CHAPTER 8
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KAYAK ASSISTIVE DEVICES FOR INDIVIDUALS WITH SPINAL CORD INJURY

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Client Coordinators: Dr. Jane D. Case-Smith, Dr. Carmen P. DiGiovine, Theresa F. Berner
Community interest: The Adaptive Adventure Sports Coalition
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INTRODUCTION

Open water kayaking is a fun, recreational outdoor activity that requires balance, endurance, and upper body strength. These assistive devices give independence during kayaking for individuals with minimal upper body function due to C6 spinal cord injury (SCI). The devices assist with two specific functions: holding the paddle and supporting the weight of the paddle while maintaining a full range of motion for normal kayaking maneuvers. To facilitate holding the paddle, a twist and lock male to female attachment secures the kayaker's hands to the paddle. A retractable wire that is attached to the center of the paddle supports the paddle weight. Upon completion, these devices were presented to a non-profit organization, The Adaptive Adventure Sports Coalition (TAASC), for recreational use. TAASC previously used thera-band straps to maintain a functional grip of the paddle, but the kayaker's hands frequently fall out of the straps. These assistive devices address the functional requirements to provide further independence to individuals with C6 SCI during kayaking with an aesthetically pleasing and comfortable solution.

SUMMARY OF IMPACT

Individuals with C6 SCI have little access to outdoor adventure activities due to their limited lower body mobility. TAASC is a teaching program that gives individuals with disabilities the opportunity to participate in adventure sports. For example, TAASC has weekly open water kayaking trips for participants and volunteers for up to five consecutive hours. Individuals with C6 SCI are either tethered to another kayak or ride in tandem with another person. Kayaking is a unique opportunity to give individuals with SCI the ability to participate on the same level as their peers, and promoting independence during kayaking trips will enhance the experience further.

Fig. 8.1. Kayaking Assistive Device.

These devices can provide individuals with C6 SCI the ability to kayak individually during TAASC's open water kayaking trips.

TECHNICAL DESCRIPTION

The paddle grip modification includes a male hand attachment and a female paddle attachment (Fig. 8.2). The male attachment pieces were fabricated from a 3-D object printer with a stainless steel pin inserted in the shaft for reinforcement. The male attachment is secured to a wheelchair push glove with thread and glue. The female attachment pieces mounted on the paddle include four 3-D object printed parts and four PVC pipe clamps. The hollow shaft in the female pieces has a slotted horizontal channel so the male piece can twist securely into place. The kayaker turns their hands with the thumbs inward to align the male pins above the female slot, and then pushes the male attachment into the slot. The kayaker can then rotate their hands so the male pins slide into the horizontal channel.

The paddle supporting device is rigidly attached to the front of the kayak with a set of four bolts and three custom built aluminum sheet attachments (Fig. 8.3). A bent rectangular piece underneath the kayak is used as a rigid stabilizer for the two pieces on the top of the kayak. A tool retractor with variable tension adjustment is used to support the paddle weight. The tool retractor wire runs through a hollow aluminum shaft that provides a point of support vertically above the kayaker's hands. The aluminum shaft has adjustable angle capabilities to adapt to various sizes of kayakers. The edges of the aluminum sheets are lined with rubber inside the kayak to reduce the risk of skin irritation.

One of the benefits of this design is that the paddle grip and support devices do not need to be used concurrently. Individuals can choose to use the paddle grip device without the paddle support device. Also, the paddle grip device allows a quick release of the paddle for the kayaker's safety. The support mechanism does not restrict the range of motion of the paddle, allowing the kayaker to use the paddle to push off of objects or paddle backward.

The approximate cost of all materials was $2,960.

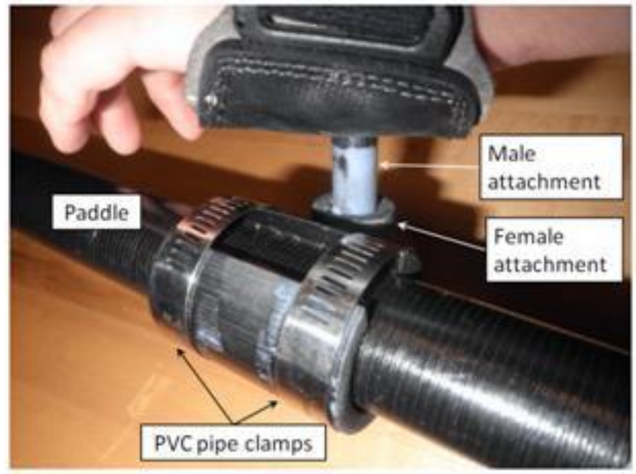

Fig. 8.2. Paddle hand grip device.

Fig. 8.3. Paddle support device

UNIVERSAL LOCK: A DEVICE THAT ALLOWS CHILDREN WITH DISABILITIES TO OPERATE A SCHOOL LOCKER

Designers: Jeffrey E. Domas, Robert L. Smith, James A. Suchocki, and Lauren L. Fisher
Client Coordinators: Dr. Jane D. Case-Smith, Dr. Carmen P. DiGiovine, Theresa F. Berner
Community interest: Dublin City Schools, Dublin Ohio
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INTRODUCTION

In middle school and in high school, almost every student secures their locker with a dial combination lock. Although dial combination locks are the most common, some other typical locks are word combination locks or padlocks. However, none of these locks fully accommodate the entire population of students in high school or in middle school. Although it is impossible for a lock or any other device to be usable by the entire population, there is currently a large portion of the school age population that cannot use the standard locks on the market. These individuals, such as those with cerebral palsy or a spinal cord injury, cannot use these locks because they do not possess all of the motor and cognitive skills necessary to open a standard lock. There are a number of currently available locks specifically designed to accommodate people who are unable to operate a standard lock; however, these locks either do not fully address their needs or are prohibitively expensive. Therefore, a large population would benefit from a new lock design which would allow those with cognitive or physical deficits to operate their school locker in a similar manner to their peers. Our team designed a new lock to accommodate these students with physical and cognitive deficits better than any commercially available lock. After our final design was chosen from a number of alternative solutions, we went through a number of design, build, test, and redesign cycles. After three of these cycles were completed, we were able to produce a lock prototype that was ready for clinical testing. We tested our device at Karrer Middle School with 6th, 7th, and 8th grade students on May 26, 2010. This clinical testing was very successful, as 9 out of 10 students with special needs and 31 out of 31 typical students were able to use our lock. In addition, the responses from the student surveys were overwhelmingly positive because most

Fig. 8.4. Front view of lock prototype with remote.

Fig. 8.5. Student using the lock.

students could operate our lock more easily than they could operate their own lock.

SUMMARY OF IMPACT

We created this universally designed lock in order to better accommodate approximately 600,000 students in the United States who cannot operate a standard lock. Through extensive research, we determined that many of these 600,000 students did not possess the physical and cognitive skills required to operate a standard lock. We defined that the problem with standard locks is the high level of physical and cognitive skills required to operate them. Therefore, our team determined that in order to better accommodate these students, our new lock must require less physical and cognitive skills to operate than current standard locks. In order to create a lock that addresses this problem, we defined a number of project requirements that would guide our group toward a solution to this problem. Next, we created a number of alternative solutions that would fulfill our project requirements. After we created these alternative solutions, we evaluated each design against criteria formed from our project requirements. The alternative solution that scored the highest against these criteria was selected to be our proposed solution. Our proposed solution was an electronically actuated, remote controlled, built-in lock that allowed the user to unlock their locker by use of a remote control. Through several design, build, test, and redesign iterations we created a lock prototype that allowed the user to unlock their locker using a remote control. This demonstrated that our design significantly reduced the amount of cognitive and physical skills required to operate a lock for a school locker. Therefore, our team successfully created a new lock design that better accommodates the 600,000 students in our target population.

TECHNICAL DESCRIPTION

Our lock is an electronic lock that is controlled by a remote control. The remote sends a binary code through an infrared signal in order to unlock the lock. The solenoid is controlled by a microcontroller circuit in the lock that interprets the infrared signal from the remote. A solenoid within the lock body controls the locking and unlocking. The lock will

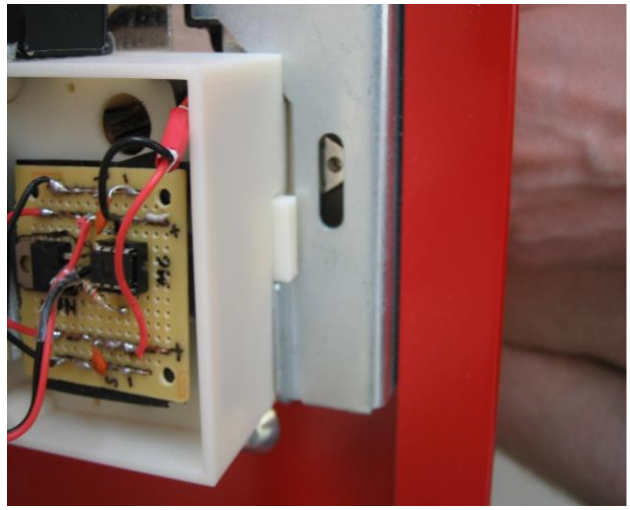

Fig. 8.6. Rear view of lock and lock circuit.

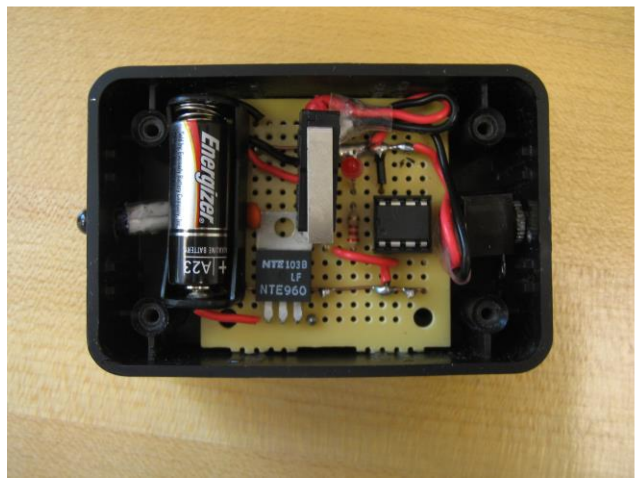

Fig. 8.7. Remote circuit

only unlock when the binary signal sent from the remote matches the binary code stored in the microcontroller. The remote is designed to be easily actuated by an individual with limited cognitive and physical skills. In addition, the remote has a 3.5mm jack so that an external switch of the user's choosing can be used to actuate the remote. This additional feature allows a wider range of individuals to use our lock because our design is compatible with a wide variety of existing switches. Further information regarding our lock design may be obtained by contacting the principal investigator.

The costs of parts and materials was about $700.

THE TRAY FOR A POWER WHEELCHAIR

Designers: Katherine Bovee, Michael Brezina, Michael Eggerichs, Matthew Yoak, Samar Shalash
Client Coordinators: Dr. Jane D. Case-Smith, Dr. Carmen P. DiGiovine, Theresa F. Berner
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INTRODUCTION

Wheelchairs allow people to lead an active lifestyle by decreasing mobility limitations and giving them an efficient means of travel. While wheelchairs have done much to increase the independence of people with disabilities, wheelchair users still face some limitations. Due to the height of manual and power wheelchairs, tables tend to be either too low to permit a wheelchair to slide underneath or too high for the client to comfortably use while sitting in their wheelchair. Although there are a variety of wheelchair trays available commercially, many of the trays lack the functionality needed to make them useful to people. The standard tray designs are either a full or half size tray that straps onto the armrests of the wheelchair. While current trays provide a flat surface for clients, many power wheelchair users lack the strength and dexterity to remove and attach the tray without assistance. Power wheelchairs offer a number of challenges when designing a compatible tray. Power wheelchairs have a joystick that the person uses to control the movement of the wheelchair. The location of the joystick, near one of the armrests, prevents a tray from being attached by sliding directly onto armrests. To address the shortcomings of the previously designed wheelchair trays and to increase the independence of power wheelchair users, the goal of our project is to design a tray for C6 Spinal Cord Injury (SCI) power wheelchairs that can be stored on the wheelchair when not in use.

SUMMARY OF IMPACT

The requirements for the tray are defined to meet the American with Disabilities Act and through interviews with power wheelchair users. Power wheelchair users now have the ability to deploy a tray when needed, however when not in use the tray can be stored on the chair by the power wheelchair user. The final tray design is stable, customizable, and is able to be attached to all power wheelchairs manufactured by Permobil and Invacare. The

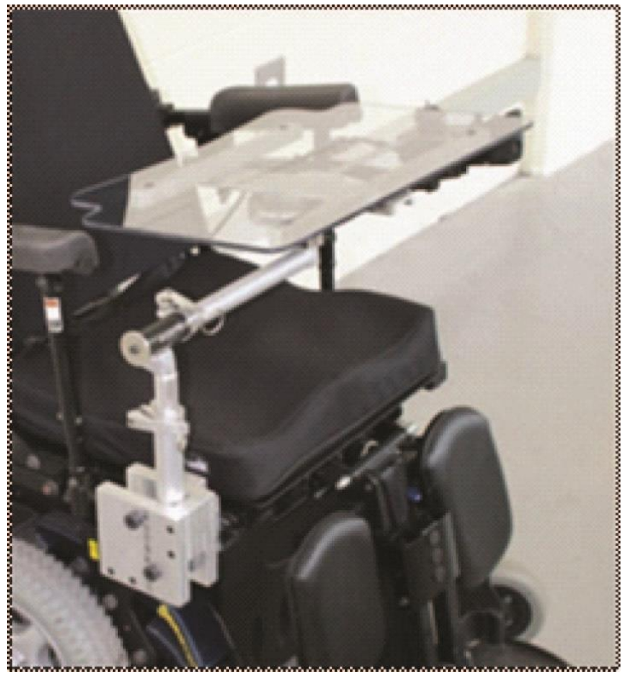

Fig. 8.8. The Tray for a Power Wheelchair.

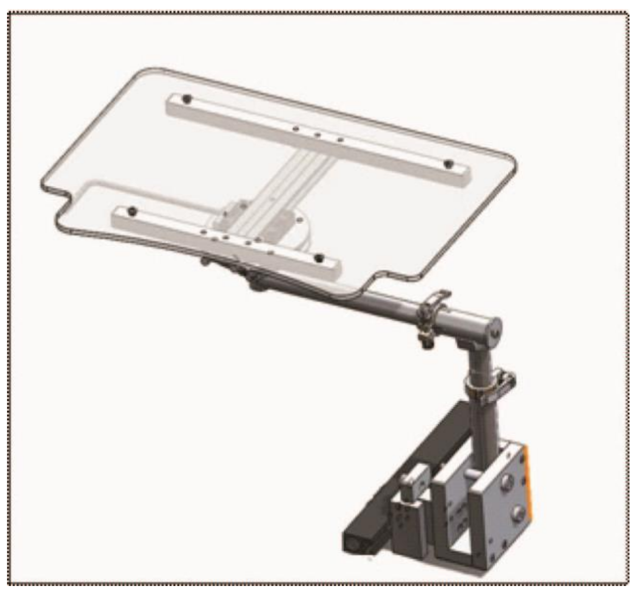

Fig. 8.9. Solid Model of Tray for Power Wheelchair.

requirement of the tray meeting ADA requirements was upheld because some of the compression clamps found on the tray require more than 5 pounds of force to operate. As a result, depending on the degree of a C6 SCI users disability determines whether they are able to independently operate our tray.

TECHNICAL DESCRIPTION

The entire tray assembly is comprised of aluminum, anodized aluminum, and steel. The aluminum makes up the entire tray aside from the screws, which are made of steel, and the track located underneath the tray surface, which is made of anodized aluminum. The tray assembly weighs 9.25 pounds. The tray requires eleven steps to deploy from the stored position on the side of the wheelchair and nine steps to retract back to the stored position. The total amount of parts in the assembly is 76. The targeted and resulting functional requirements can be found in Table 8.10.

The final cost of the tray is $1335.82

	Specifications	Target	Results
Functional	Stores on power wheelchair	Yes	Yes
	Amount of load tray can support with no deflection	15 lbs	5.9 lbs
	Amount of load supported with 5 degrees of deflection	60 lbs	36.7 lbs
	Able bodied person required assistance to deploy/retract tray	No	No
	Assistance required to deploy/retract tray	No	Yes

Table 8.10. Functional Requirements

THE GAIT TRAINER FOR CHILDREN WITH CEREBRAL PALSY

Designers: Erin Ansley, Ryan Bucio, Brianne Cattran, Keira Gaudette, and Chantale Levert
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INTRODUCTION

The gait trainer is designed to improve the user's gait and encourage normal gait motion. After observing children with Cerebral Palsy, it is clear that existing walkers and gait trainers need to be improved to encourage normal gait. Many of these assistive walking devices do not encourage proper postural alignment and had insufficient weight support. The motivating factor behind designing this gait trainer is that there are hundreds of thousands of children with CP who require a device to aid them in walking and to encourage more social interaction with their environment and with their peers (www.cerebralpalsy.org).

After completion, the gait trainer was tested with children at The Nisonger Center in Columbus, OH. There were two children at this center with Cerebral Palsy who tested our gait trainer. Ultimately, our gait trainer is intended to promote ideal postural alignment, normal gait, and increased social interaction.

SUMMARY OF IMPACT

Many gait trainers and walkers do not focus on improving postural alignment or encourage normal gait for children with Cerebral Palsy, but are designed to get the child from point A to point B. This provides no long term benefits for the child. The main design requirement for our gait trainer is to enable the user to stand with proper postural alignment and to encourage the child to support most of their own weight, leading to increased muscle awareness, socialization, and independence. The health benefits of standing include an increase in circulation, muscle activation, as well as bone and muscle growth. Standing also helps to normalize respiratory function by encouraging proper posture and allowing the chest to expand properly while breathing. Standing also causes the stretching of muscles, which can help reduce muscle spasticity and aid in better joint development.

Fig. 8.11. Final prototype of gait trainer.

TECHNICAL DESCRIPTION

The final gait trainer design consists of a postural alignment system (vest and back pad), weight support system (harness), caster wheels with multiple drag options, and a lightweight and adjustable Aluminum frame. A harness that attaches to the frame helps support 50% of the client's weight while he is walking. Often children with CP have poor muscle strength and tone and the harness will help to give the users the ability to stand. The amount of weight that the harness supports is important, because if it supports too much weight, then the child will be in a seated position and not standing up properly with their feet flat on the ground. For this reason, the harness is designed to be very adjustable.

It is also very important that the gait trainer be adjustable to fit each client properly. The straps and buckles of the vest and harness are all easily adjustable. The frame is also adjustable in height and width. The back pad can also be adjusted to move towards the front or back of the device as well. The adjustable back pad will help to increase the stability of the device and also allow the child to move forward in the device to be closer to a table, for meals or play.

The frame of our gait trainer must be strong and stable because the frame needs to withstand static and dynamic loads from the child. Several characteristics are included in the frame so that is practical and effective: it supports the harness, vest and back pad, is open in the front to make it easier for the users to approach a table or interact with their peers, and is also lightweight so that a child with minimal leg strength is able to use our device. The frame is also adjustable and constructed of durable materials that will last several years as the child grows. Once the child grows out of the gait trainer, another child will be able to use the device. The frame is the foundation of our design and must be robust, lightweight and safe.

Lastly, the inclusion of brakes, variable drag options, swivel locks, and the directional capability of the Rifton Medium Pacer wheels are extremely beneficial for our gait trainer. Having locks on the wheels allow the child to be able to stand in one location without needing to control the device. The locks also provide a more stable, stationary frame for the caregiver when they are trying to get the child into and remove the child from the device. The variable drag provides an additional method to control the pace of the child when walking and the swivel locks, if needed, will help to guide the child in a straight line. Finally, the directional option on the wheels will not allow the child to move in reverse if the child is likely to tip over backwards. These Rifton wheels are used for the two front wheels of the device, with two stroller wheels in the back. These four features on the Rifton Medium Pacer wheels are valuable for the device and help to accommodate children with different needs.

The total cost of parts and material is approximately $916.

Fig. 8.12. Child using the gait trainer final prototype

DYNAMIC COMPRESSION VEST FOR CHILDREN WITH AUTISM

Designers: Gregory Chernov, Jarred Kaiser, Jessica Modlich, Shea Mogg, Sarah Chafins, Laura Piper
Client Coordinators: Dr. Jane D. Case-Smith, Dr. Carmen P. DiGiovine, Theresa F. Berner
Community interest: Easter Seals of Central Ohio
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INTRODUCTION

The dynamic compression vest is designed to provide sensory integration to children with autism in order to help them process sensory input in an organized way. Current devices on the market that provide sensory integration include weighted vests that apply a downward force to the child and static compression clothing. Children assimilate to the static compression these devices provide, so the effect wears off. These devices must also be removed at least every 30 minutes. The dynamic compression vest allows the application of the compression to vary so the child does not assimilate to it, and without the need to remove the vest frequently.

SUMMARY OF IMPACT

The vest applies dynamic sensory integration to children with autism so the calming effect last for a longer period of time. This allows children to be more comfortable in their environment and engage in more activities. The vest also helps parents and caregivers. Since the vest will apply compression only at timed intervals, the vest can be worn all day, and the parents or caregivers will not have to remember to remove the vest.

TECHNICAL DESCRIPTION

The vest consists of an electrical sub-system, a pneumatics sub-system, and the vest itself. The compression is provided through five rubber bladders within the vest which inflate and deflate at timed intervals. There are two bladders in the front of the vest and three in the back, and they inflate so the anterior and posterior have the same pressure at the same location. This requires control of three rows of bladders.

The bladders are modified blood pressure cuffs, and a diaphragm pump is used to inflate and deflate them. The bladders are connected to the pump through solenoid valves by 1/8 inch tubing. The timing of the inflation and deflation is controlled by a microcontroller. The top row of bladders inflates first, and then moves to the bottom row. The bladders all hold pressure for one minute, and then they deflate. This quick timing hopefully allows for the child to not habituate to the pressure so the vest will be more effective than static devices. While

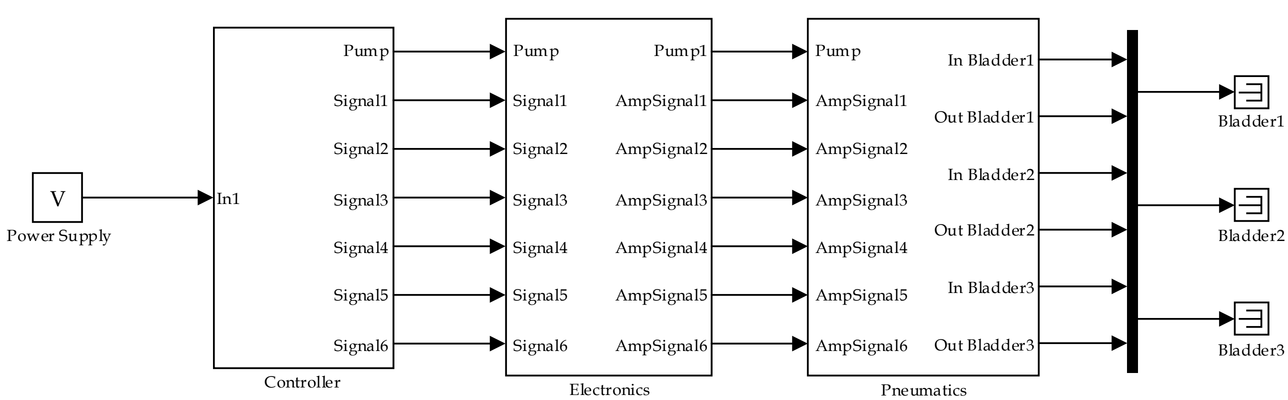

Fig. 8.13. Diagram of entire system.

there is no evidence to support this timing scheme, further testing will be done to modify the timing. The inflation and deflation is achieved through a feed forward system. Feedback will also be implemented in future prototypes to determine the pressure within the bladders.

In order to supply the correct voltage needed to each component an electrical circuit is used, which is currently on a breadboard, but will eventually be moved to a circuit board. The circuit in this prototype supplies 12 V to the pump and two of the valves, 6 V to the remaining four valves, and 5 V to the microcontroller. The circuit is powered by a standard laboratory voltage source.

The vest has internal compartments to hold the bladders in place. The vest is split into an internal fabric and an external fabric to ensure the air pressure within the bladders is being applied directly to the torso and not inflating outwards. The internal material is rayon, and the external material is reinforced cotton. For this prototype, the pneumatic and electronic systems are located outside the vest, however, in future prototypes these will be inside the vest, so the vest will be portable when children wear it.

The cost of all materials is around $900.

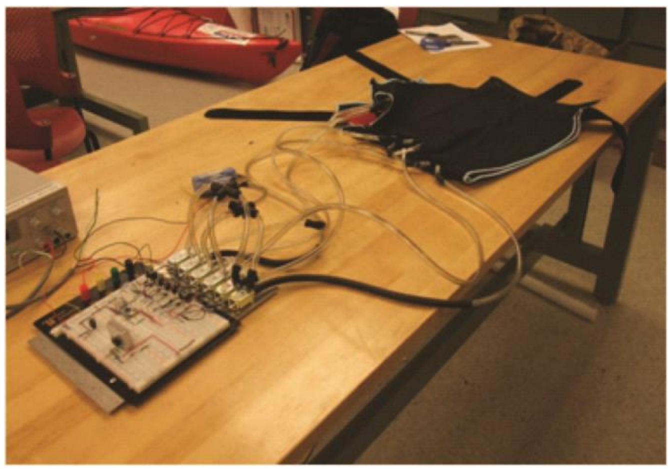

Fig. 8.14. Picture of pneumatic and electrical system.

Fig. 8.15. Internal bladder compartments in vest

TIME MANAGEMENT DEVICE FOR CHILDREN WITH DOWN SYNDROME

Designers: Krista Alley, Kristen Cornelius, Elise Dew, Alex Hegedus, Kyle Johnson, Cecilia Shiroma. Carrie Weisbecker and Katie Whitehouse
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Community interest: Down Syndrome Association of Central Ohio
Supervising Professor: Dr. Peter Rogers, Dr. Robert A. Siston
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INTRODUCTION

The Ohio State University Time Team (TT), in partnership with the Down Syndrome Association of Central Ohio (DSACO), is designing and commercializing a product that provides two primary benefits including that the product improves the independence of children with Down syndrome learning to manage time, and the resulting commercial income provides an alternative revenue source to help sustain our non-profit partner. Current methods to help manage time, including drawing out events and kitchen timers, do not focus on the needs of children with Down syndrome. DSACO and the TT worked together throughout the design development to validate each step. The product visually displays pictures of events in their chronological order, a proportional comparison of the events' duration, and a real-time representation of time passing through the event sequence. To make sustainability possible, a unique agreement is in place with the university through which they will exclusively license all newly created intellectual property at no fee to ensure all royalties return to the non-profit partner and to our program. The TT is piloting this project and creating a unique social enterprise model that provides an effective social outreach while providing entrepreneurial students with a learning opportunity.

SUMMARY OF IMPACT

The time management device for children with Down syndrome created by the TT serves multiple purposes. First, the product will increase the self-sufficiency of children by enabling them to manage their time independently. The goal is to provide a tool to aid children learning the concepts of time, relationships between the timing of multiple events, and sequential reasoning. The product will also help mitigate the frequency of occasions that a caregiver must remind the child to stay on task. One of the final main goals of the project is to provide an alternative revenue source to help sustain DSACO and the Social Innovation program to benefit future projects. In providing a revenue source to DSACO, many children with Down syndrome will continue to receive critical services provided by the organization. The design abides by the project requirements and will continue the validation process to ensure it fulfills its goal.

TECHNICAL DESCRIPTION

The product fulfills the need for time management by implementing two main functions: providing a visual sequence of events and displaying a proportional amount of time. It presents time and events in a simple and effective way using multiple sensory stimuli that specifically address the cognitive and physical disabilities of children with Down syndrome. The time device linearly portrays several tasks in chronological order, shows expected task duration in relation to its surrounding events, and depicts elapsed and remaining time for the event series using a dynamic proportional LED light bar. The LED bar is capable of displaying up to five separate colors, indicating lengths of time for the five different tasks. The user chooses the lengths of time by way of potentiometer knobs and those lengths program into the device upon each use. The lights turn off at a constant rate as time passes, showing a decrease in the length of time left. Pictures of the event tasks lay over individual backgrounds whose colors correspond to the colors on the LED. Based on results from validation testing of preliminary concepts conducted with 21 parents of children with Down syndrome, the device employs interactive features to provide the child a sense of accomplishment. Visual reinforcement of the completion of a task takes the form of a window that closes over the event's picture. Closing the window also closes a circuit loop, activating a positive sound. The device is robust, portable and adaptable. It has visual appeal, is easy to use, and requires minimal set up time. Currently, there are no products similar to this on the market. The team conservatively forecasts cumulative revenues for the first three years of production at $2.5 million (represents selling 50,000 units at $50.00). The total project cost is $2529.97.

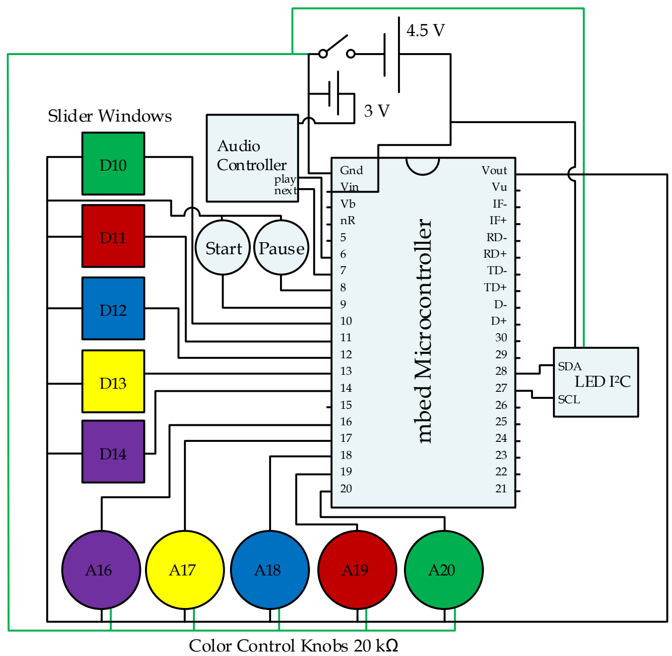

Fig. 8.16. Control System.

Fig. 8.17. Basic design of the device.