Design Brief

Strider Hip Flexion Assist Device (HFAD)

Problem Statement/ Research Question and Background

The aim of the Strider Hip Flexion Assist Device (HFAD) project is to create a wearable, low-profile orthotic device that provides energy to the hip during the early swing phase of the gait cycle and mitigates excessive hip rotation.

The HFAD project began as senior design project through UTDesign and under the sponsorship of Dr. Karen McCain, a physical therapist and professor at UT SouthWestern specializing in gait and balance rehabilitation. Dr. McCain saw that while there exists a range of ankle-food orthoses to assist people with below-knee gait pathologies, the market for orthotic devices that help with gait disorders above the knee is virtually nonexistent. The Strider team, consisting of six senior engineering students at UTD, working under technical mentor, Dr. Nicholas Fey, has worked to design, build, and test a device to accommodate this need.

Methods/ Approach/ Solutions Considered

Strider approached the project initially by consulting with Dr. McCain about the only current market device and its shortcomings, and about an in-house solution that she was using for therapy. The existing device consists of a very large waistband to which two rubber tubes are attached. The tubes run down either side of the leg and attach via a large metal clip to the user's shoelaces. Problems with this device include sagging from the waistband, limited and clunky adjustability of band tension, and the metal bracket digging into the user's shin. The in-house solution used by Dr. McCain mimicked this idea, but simply used a multipurpose waist belt with a buckle, and a Thera-Band® running from the belt, under the shoe, and back to the belt. This significantly cheaper and less complicated solution had already proven more useful in therapy than the market device. Seeing these two designs and what worked and what did not work about each was our starting point. The primary issues the team identified were selecting the source of energy delivery, and ergonomically distributing the load from the energy source.

For the energy source, Strider considered two paths: rubber bands or springs. The advantage of a clock-style spring mounted at the hip is that the energy is delivered immediately as a moment in the correct location and direction. However, a clock spring that fit our needs was difficult and expensive to source, not adjustable, and would require rigid linkages running down the leg to deliver the assistance. Rubber bands would not require rigid components and offered cheapness, easier adjustability, and a greater variety of available strengths. Furthermore, as Thera-Bands® and similar "resistive bands" are ubiquitous among physical therapy clinics, a device that relied on such products would be cheaper to produce and would allow the therapist administering the device to customize the assistance however they see best fit.

Having settled on incorporating Thera-Band® in the device, the issues of how to attach the bands in an ergonomic fashion became the focus of the project. The mounting points for the bands had to be sturdy enough not to slip or sag, and the load had to be distributed evenly enough not to cause pain or discomfort in the areas where the bands attached. While many routes were explored, the team concluded that incorporating the torso via suspenders attached to a waist belt would be an effective way to combat the sagging of the belt that was observed in the two existing devices. Additionally, the span of the bands would be shortened to terminate at the knee, and the bands would cross over the thigh. This would cause less interference should the user wear the device underneath their clothing, and preliminary tests shows that hip rotation was easier to influence about the knee than about the foot. The crossed over, “antagonistic” band configuration is also intended to correct excessive hip rotation. The process of selecting an easy and effective way to connect the bands to the knee and waist demanded frequent returns to the drawing board and redesigns for simplicity at each iteration of the device.

Description of Final Approach and Design

The final design for the HFAD includes a knee brace, waist belt, suspenders, and two lengths of Thera-Band®.

Figure 1: HFAD on a mannequin

The knee brace is a simple low-profile design with one strap above and one strap below the knee. The brace is modified with an overall-style button on the medial and lateral sides of the knee. These buttons serve as connection points for the bands.

Figure 2: The knee brace and overall-style attachment

The waist belt consists of a soft neoprene fabric “carrier belt” and a nylon-webbing “outer belt” that sits in loops on the carrier belt. The carrier belt is fastened with hook and loop fasteners, and the carrier belt has an adjustable slide-release buckle that provides more secure fastening. Two 3D-printed pieces with overall-style buttons are mounted on the outer belt, providing the upper attachment point for the bands. The suspenders simply hook on to the outer belt, and can be individually adjusted.

The Thera-Bands® are folded twice lengthwise and attach to overall-style buckles on both ends. A simple strap adjuster at each end functions to secure the band at the desired length.

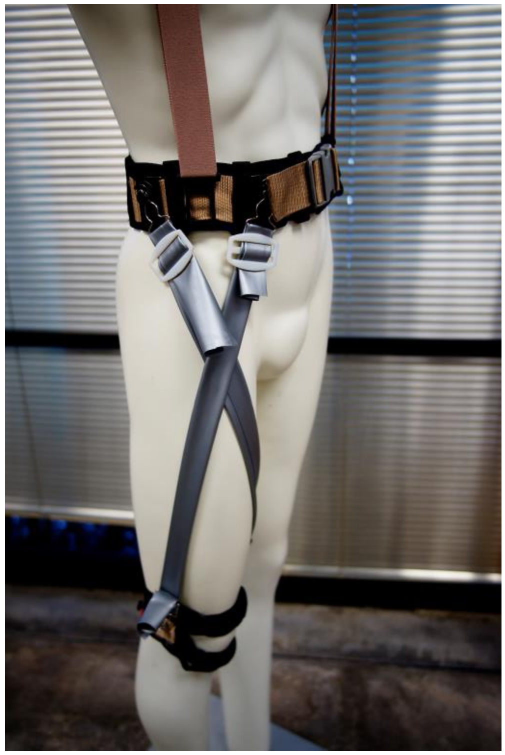

Figure 3: Band attachment points at waist belt and knee

The initial setup of the device requires some work from the therapist, but once properly fit it is simple to don and doff. The Thera-Bands® are first adjusted to the desired length with the help of a "band length calculator" program. The therapist inputs the user's weight, lengths between each connection point, and desired percentage assistance, and the calculator outputs the appropriate length and color of Thera-Band® to achieve this assistance. Once the knee brace and waist band have been appropriately fastened, the bands are simply attached like overall straps and the suspenders are clipped on and adjusted.

Outcome

The HFAD has shown promise in initial tests by group members. Initiation of swing feels significantly aided by the device. Testing is under way at the time of writing this brief. Electromyography, ground reaction force, and motion capture data are being collected, but the data have not been sufficiently analyzed to comment on in good conscience.

The device has also been fitted to a family member of one of the Strider team who suffered a traumatic brain injury several years ago that resulted in gait abnormality. In his right leg, he has difficulty initiating swing and suffers from excessive external rotation. He reported that the HFAD both made it easier to pick up his right foot and significantly reduced external rotation. His test can be seen in the video submission.

Cost

The Strider HFAD is made primarily with widely available and inexpensive materials, keeping costs low. Materials have been purchased in bulk, but the cost rundown for a single HFAD is in the table below:

Part	**Purpose**	**Qty/Amnt**	**Cost for Qty**
2” Flat Nylon Webbing	Outer belt material	3’	$2.07
¾” Flat Nylon Webbing	Belt loops	2’	$0.70
2” Slide Release Buckle	Outer belt buckle	1	$5.88
Thera-Band® of choice	Powerhouse for HFAD	1	$5.04
Dickies Perry Suspender	Suspenders for belt	1	$11.25
3 mm B Foam Neoprene Fabric	Carrier belt material	4”x36”	$4.33
Uline Hook and Loop Strips	Fastener for carrier belt	1’	$1.13
Jean Buttons	Knee anchor for bands	2	$1.80
ACE Dual Knee Strap	Knee brace for anchoring	1	$12.63
3D printed belt anchors	Waist anchor for bands	2	$15.00
Amanaote 1.5” Suspender Buckle with Rectangle Sliding Buckle	Band securement	4	$1.99
		TOTAL COST	$61.82

With a per-unit raw material cost of just over $60.00, the Strider HFAD is an inexpensive device. With manufacturing costs, it could realistically go to market for well under $150.00. The existing HFAD on the market is currently priced at $230.00.

Significance

The Strider HFAD fills a vacancy in the orthotics market for a wearable device capable of aiding hip flexion. Dr. McCain has voiced her need for such a device time and time again. As a specialist in gait rehabilitation, she is frustrated by both the lack of variety in hip flexion devices, and the inadequacy of the only available device (with its bulky, uncomfortable, and minimally-adjustable design).

For the Strider HFAD, hip flexion and prevention of excessive hip rotation are the basic functions of the device. What makes it a product ideal for filling the void in the marketplace, however, is its viability as a worn-daily orthotic. Through an iterative prototyping process, the Strider team has made continual adjustments for ergonomics. The result is a device that can be comfortably worn for long durations and concealed beneath clothing. A device with these attributes and sold at an affordable price point has the potential to positively impact the lives of many thousands of people living with gait abnormality.

Acknowledgements and References

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