Design of a 3D-Modeled Ankle Brace

Analysis of the Underrepresentation of Ankle Brace Technology for Certain Demographics

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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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Introduction

Acute ankle sprains are one of the most common musculoskeletal injuries with a high incidence among physically active individuals. In the United States alone, approximately 2 million acute ankle sprains occur annually (Herzog et al., 2019). Acute ankle sprains have a high recurrence rate, which is associated with the development of Chronic Ankle Instability (CAI). Without proper treatment such as the use of an ankle brace, it is very likely for an individual's ligament to not properly heal leading to this disease. Most braces for CAI use the one-size-fits-all model, which ignores the needs of the atypical user and underrepresents certain demographics (*Do Over-the-Counter Knee Braces Help?*, 2021). No patient has the same needs when it comes to ankle recovery and support, making it necessary to develop a custom-fit ankle brace that is uniquely designed for each person.

I will design and prototype a 3D-modeled ankle brace that is custom fit to each patient's ankle and allows for adjustable stability. The development of this highly specialized device caters to each individual's need and provides a personalized, cost-effective ankle bracing option to combat CAI and acute ankle injuries.

While the development of a new ankle brace is very important, it is also important to consider the social and political factors that must be taken into account in order to ensure the device is inclusive. To better understand these factors I will investigate how the one-size-fits-all model used by Brandy Melville, a popular teen clothing company, performs social and political work by privileging groups that conform to their ideal body type and marginalizing groups that do not. By taking these factors into account I will be able to ensure that the device I create encompasses all groups equally and will not face the same problems as current bracing options.

Given that the problem with current ankle braces to mitigate CAI is sociotechnical, consideration must be given to both the social and technical aspects of the problem. In what follows, I propose a technical project that seeks to develop a 3D-modeled ankle brace with adjustable stability. Additionally, I will examine Brandy Melville to explain how their one-size products have led to an underrepresentation of certain groups and the social and political impact the product has had on these groups.

Technical Project Proposal

Ankle injuries account for up to 30% of all sports injuries and occur when there is a sudden change of weight on your ankle joint, causing the supporting ligaments to stretch or tear (Al-Mohrej & Al-Kenani, 2016). These stretched and torn ligaments sometimes do not heal fully leading to weaker ligaments that are unable to support the ankle joint effectively, leading to more frequent sprains and the disease, CAI. Of the ankle injuries that occur, 20% lead to the development of CAI, which is defined as the failure of functional rehabilitation after an acute ankle injury (Herzog et al., 2019). CAI gradually worsens over time and can eventually lead to degenerative changes such as osteoarthritis or the degeneration of joint cartilage (*What Is Chronic Ankle Instability (CAI)?*, n.d.). Many different types of ankle injuries can lead to CAI, and their pathologies are dependent on the specific ligaments affected by the injury. The most common forms of CAI are drop foot and lateral ankle sprains (Al-Mohrej & Al-Kenani, 2016). Drop foot is the general term for difficulty lifting the front part of the foot and primarily affects the muscles that control dorsiflexion, the action of raising the foot towards the shin (*Foot Drop - Symptoms and Causes - Mayo Clinic*, n.d.). Lateral ankle sprains include supination, which is

when the foot is twisted over the outer edge of the foot, and protonation, the twisting over the inner edge of the foot (*Ankle Supination Trauma*, n.d.).

For patients with CAI, nonsurgical management is typically recommended, with the most common method being bracing (Al-Mohrej & Al-Kenani, 2016). There exist three main types of braces including lace-ups (fabric-based), hinged (semi-rigid plastic shell), and hinged-cuff (semi-rigid or flexible shell with straps) as seen in Figure 1 (Peters, 2017).

Figure 1: Three most common types of ankle braces (Peters, 2017).

Although there is a plethora of ankle bracing options, they have issues with comfort, adjustability, and invasiveness. Current bracing options are also limited in their treatment of CAI because they are tailored to the 50th percentile male (A. Douglas Spitalny, 2016). This results in the underrepresentation of bracing technologies for specific demographics such as people with disabilities, people who are overweight, and women. In addition, the current braces prevent the user from tailoring their brace to their unique severity of CAI. Lastly, current designs of ankle braces are relatively invasive and cannot typically be worn constantly due to their obtrusiveness. If these issues are not addressed, CAI cannot be adequately treated resulting in recurring ankle sprains and increased severity of CAI.

I propose a 3D-modeled custom ankle brace with adjustable stability and multi-axial control. The ankle brace will be custom-made for each individual based on their ankle and their specific form of CAI, allowing them to maximize both stability and comfort. Another key feature

of the brace will be the ability of the user to customize the level of stability for their brace through the use of a BOA dial. The BOA dial allows users to manually increase or decrease the amount of tension in the brace, allowing the user to adjust the brace to their desired optimum amount of stability. The 3D-modeled ankle brace will allow for a full range of motion in all axes, apart from the correction axis. The ankle brace will be designed for Icarus Medical Innovations, a medical device startup located in Charlottesville, VA that develops custom 3D-modeled orthopedic braces. Icarus's technology uses a mobile device to take a 3D scan of a patient's knee, designs their knee brace in Autodesk Fusion, and 3D prints a custom brace. We will apply this technology to develop an ankle brace.

To execute this project, we will design and iterate upon existing prototypes, acquire data-driven results on the effectiveness of the brace, and validate these results through biomechanical analysis. To design a set of custom 3D-modeled ankle brace prototypes to combat various forms of CAI, we will determine the most prevalent forms of CAI (supination, protonation, and drop foot) and their specific pathologies based on ankle anatomy. Next, we will create force diagrams to determine where the ankle needs support based on the ligaments affected and then use the wire vectors from the BOA dial to provide stability. Material sourcing will also be very important to formulate a professional product that can be showcased to patients and doctors. Factors that must be accounted for include ease of manufacturing, cost, comfort, and ease of use. Prototypes will be tested on human subjects to test the functionality of the devices. . Testing will include both qualitative and quantitative data. Qualitative data will include comfort, aesthetics, and functionality, while quantitative data will include mechanical durability, force applied, and time to don/doff. These results will then be used to improve the brace design.

Computational modeling will be performed using OpenSim to quantify the overall mechanical support provided and validate the product's biomechanical functionality.

STS Project Proposal

One-size-fits-all means that a specific product is designed to fit a person of any size (*One-Size-Fits-All*, n.d.). The one-size-fits-all model has been commonly used in various bracing options such as knee braces and ankle braces, because it allows the manufacturer to mass produce the product, thus reducing the cost and hassle of manufacturing.

An example of a company that employs this model is Brandy Melville. Brandy Melville is a popular international Italian clothing company directed to teen girls for its cute and simplistic clothes (Burleyson & Davids, 2021). The company used this method because they say it allows for easier purchasing of clothing due to consumers not having to consider sizes. These factors allow Brandy Melville to keep their clothing prices cheap compared to competitors making them a very attractive company for certain groups. The problem with this one-size clothing is that it is a false idea. People have different body types making it impossible for any one product to conform to everyone. When companies create one-size clothing, they are essentially forcing their ideal body type on consumers who want to wear their clothing (Sabre, n.d.). In the case of Brandy Melville, this body type is a "woman over 5 feet 7 inches tall with a tiny waist, long legs, and skinny figure" (Nemerov, 2017). If a woman does not closely conform to this body type the one-size clothing will not fit them. This sizing policy discriminates against women who may not fit into the "normal" sizes perpetuated by Brandy Melville.

There are a wide variety of body types, eliminating any possibility that these clothes can fit all people, but when a young woman does not fit into these clothes they often feel like their

body is not normal which can greatly damage an individual's self-esteem. While the product may be beneficial for a certain group of people, other groups are largely marginalized and essentially being body shamed for not being able to conform to Brandy Melville's ideal body type that they designed their clothes on (Burleyson & Davids, 2021).

If we continue to think that their products are only performing the function of cheap one-size clothing, we will miss how it also works to express Brandy Melville's idea of an ideal body type and the effect that this has on women who do not conform to this. Using the framework of Technological Politics (TP), I argue that the products perform social and political work by privileging groups that conform to this body type while marginalizing groups that do not (Winner, 1980). TP is a theory that states that technological artifacts embody politics because particular political ideas, needs, and interests are embedded into them. In the framework of TP, "politics" are defined as the arrangement of power and authority governed by humans (Winner, 1980). Intentionality is a key idea in TP as it determines whether bias is an intended or unintended consequence of design. While Brandy Melville may not have intended for their one-size clothing to express implicit bias, by only designing their product to fit a certain body type they are greatly underrepresenting certain groups and having an immense social and political impact. To undertake this analysis, I will utilize evidence from the design consideration documents of Brandy Melville's clothing, consumer testimonials, and research papers that discuss the effect of body shaming and on-size-fits-all clothing.

Conclusion

The result of the technical project discussed above will be a 3D-modeled ankle brace that is custom fit, adjustable, and minimally intrusive allowing patients to more effectively manage

their unique case of CAI and address their specific needs. The STS research paper will examine how the one-size-fits-all model of Brandy Melville's clothing underrepresents certain groups and the effect that this has on them using the framework of TP. This model has also been used for ankle brace making it very important to understand its pitfalls. By understanding the effects that the one-size-fits-all model has and the factors in its design that led to its discrimination of certain groups, I will be able to ensure that the 3D-modeled ankle brace I create is an equitable device that can be used by all demographics and groups to treat CAI.

Word Count: 1886

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