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Mitigating Difficulties Associated with the Donning of Compression Stockings

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Abstract

Chronic venous insufficiency is a common ailment that affects millions of Americans annually. Compression stockings are the gold standard of treatment however, studies have indicated difficulties associated with donning them which can result in lack of use, leading to development of more severe conditions. The goal of this project is to develop a device that shall reduce the forces necessary to don a compression stocking that is financially accessible and can be used by those with a low strength capacity. Multiple designs of this device were created although a final design was unable to be 3D printed and tested due to COVID-19.

Introduction

Vein valves are what keeps blood moving from the limbs back up towards the heart. When these vein valves aren't properly functioning, it can cause a pooling of blood in the lower extremities, an ailment that countless people suffer from known as Chronic Venous Insufficiency (CVI). Common symptoms of CVI include inflammation, varicose and spider veins, chronic pain, leg edema, ulcers, and blood clots. These all could lead to other severe Chronic Venous Diseases such as Deep Vein Thrombosis (DVT), a Pulmonary Embolism, or even worse a combination of the two known as a Venous Thromboembolism. Potential causes of these vascular ailments are numerous. However, the treatment options for those who suffer from CVI are limited. Either the use of compression stockings is advised by physicians or, in more serious cases, procedures like angioplasties and vascular stenting are performed to reduce symptoms. To help the onset of the conditions previously mentioned above, it is important that preventative measures be taken. However, compression stockings are widely considered to be the gold standard in treatment and prevention. Upon research, many populations (the elderly, those with arthritis, etc.) have severe difficulties in donning these stockings due to the required force. This can lead to [illegible] conditions, such as those mentioned above.

Figure 1. Existing solutions of devices which assist in the donning of compression stockings

Methods I Design I Analysis

The design created utilizing SolidWorks and was 3D Printed utilizing PLA filament for the mechanism and titanium for the fin pieces. A design iteration was conducted to maximize ease of use. Prototype I utilized a spring mechanism to open the compression stockings while Prototype II utilizes two linear actuators. Design specification testing shall utilize a force transducer to confirm that the force required to don a compression stocking with the device is at least 50% less than the forces required without. Final testing was intended to be conducted on 25 random users, who would be asked to don a compression stocking with and without the device. The level of difficulty (1-5) shall be reported for each attempt. Final testing would have assumed a null hypothesis of the median score difference between data sets equal to zero (Wilcoxon Signed Rank test).

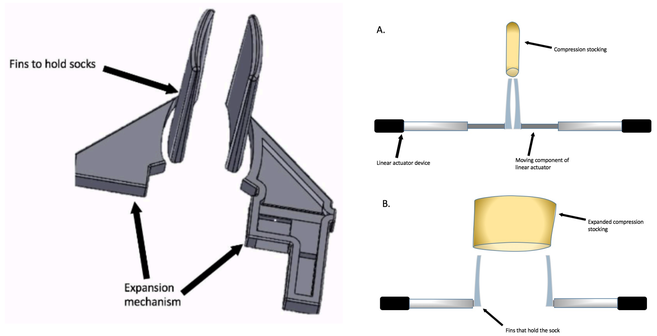

Figure 2. The leftmost image shows Prototype I of the device. Images A & B show the concept of Prototype II, which features the use of linear actuators for the opening/ closing mechanism.

Results

- Assembly and testing of a final product were unable to be completed due to COVID-19
- Initial Killer Experiment trials indicated the need for stronger fins. The decision was made to transition from fins made from PLA filament to titanium. Both sets of fins were designed in SolidWorks and were 3D printed.
- Initial Killer Experiment trials indicated lack of feasibility with spring loaded system. Further designs utilized a linear actuator as an alternative to the spring/trigger system

Conclusion

- The design and prototype of the device attempted to mitigate the difficulty of donning compression stockings in all population in an affordable manner
- Given the extraneous circumstances of COVID-19, design validation and statistical analysis were unable to be completed
- The condition of affordability was assured via 3D printed prototype manufacturing and assembly
- If statistical analysis was able to be conducted, rejection of the null hypothesis would have verified the decrease in donning difficulty

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