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Improved Device for Passive Foot Dorsiflexion for Prevention of DVT

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BIOMEDICAL

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Introduction

After an operation patients are recovering from anesthesia and are still too weak to move around. This causes poor circulation because veins rely on muscle movement to get blood back to the heart. The lack of circulation makes the patient susceptible to the formation of a blood clot. This condition is known as deep vein thrombosis (DVT). This is an extremely serious problem because it can lead to a pulmonary embolism which could ultimately result in death. The aim of this project is to create a device that can move blood back to the heart from the lower extremities with the use of a device that contracts the muscle.

Project Objective

In order to prevent DVT in postoperative patients, a device was designed to cyclically flex the patient's foot at a set interval to improve blood circulation.

Deliverables:

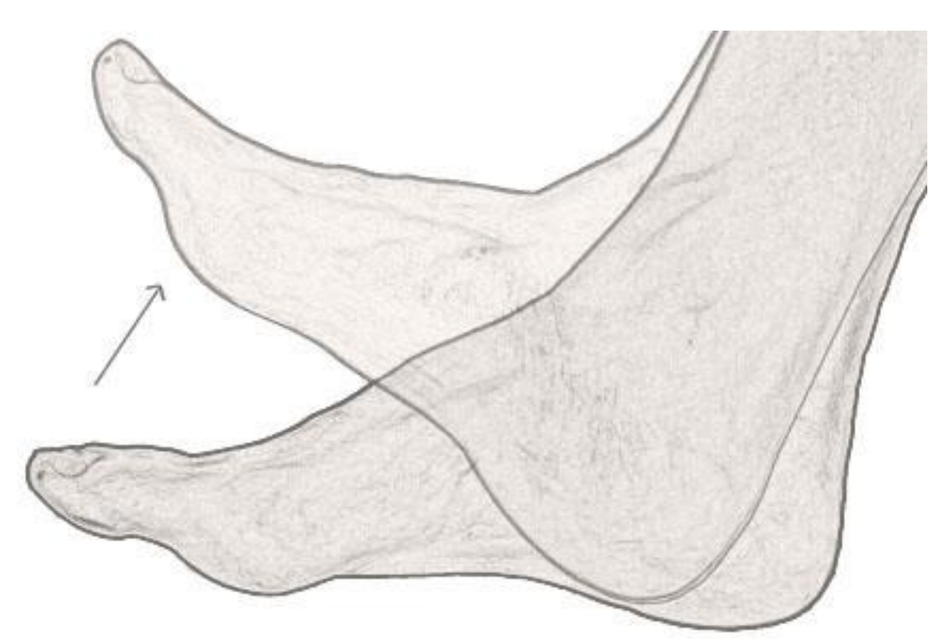
- -Detailed design
- -Fully functional prototype

Design Process

The initial design for this project was to piggyback off the idea from the previous year by creating a small boot, however instead of implementing a large frontal motor, two small rotary motors would be placed on the sides of the boot to provide dorsiflexion. However, this method did not seem feasible because the motors would have to supply too much torque. In order to fix this problem, the new design concept involved a pulley system in combination with a motor to reduce the torque required. The aim for this device was to make sure the device was more sleek than the previous iterations of the boot. Another major key for this device was for it to be comfortable for the patient and painless to remove. The final design was approved by our advisor and the prototyping started.

Work Plan

Our work plan included six main stages; background research, design, acquiring new skills, modeling, prototyping, and testing. After researching the unmet need and current solutions, we were able to create design requirements for our final product. After evaluating our proposed design concepts against the requirements we chose one final design. Once our design was finalized we worked on acquiring the skills needed to create our prototype which included learning circuit design, microcontroller programming, and designing a pulley system. We used a microcontroller to program a servo motor that we attached to an old boot from the bioinstrumentation lab to create our initial model to provide a proof of concept. Next we acquired materials to construct our prototype. A stronger motor was used in conjunction with a belt and pulley guide to acquire the desired pulley mechanism. A speed controller circuit, microcontroller, 12 V DC battery power supply, and switch were used to control the motor. Finally a spring mechanism attached to the hinge of the boot was used to bring the platform of the boot down once the motor brought it up. The prototype was tested using a human foot and was successfully able to provide enough force to provide swift and adequate dorsiflexion.



Description of Prototype

Our design will enhance the previous year's design by making a more compact boot with a smaller motor that is easier to put on for the patient. Our prototype is a simple, less bulky dorsiflexion device that is fully functional. It consists of a durable plastic mold boot with a dorsal motor attached and a pulley-belt guide system. The belt extends from the motor, around a wheel at the top of the boot, and is anchored at the tip of the foot platform. There is also a speed controller circuit, microcontroller, 12 V DC battery power supply, and switch controlling the motor to get desired dorsiflexion for the patient. When the boot is worn, the patient will be able to set a desired speed of dorsiflexion using a knob of the device. They can then turn on the switch, which will cause the platform of the boot to elevate while sustaining the weight of the patient's foot. The microcontroller allows for different speed options. Once the switch turns on, the programmed motor will rotate at certain time intervals causing the platform to rise. Every time it rises, an extension spring attached to the bottom of the platform will then bring it down.

Problems Encountered

Our biggest obstacle was the implementation of a suitable motor to the size of our plastic mold. As described earlier the motor had to be strong enough to dorsiflex a foot but small enough to not weigh down the boot. However, the motors available on the market were either too weak or too large. We opted for the latter option. Furthermore the process to aquire materials slowed down the construction process considerably. The boot had to be built with the parts in a specific order, and waiting for each part to be delivered halted progress on the construction. Lastly the resources for this project constricted us to generic parts rather than made-to-order parts which decreases the aesthetics of the boot.