this study, it was determined that the 2 mm thickness was the most ideal to use.

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