CHAPTER 22
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WHEELCHAIR FITTING PROCESS

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INTRODUCTION

For a wheelchair user, an improperly fitting chair can have devastating consequences, including pressure sores, tipping over backwards, overuse injuries, restricted mobility, and limited accessibility. The SitKit project at MAX mobility aims to decrease the number of individuals subject to such consequences by providing an accurate and consistent method for clinicians and direct medical equipment (DME) dealers to evaluate and determine the optimal wheelchair set up for a specific individual.

SUMMARY OF IMPACT

Understanding the wheelchair fitting process is essential to identify any areas in need of improvement. The hardware component of the project, a set of tools (SitKit) for measuring an individual and a wheelchair, is selected as the focus of the assessment. A study of the current methods employed to determine wheelchair set up provided valuable feedback for the project. Following clinical observation and collaboration with local clinicians and DME dealers, changes to the tools were proposed. Refining the SitKit tools will increase the feasibility and efficiency of using SitKit while maintaining the overall goal of improved accuracy and consistency in determining the optimal fit of a wheelchair to the user.

TECHNICAL DESCRIPTION

The proposed changes for SitKit apply to the linear measurement tools, which include calipers and a height gauge. The caliper and height gauge are used to obtain a variety of measurements, and tools must be interchanged for the particular measurement needed. Pressure paddles are attached to the end of the calipers when measuring hip width, and a caliper or horizontal laser beam is used to mark a measurement with the height gauge.

During an evaluation clinicians must be able to maneuver tools, obtain and record measurements, and often times support individuals who lack sufficient stability to sit independently. The current set of calipers and height gauge hinders this because they are heavy, cumbersome, and require switching tools between measurements.

Fig. 22.1. Calipers with pressure paddles.

Consolidating the caliper set and height gauge into one tool with interchangeable parts, reducing the weight of the tools, and simplifying the method of assembly will make the measurement process more efficient and SitKit tools more desirable to clinicians. Combining the calipers and height gauge into one tool might be accomplished by altering the method for attaching and removing tool components. Creating a system in which attachments are not screwed together, but rather pulled on and off, would allow multiple tool configurations to be efficiently achieved during the course of an evaluation. Removing material from the center of the calipers, measuring stick, and pressure paddles while maintaining mechanical structure and stability is recommended as a way to reduce weight and make the caliper set easier to handle. Additionally, in order to facilitate maneuvering the tools into the correct position, a short caliper is recommended to replace one of the long calipers, with additional attachment pieces that can lengthen the caliper when necessary. Using a caliper, instead of a laser beam, with the height gauge is recommended for measurements where the laser light disappears across the boundary of the body, such as height to top of shoulder. The changes proposed for the SitKit tools are currently under review by the original project developers, and alterations will be implemented as funding is available. Cost is to be determined but is expected to be in a range of $1500 to $3000 per kit. The tools are expected to be on the market within the next six months.

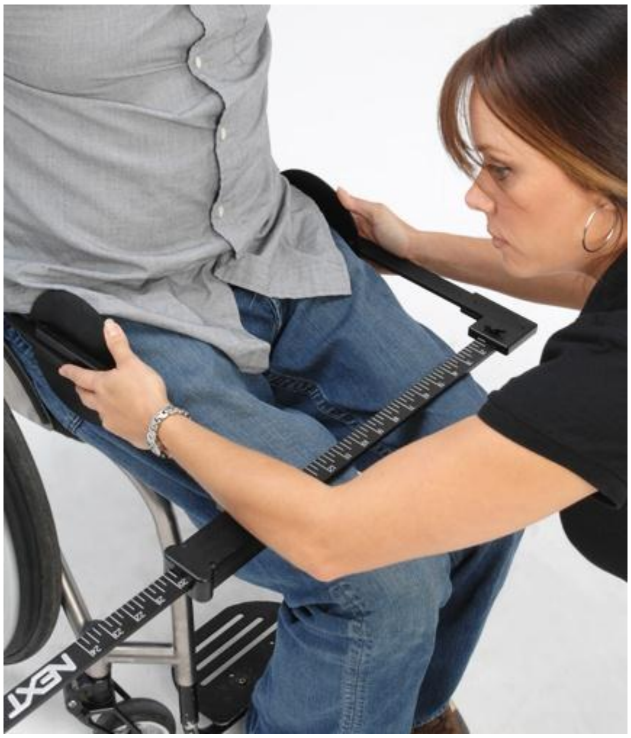

Fig. 22.2. Demonstration of calipers with pressure paddles used to measure hip width.

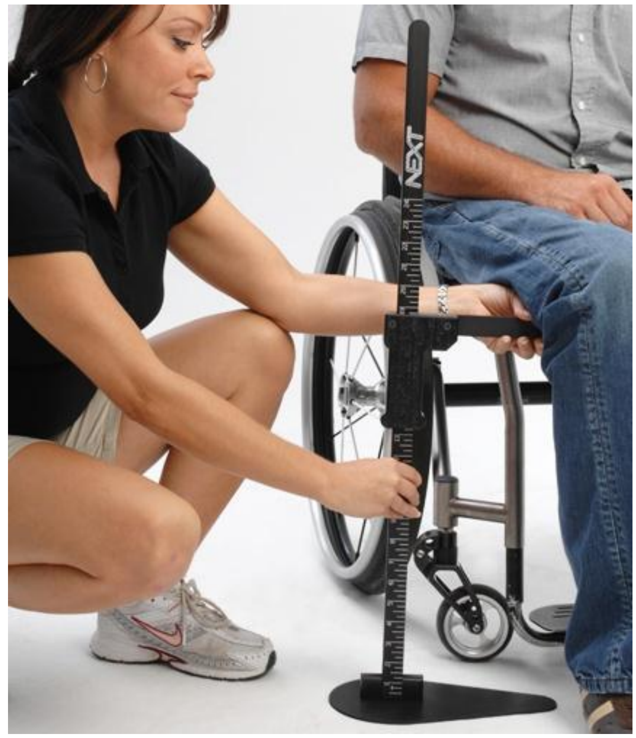

Fig. 22.3. Demonstration of height gauge with sliding caliper used to measure lower leg length.

THE MOBILITY ENHANCEMENT SYSTEM FOR WHEELCHAIRS

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INTRODUCTION

A vast amount of fatigue injuries occur in the wheelchair population, creating a great need for a more ergonomic and less injury-prone wheelchair propulsion setup. Several solutions have been previously proposed and can be broken into two categories: power assisted and geared technologies. In power assisted systems a small motor is typically utilized to provide propulsion. The benefits to the user are mainly decreased muscle strain; however, such systems are generally heavy, weighing between 46 and 85 pounds, and expensive (~ $7,000). Additionally, the range of the wheelchair is limited by the battery life. Other options including geared technologies have been utilized in a number of different ways, mainly lever drive systems and hand-rim systems that provide mechanical advantage to the user. One downside, though, is that such systems maintain the same arc type path as a normal manual wheelchair and actually demand more full arcing movements to traverse a given distance. Consequently, their use does not prevent injuries.

SUMMARY OF IMPACT

This design aims to allow wheelchair users the option of an inexpensive augmentative power system for their wheelchair. The long-term goal is to make this technology available at low cost as an alternative to more expensive solutions as mentioned above.

TECHNICAL DESCRIPTION

The final design includes an 18 V DeWALT electric motor (part # 393111-15) and transmission (part # 380264-15) with a 25.9 V 10 Ah Li-ion battery. We developed a custom aluminum frame, a drive wheel/belt combination, and a relay controlled high/low speed selection mechanism. With our design the total weight of the system is 11 pounds, and up to 533 in-lbs. of torque can be developed.

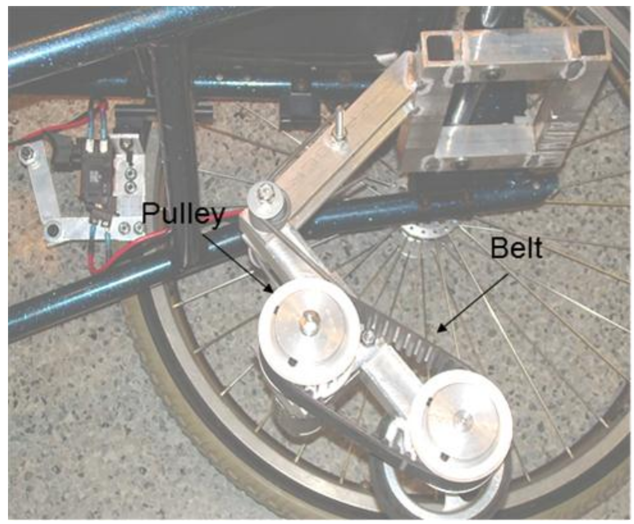

Fig. 22.4. Left Hand View of Augmentative Power Assembly.

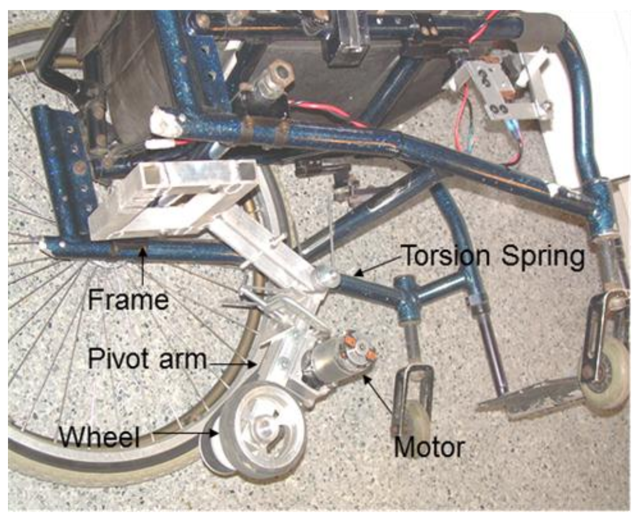

Fig. 22.5. Right Hand View of Augmentative Power Assembly.

Performance tests with a 19lb wheelchair and 170 lb. man indicate the maximum ranges of 4.68 and 3.43 from current and speed measurements at high and low speeds.

The expected MSRP is calculated as a three-fold markup of the total manufacturing cost. It is evident that the battery is both the heaviest and most expensive component. The battery, however, is a critical design component, for it provides propulsive power. Thus the battery capacity represents a conflicting design variable. Increased capacity gives increased range to the device but also increases the weight and cost of the device. Increased weight reduces the detachability of the system, and increased device cost may overshoot target market. Both the motor and control system also present design conflicts however, their weight and cost were much less than that of the battery. The battery design conflict was solved by selecting a battery that fit within our device weight (~10 lb) and cost ($1,500 - $7,500) constraints while providing adequate energy capacity for ranges of above 3 miles. Additionally, battery capacity could be tailored to individual customer demands. Those customers needing only a two mile per day range may opt to purchase this device with a smaller battery in order to reduce the weight and cost of the device. Those wanting increased range may purchase a battery with greater capacity. Estimated expenditures were $1400.

IMPROVEMENTS IN COMFORT FOR WOMEN IN WHEELCHAIRS

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INTRODUCTION

Women who use manual wheelchairs are more likely to develop overuse injuries than men. We interviewed female wheelchair users to assess their usage patterns and needs. Rather than building and designing a completely new wheelchair, modifications are made to an existing wheelchair. These modifications are based mainly on user feedback and research.

SUMMARY OF IMPACT

Wheelchair modifications specifically aimed towards women users may impact approximately half of all wheelchair users in a positive fashion. Specific goals addressed involved high heel use, storage problems, and user modesty.

TECHNICAL DESCRIPTION

Our goal is formally stated as: "To improve functionality and comfort of wheelchairs for women by modifying a wheelchair seat cushion: Modification #1: Develop a new method of securing an individual's legs when using a wheelchair, Modification #2: Create more accessible storage compartments, and Modification #3: Develop a way to alleviate pressure sores and increase stability when wearing high heels"

To meet the first goal a seat cushion is modified in a way to keep the user's knees together while in motion. Because wheelchair users usually do not

Fig. 22.6. Modifications one and two and evident in this photograph.

have function of their legs, it is difficult to keep their knees together throughout the course of the day. This can be especially frustrating for women when wearing skirts or dresses. The only current method to solve this problem is a shin strap which attaches around the wheelchair and users legs. While this method is very functional, it is not comfortable or aesthetically pleasing. Our solution to this problem is to alter the current structure of a seat cushion by raising the sides of it. Raising the sides of the cushion forces the knees to stay together in a more functional, aesthetically pleasing way.

The current storage methods available for wheelchair users are in the form of a back pack, "fanny pack" or net which hangs underneath the seat; however, neither is optimal for female usage. Back packs are susceptible to theft and are very difficult to access depending on the position of injury. The "fanny pack" or net storage methods hang under the seat of the wheelchair. They are not susceptible to theft, although objects are more likely to fall out and get lost. Like the back pack storage method, this storage method is also difficult to access because it requires the user to reach between their legs to access their belongings. Our solution to this problem is to place two storage pockets on the sides of a seat cushion. Placing the storage pockets here allows the user easier access to their belongings. Here, they are also less susceptible to theft or loss of items because they sit closer to the body of the user. The above two changes may be seen in Fig. 22.6.

The third and last modification made involves creating heel inserts. These inserts are intended to diffuse the pressure on the legs and buttocks while the user is wearing heels. Wearing heels elevates the user's legs and thighs and increases the pressure on the buttocks. This increase in pressure is one reason pressure sores develop which can be very detrimental to the user as it can lead to infections. Our solution to alleviating pressure sores when users wear heels is to create foam inserts (triangular shaped wedges) to be placed between the seat cushion and seat. These inserts increase the height of the user seat cushion and allow them to place their feet flat along the wheelchair step. This keeps the user's legs and thighs along the seat of the chair and minimizes the formation of pressure sores when wearing heels.

Fig. 22.7. Above wheelchair with triangular insert for high heel use.

WHEELCHAIR CLEARANCE MEASUREMENT DEVICE

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Client Coordinator: Theresa Plummer, MSOT, OTR, ATP, Belmont University, Nashville TN
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INTRODUCTION

Children that are born with mobility impairments have been shown to develop perceptual skills more slowly than active children. These children, when prescribed power wheelchair use regimens, have perceptually developed at increased rates and have been able to adapt earlier and more fully than children who continued to lack the stimulation provided by auto-mobility. Injury amongst these children is a serious concern due their inability to pilot the wheelchairs properly. To decrease the chance of injury, this design is focused on creating a prototype proximity detection alarm system.

SUMMARY OF IMPACT

Our first goal, to create a system that reduces the chance of injury when using a wheelchair, is achieved through the proximity sensor modifications and the designated pre-made sensor choice. This system as a unit enhances the safety of patients using wheelchairs, even those that are unable to pilot the wheelchair without some aid. The low cost of the proximity sensor (~$90 plus labor, installation, and training costs), meets the specifications laid forth by the second goal. The third goal, adaptability and versatility of the system, is met by designing modular stages capable of providing side-discriminating, distance-discriminating, or both side- and distance-discriminating outputs. The fourth goal, adapting the output to the target demographics' needs, is achieved through the use of auditory outputs rather than visual or otherwise. Our final goal is longevity, reliability, and maintainability. Our system does not use quickly consumed or fragile components, so we feel strongly that, if installed with proper care, the system will be resistant to damage and wear-and-

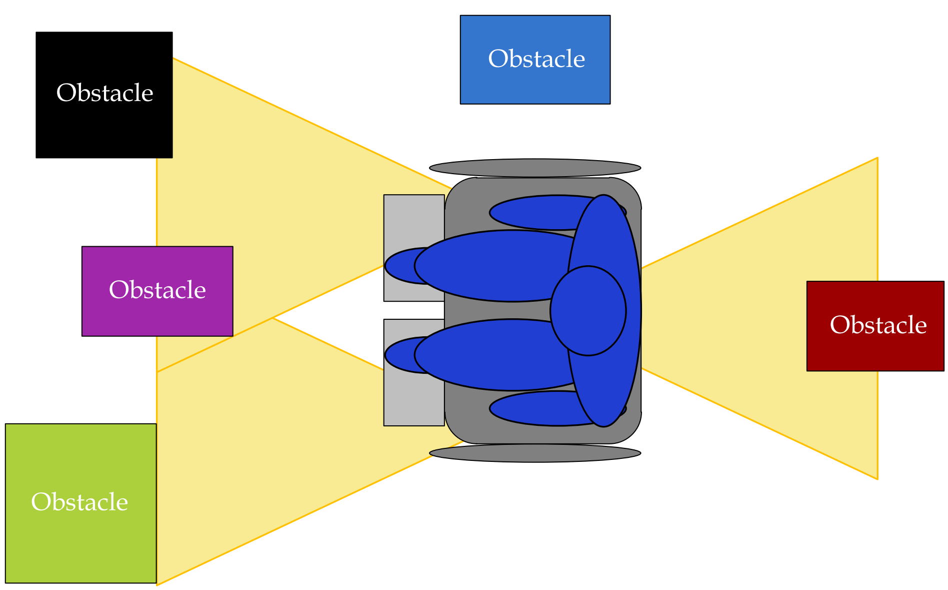

Fig. 22.8. Schematic of detection system –detection areas.

tear.

TECHNICAL DESCRIPTION

This design implements the "GERAFLAG Parking Sensor System". This system retails for $20 each. It uses an ultrasound sensor system and is able to detect objects in the range of 0.3 – 1.5 meters. The unit comes with four sensors (2 left, 2 right.) The associated electronics detect the object within the minimum distance in the left or right position. Modifications of this system include an output of two different sounds. These sounds correspond to detection on the left and on the right. As the object approaches, the system engages and beeps with higher pulse frequency when the object is closer. There is a 0.19s beeping delay for a 1.0-1.4m detection distance, a 0.32s beeping delay for a 0.5-0.9m detection distance, and a 0.70s beeping delay for a 0.3-0.4m detection distance. The analog circuitry contains two capacitors that delay the start of the beeping by about 0.5s and the stop of the beeping by less than 1.0s. We believed that this delay is acceptable, and furthermore that the delay in sound cessation is beneficial. The noise in the signal does not cause sporadic breaks in output when the capacitors must be discharged before sound stops. A schematic of the desired detection system may be seen in Figure 22.8. A schematic of the circuit desired and developed may be seen in Figure 22.9 below. The prototype system is demonstrated but has not yet been field tested on an actual wheelchair system. Modifications such as an automatic override of wheelchair power in case of an imminent crash must be considered for future implementations.

Estimated expenditures are $120.

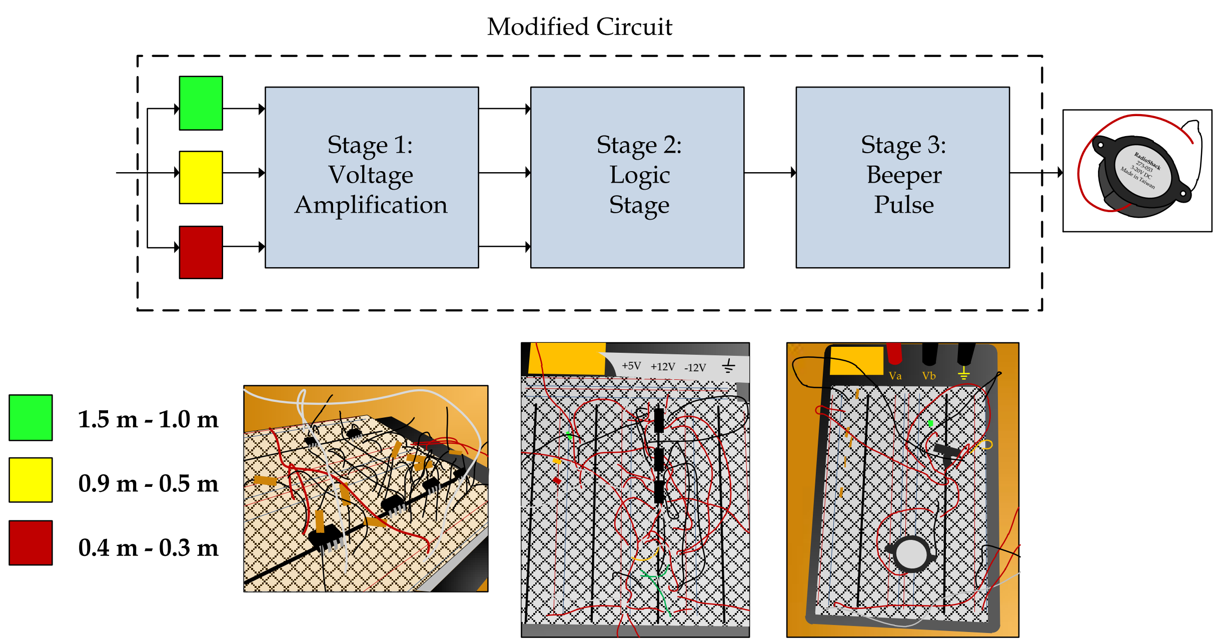

Fig. 22.9. Circuit schematic and breadboards for system.