Project Proposal

Comfort Head and Neck Support Device and Multi-Use Table

Team #1
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Project for Client: Annalee Hughes

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Executive Summary

This senior design project for Annalee Hughes will include a head and neck positioning device, as well as a multifunction table for her wheelchair. Since she has cerebral palsy, it is necessary to design a device that gently promotes better postural alignment and also provides a work station. While there are several devices currently on the market, they are too expensive for the client, and some of them do not work well. Using data and knowledge from previous work, the goal of the project is to design a superior product that is customized for Annalee. The neck and shoulder positioning device will improve posture while also providing positive biofeedback that will encourage correct body position. This will be the first product that incorporates some type of biofeedback into a cerebral palsy positioning device. The multifunction table will be able to store various materials, and will also provide a supportive work space that can be used for homework, art, or eating. Each separate part of the project will be carefully designed, and the proper materials will be selected to ensure ultimate quality.

1 Introduction

1.1 Background

Cerebral palsy (CP) is a neurological disorder caused by abnormalities in parts of the brain that are a result of oxygen deprivation to the brain at birth. Muscle tightness or spasticity, involuntary body movements, awkward walking patterns and posture, and muscle weakness are all effects caused by CP. Annalee is a 10 year old girl suffering from CP. Annalee is a very enthusiastic child with a sharp mind, but she is unable to sit or stand without assistance due to her muscle spasticity and lack of body movement control. Annalee spends most of her time throughout the day in a power wheelchair that she is able to operate and control. A standard headrest is on the back of the chair, but Annalee’s head rarely makes contact with this headrest. Due to her weak neck and back muscles, Annalee’s head is almost constantly in a downward flexed position. She is able to raise her head for a few seconds at a time but cannot maintain the position. If Annalee tries to completely raise and extend her neck, the result is overextension and her neck is severely arched. A comfortable and supportive device is needed to allow Annalee’s head to be positioned erectly and medially in line with her body. This will limit the strain on her neck from the weight of her head as she sinks forward, and will prevent hyperextension. Schoolwork and extracurricular activities are very important to Annalee. The limitations of her power wheelchair include the inability to allow her access to certain desks and small areas. An ideal space for Annalee to do her school work, computer work, and crafts would be right in front of her on an easily adjustable and accessible desk top.
1.2 Purpose of the Project

The purpose of this project is to design two types of wheelchair attachments for a young girl with cerebral palsy. The first attachment piece must be a multifunctional and adjustable table that can be mounted to Annalee’s current wheelchair. The design of this table should allow Annalee to place her materials (e.g. laptop, books, arts and crafts) at a comfortable viewing level and be able to store smaller materials (e.g. writing utensils, and television remote). The table should also be detachable or easily storable somewhere on the wheelchair for when it is not needed. Material strength consideration is necessary, as Annalee will be placing a considerable amount of her body weight on the table to adjust her seating position throughout the day. The second attachment design must function to adjust and correct Annalee’s head and neck position while seated in her wheelchair. The design must be aesthetically pleasing to the client, provide the proper amount of restriction to maintain her head and neck in the correct anatomical position, yet not be too restrictive so that it would hinder her everyday activities. This system may include a head support, neck support, and shoulder support as needed to obtain the proper anatomical seating position. A biomechanical feedback system must be incorporated into the design of the head and neck positioning system. The client’s parents and physical therapist have agreed that some type of positive feedback reward should be given to Annalee when her neck and head are in the correct anatomical position in order to encourage her to sit properly more often. The long term goal of this attachment is to have Annalee strengthen her weak neck and back muscle groups over time with the aid of the positioning system, while also training her to hold her head correctly with positive reinforcement. These designs should improve the quality of life for the client by making the restriction of her wheelchair more functional for her daily activities through a multifunctional table, and should be beneficial to the client’s health by comfortably supporting her neck and head.

1.3 Previous Work Done

1.3.1 Products

Multi-Function Tables

Wheelchair desks are commonly available from a variety of medical equipment and product providers. Common wheelchair desks are made to tilt forward, backward, or lie flat. Desks are available to fit common wheelchair sizes ranging from 18”-24” in length. Many designs include cup holders and storage compartments for small belongings or books. Many desks are attachable to the wheelchair at the arm rests, and some designs feature a cut out for the body cavity or wrist/wheelchair control. These specially designed desks are available at an increased cost. Desks are available as rigid bodies, or on a swivel or fold away coupling. Common materials for the construction of the desks include polyethylene for the desk itself with the use of steel tubing and aluminum brackets for securing the desk to the wheelchair.
**Head and Neck Support Devices**

Six widely used and common head and neck positioning systems are described below. A major company responsible for the sale of these designs has been listed, along with a description of the product. While all of the products function to keep the head in midline positioning, they are based on very different designs. Each design has limitations involving materials, aesthetics, and cost. The approximate costs of these devices are discussed in the budget section of this proposal. Figure 1 displays an image of each of the respective numbered devices.

1. **The Dynamic Forehead Strap System** is made by Whitmyer Biomechanix Inc. Whitmyer Biomechanix Inc. makes a variety of headrests and forehead strap accessories that assist in keeping the head in an upright position while seated in a wheelchair. Most designs are based on a S.O.F.T design (Sub Occipital Formed Three-piece) holding piece for the head and neck region.

2. **Heads Up** is a flexible head support system involving tension in elastic bands disguised by a common baseball cap or lady’s floppy hat.

3. **Metalcraft Industries** makes a variety of pads for head positioning assistance. A contoured headrest, posterior lateral, posterior lateral occipital, adjustable wing collar, rigid occipital wing collar, and an occipital angle bar and T-bar are available as padded attachments for wheelchairs. These attachments are sold in a variety of dimensions but are not custom made.

4. **The i2i Head and Neck Positioning System** by Stealthproducts includes a lateral and sub-occipital support, anterior stabilizing arms, and a chin prompt. This device advertises improved patient eye contact, ease of feeding, saliva management, and communication, and requires less caregiver time for repositioning.

5. **The TOT Collar** by Symmetric Designs is made of a loop of soft PVC tubing that is bridged by two short nylon tubes. These tubes are positioned anterior and posterior to the crest of the trapezius. The PVC tubing is fastened with a Velcro strap. The TOT collar encourages central positioning for the head and is aesthetically pleasing with the clear tubing.

6. **Headmaster Cervical Collar** by Symmetric Designs provides firm support for the head and neck while having low profile appearance and low heat retention. This collar consists of the framework of the typical cervical collar, creating a chin rest and providing neck support. The rigid, yet adjustable framework maintains a constant upright head position and prevents the head from falling forward.
Comfort Padding

Slow recovery memory foams are available for padding. Orthopedic pads have been designed to improve circulation and functionality of the covered region. Advances in medical foams and pads continue every day. Not only are foam pads available, but medical gel pads are also used. Foams and gels take into consideration body heat, body contour, pressure distribution, and the patient’s security and comfort. Medical foams and pads are made to be extremely durable and capable of supporting a large amount of weight. An industrial example of a high quality comfort pad is one manufactured by SpanAmerica. SpanAmerica designs contoured viscoelastic gels and memory foams that function to equalize and disperse pressure. Like many medical foams, these foams are recognized for reimbursement by Medicare.

Summary

Based on our product research, many attachable laptop desks are available for wheelchairs. Some include adjustable positioning and storage. Less commonly found are desks that include an adjustable height function as well as a tilting function. The cost of these designs is highly inflated, since they are considered medical equipment.

In addition, a variety of head and neck positioning systems are currently available, along with a wide range of contoured foams for padding. The available products provide a correction mechanism (i.e., tension in elastic bands and straps) that allows freedom in range of motion but also limits movement so that no distortion or incorrect posture is produced. However, the cost of
these products is inflated, and none currently includes a biomechanical feedback system incorporated into the positioning system.

1.3.2 Patent Search Results

Patent search results produced a variety of out-of-date head and neck positioning systems. The initial patents on tethering systems, restraint helmets, and halo restraints and their respective designs are all available, yet are inapplicable to this project except for their similar principle function. A combination wheelchair desk and storage area design was patented by Fred Ringer in 1995. This basic design is similar to the anticipated design for Annalee. Annalee’s design will be more modern and involve a durable polymer plastic material rather than wood, and the desk will be compactable or storable on the side of the wheelchair. Figure 2 shows the basic design for this wheelchair combination desk.

![Figure 2. Fred Ringer’s patented wheelchair combination desk.](image)

2 Project Description

2.1 Objective

For this design project, the design team separated the project into three distinct parts: the multifunction table, the shoulder support device, and the head and neck biofeedback support system. Each piece of the design project will have its own specific function, unique design, and individual implementation.

2.1.1 Multifunction Table

First, the multifunction table as a whole will provide a stable platform for Annalee to complete many different tasks. The desk will provide Annalee a functional space to read books, use her laptop computer, eat food, complete homework assignments, listen to music, watch TV, and perform art projects.
The following characteristics should be incorporated into the design of the multifunction table in order to fulfill the specific needs of Annalee requested by her parents.

1. The multifunction table should be ergonomically correct, and should position reading and writing materials at the proper angle and distance.
2. Storage compartments should be added to the table to increase its functionality.
3. The device should be interchangeable so that it can be attached to more than one power chair, and should be customizable so that it can be adjusted as Annalee grows older.
4. The multifunction table should be durable to withstand constant use, and strong enough to support school textbooks.
5. The device should be collapsible and storable to allow Annalee to enter and exit her power chair easily and quickly in case of emergency.
6. The overall design of the device should be aesthetically pleasing to a young growing girl.

In order to implement these design specifications, the design team must incorporate the following into the design.

1. Adjustable screws, tightened by hand knobs, and a movable tabletop will enable Annalee to position reading and writing material at the correct height according to her position in her power chair.
2. Hollow compartments or easy-to-open drawers will allow Annalee to store various items such as school supplies, personal items, and electronic entertainment.
3. By using an adjustable clamp or bolt mechanism, the multifunction table will be removable from her current power chair to another one purchased in the future. Adjustable knobs will allow the table to be correctly positioned due changes in height.
4. To increase durability, the multifunction table will be constructed of a lightweight metal frame covered by a high strength plastic exterior. The lightweight metal was selected to provide a rigid, durable frame, while the plastic exterior was chosen to make the multifunction table as light as possible.
5. Through the use of a hinge or clips, the multifunction table can be stored along side the power chair. This will allow the multifunction table to be stored when not in use, and will keep the profile of the power chair to a minimum.
6. The color of the multifunction table should be something chosen by Annalee and should contain some graphics of her choosing.

2.1.2 Shoulder Support Device

Second, a shoulder support device will ensure correct positioning by adjusting the shoulders so that they do not fall forward. Currently, Annalee tends to slump forward and cannot support herself in the correct upright position, which places extra stress on the spine and muscular system. Poor posture also makes it difficult to perform everyday tasks such as eating or doing homework or art.
There are several characteristics that should be incorporated into the design of the shoulder positioning device.

1. The shoulder positioning device needs to pull the shoulders back so that the spine is better aligned and straight. It should eliminate excessive curvature of the back and shoulders and prevent Annalee from folding in half at the waist.
2. Since she has increased muscle tone, the device needs to be strong enough to resist her natural pulling and movement.
3. Although it needs to be able to withstand any sharp accelerations of the body, it also should have some degree of flexibility and give. This would make it more comfortable for the user while not being too restraining.
4. One key feature of the design is that it will serve to guide correct body position without forcibly restraining Annalee. There needs to be some freedom of movement so that she does not feel locked in place. This may be done by designing the device to leave some space between the body and the actual positioning device, or by incorporating springs that are flexible.

A restraint system is not ideal for Annalee because it does not allow her to consciously focus on her posture and grow stronger. A shoulder guidance system should provide enough of a stimulus to keep the upper body in the proper anatomical position, but should also allow the muscles to be activated. Eventually, the muscles will grow stronger and she may be able to sit properly without any external device.

The following specific attributes should be included in the design of the shoulder device.

1. In order to pull the shoulders back, the shoulder device needs to have some mechanism to prevent the shoulders from rounding and moving forward. This may be done by using straps or short lever arms that encircle the shoulders from above or below.
2. The guidance arms can either go completely around and under the armpits or just partially enclose the shoulders.
3. The system should be easy to remove but should also be sturdy enough to accommodate any body movements.
4. The frame needs to be made out of a lightweight, sturdy metal or plastic that also provides some amount of flex.
5. It is also important to sufficiently pad the device with foam or gel so that is does not cause pressure points. The shoulder positioning device needs to avoid skin breakdown due to constant pressure or rubbing, and needs to be generally comfortable for the user.
6. Since the device may be worn throughout the day, it is important to make it easily cleanable and sanitizable.
7. The device also needs to have a low profile so that is does not distract other people or make the user feel overly self-conscious.
2.1.3 Head and Neck Biofeedback Support System

Third, the head and neck biofeedback support system is designed to provide Annalee the necessary support for her head and neck and incorporate biofeedback to create muscle memory and strength.

The following characteristics should be implemented into the design of the head and neck biofeedback support system to fulfill the required characteristics given by Annalee’s parents and her physical therapist.

1. The head and neck biofeedback support system should provide support to the head and neck region without becoming too constraining.
2. Biofeedback (i.e., positive or negative feedback given as result of a biological stimuli) will reward Annalee for maintaining the correct anatomical head position while providing encouragement when in the incorrect position.
3. Annalee’s parents or her physical therapist should be able to easily adjust the head and neck biofeedback support system as Annalee grows older.
4. The head and neck biofeedback support system should position the head in the correct position by tucking the chin down and holding the head back.

To implement the required characteristics of the design, the design team should incorporate the following design details into the project.

1. The head and neck biofeedback support system will support Annalee’s head with supports under the chin and around the neck. By supporting the head in these areas, the head and neck biofeedback support system will be as compact and as unrestrictive as possible.
2. Sensors in the head and neck biofeedback support system will determine whether Annalee is in the correct anatomical position. When in the incorrect anatomical position, a negative effect will be triggered. The negative consequence will involve the muting of the television, muting of music played from an iPod, or spoken auditory command from an external speaker.
3. By using easily adjustable screws with hand knobs, Annalee’s parents and physical therapist can easily and quickly adapt the head and neck biofeedback support system as she grows.
4. The head and neck biofeedback support system will use soft foam surrounding lightweight metal along with minimal restraints to correctly position the head. A soft, easy to clean fabric will surround the foam and lightweight metal interior.

2.2 Methods

For this design project, the design team will brainstorm, plan, design, produce, and test three unique devices. The first of the three devices includes a multifunction table to provide the
client, Annalee, a specially designed space for her to complete homework, dine, and read. The multifunction table will be able to be attached to the wheelchair during use, but will also be able to be removed or stored quickly. It will be strong enough to support her weight, and will serve as a place to push off during repositioning. Its position will also be adjustable, and some sort of storage compartment will be able to accommodate necessary items. Second, a shoulder support system will be created to provide corrective trunk and upper torso support and alignment. The shoulder device will bring the shoulders back into a correct posture while allowing for muscular development. Third, a head and neck biofeedback support system will provide the necessary head and neck support for Annalee (who tends to lean forward), and will incorporate biofeedback to remind her when the correct position is not maintained. It will be a removable device that serves to promote proper head and neck alignment while strengthening the neck muscles. All parts of the project will be made in a sturdy fashion, but will not obstruct normal functioning and movements by being overly bulky. Each device will require its own specific design, materials selection, and manufacturing process.

The first step will be to create a variety of possible designs that can be used for each of the three sections. These designs will then be shown to Annalee and her family to get their feedback on the final design. They will be scrutinized by an engineer, and one design for each part will be selected. The design that seems to work the best will then be modified and optimized so that it is indeed the best design. The proper size and dimensions will be determined so that the devices fit to Annalee and are not too large for her. It is important that each part be completely customized for Annalee so that they work properly and can be effective in their designed task. Once this is done, a CAD drawing of each part will be produced and mechanical stresses will be analyzed using the computer. Static and dynamic analysis will be used to determine the anticipated applied loads and to help redesign the project to withstand the stresses.

The next step will be to determine the best materials for the project, as constrained by the loading and budget. Throughout each step, revision of the project to fine tune each detail will be necessary so that the design is fully optimized. When the design has been fully developed, a prototype will be constructed from readily available materials. This will allow dimensions to be confirmed and to eliminate possible construction problems later in the process. This prototype can be shown to the client to ensure that the design meets the specifications required by Annalee. After all aspects of the design have been satisfied, the proper supplies will be ordered and parts fabricated. They will then be assembled according to the design, and any problems will be addressed. Once each part has been assembled, they will be finished and presented to the client. The block diagram below illustrates the main steps that will be taken in order to successfully complete the project.
Figure 3. Project Overall Process
2.2.1 Multifunction Table

To design and produce the multifunction table, the design team must acquire and apply the dimension of Annalee’s power chair to any multifunction table design. Based on the given dimension and location of armrests, joysticks, and other structural components, the design team will create various designs that fill all the requirements given by Annalee and her parents. Essential characteristics of the multifunction table include the requirements that the table be adjustable to prevent strain while reading and writing, storable to allow easy movement in and out of the chair, and strong and durable enough to provide a suitable platform for work and correcting body position. Designs which meet these requirements will be created in a digital model using one of the following computer drafting programs AutoCAD, AutoDesk Inventor, or SolidWorks. From the computer design, the design team will perform mechanical analysis of the structural integrity of the design. Designs that successfully pass the mechanical analysis will be converted to a three dimensional prototype to easily visualize dimensions and physical characteristics. Using the prototype as a template, the design team will implement the actual design using the purchased materials.

2.2.2 Head and Neck Biofeedback Support System and Shoulder Support

Due to Annalee’s cerebral palsy, she is unable to hold her head, neck, and upper torso in the correct position. Annalee’s upper body is unable to maintain a constant position. Her head has a tendency, due to weak neck muscles, to fall forward and bend at the neck. Furthermore, Annalee’s upper torso leans forward, bending at the waist, because of weak muscles in the abdomen and lumbar regions. However, when she does hold her head up, she tends to look up with her chin pointed upward. To correct this abnormal position, the head and neck biofeedback support system will provide support under the chin and at the base of the skull in the occipital region. Applying support at the occipital bone will correctly align the head in the vertical direction, thereby eliminating the upward point of the head when the head is upright. Next, supporting under the chin will prevent over compensation of the head, which causes the chin to point forward. Furthermore, the shoulder supports will provide the necessary support to hold the upper torso against the back of the power chair. The combination of the head and neck biofeedback support system and the shoulder supports will give Annalee the correct upper body position.

In addition to physical restraints to enable Annalee to have correct body position while in her power chair, the design team has added a biofeedback system to the head and neck support to train Annalee’s muscles in the neck region. At the request of the family and Annalee’s physical therapist, a simple biofeedback circuit will reward Annalee for the correct body position and will provide a negative response or a verbal command when the correct body position is not maintained. To accomplish this, the biofeedback system will contain a series of button switches that will provide an electrical response to the location of Annalee’s head and neck in the support device. The button sensors will be connected either by a combination of series and parallel circuitry or through the use of a user programmed microcontroller. Working in connection with
the television or an audio player, the biofeedback system will mute the television or audio player when Annalee is in the incorrect body position. Furthermore, the biofeedback system will contain an option for an audio command, such as “Sit up straight Annalee”, when the correct body position is not maintained. The following figure, Figure 4, displays a flow chart for the concept behind the biofeedback system. By incorporating biofeedback into the design of the head and neck support, the design team will allow Annalee to strengthen the muscles of her neck, be reminded when she is not in the correct position, and remove the burden of reminding Annalee from her parents.

![Figure 4. Biofeedback System Concept](image)

3 **Budget**

All three designs (i.e., the head and neck support, the attachable desk, and the biofeedback system) will be created from raw materials. The raw materials will include various plastic components to build the desk and adjustment levers. Comfort padding will be required for the head and neck positioning system. Currently, many high quality gels and foams are available through medical product companies; however, these pads increase in cost with an increase in quality. The choice of foam will be based on budget and the ability to customize the foam based on the design of the system. A fabric covering will be necessary for the comfort padding material. Variations of metal components will be necessary for the mounting system of the multifunctional table and the head and neck support system. Electrical components and hardware will be necessary for the biofeedback system. Table 1 presents a summary of the material costs.
<table>
<thead>
<tr>
<th>Multi-Function Table</th>
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<th></th>
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</thead>
<tbody>
<tr>
<td>Desktop</td>
<td>HDPE 24&quot; x 24&quot; 1/2&quot; Thick</td>
<td>$38</td>
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<tr>
<td></td>
<td>HDPE 24&quot; x 24&quot; 1/4&quot; Thick</td>
<td>$20</td>
</tr>
<tr>
<td>Base</td>
<td>6&quot; Aluminum 1/4&quot;x1&quot; rectangular tube</td>
<td>$15</td>
</tr>
<tr>
<td>Bracketing</td>
<td>Hinge</td>
<td>$30</td>
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<tr>
<td></td>
<td>Adjustable knob/lever</td>
<td>$10</td>
</tr>
<tr>
<td>Fasteners</td>
<td>Various nuts, bolts, screws etc.</td>
<td>$15</td>
</tr>
<tr>
<td><strong>Total:</strong></td>
<td></td>
<td><strong>$128</strong></td>
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**Shoulder Brace**

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<table>
<thead>
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<tbody>
<tr>
<td>Metal Components</td>
<td>1/8&quot;x1/2&quot;x6' 304 Stainless Steel</td>
<td>$30</td>
</tr>
<tr>
<td>Foam Material</td>
<td>1&quot;x36&quot;x96&quot;Extra Soft Neoprene Foam Rubber</td>
<td>$70</td>
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<tr>
<td>Fabric</td>
<td>60&quot;x120&quot; Neoprene coated Nylon Fabric</td>
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<tr>
<td>Foam Material</td>
<td>1&quot;x36&quot;x96&quot;Extra Soft Neoprene Foam Rubber</td>
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<td><strong>Total:</strong></td>
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**Head and Neck Support**

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<table>
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<tbody>
<tr>
<td>Metal Components</td>
<td>1/8&quot;x1/2&quot;x6' 304 Stainless Steel</td>
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</tr>
<tr>
<td>Multi axis-ball and socket bracket</td>
<td>1/2&quot;x1/2&quot;x24&quot; rectangular tube 304 SS</td>
<td>$15</td>
</tr>
<tr>
<td></td>
<td>Inclined booted ball joint linkage</td>
<td>$15</td>
</tr>
<tr>
<td>Vertical Tube slide for posterior adjustment and attachment</td>
<td>1/2&quot;x1/2&quot;x12&quot; rectangular tube 304 SS</td>
<td>$10</td>
</tr>
<tr>
<td>Related Fasteners</td>
<td>Truss Head Phillips Drive, w/Patch</td>
<td>$5</td>
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<tr>
<td></td>
<td>Button Head Hex Drive, w/Patch</td>
<td>$5</td>
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<td></td>
<td>Point Knobs</td>
<td>$5</td>
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<td></td>
<td>Adjustable Lever Knob</td>
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<tr>
<td></td>
<td>Socket Head Cap Screw, w/Patch</td>
<td>$5</td>
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<tr>
<td>Foam Material</td>
<td>1&quot;x36&quot;x96&quot;Extra Soft Neoprene Foam Rubber (Quoted in shoulder support)</td>
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<tr>
<td>Fabric</td>
<td>60&quot;x120&quot; Neoprene coated Nylon Fabric (Quoted in shoulder support)</td>
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<td><strong>Total:</strong></td>
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**Biomechanical Feedback System**

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<tr>
<td>Electrical Components</td>
<td>Pressure Sensors</td>
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<tr>
<td></td>
<td>Microcontroller</td>
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<td></td>
<td>Protoboard</td>
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<td></td>
<td>9V battery</td>
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<tr>
<td>Miscellaneous Electrical Parts</td>
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<td>$25</td>
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<td><strong>Total:</strong></td>
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<td><strong>$175</strong></td>
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**Grand Total:** $653

*Table 1. Cost of Raw Materials (US$)*
The design team has budgeted for 30% error/waste which brings the overall budget total for the project to $850.

Error or waste will mostly stem from re-design using raw materials. Especially taking into consideration the head and neck positioning system, many different positions will need to be tested by the client. Optimal angle and positioning measurements will be taken initially. However, re-designs to make the device perfectly modeled and adjusted to the client are anticipated at various stages throughout prototype testing.

The design team intends to use the UConn Model Shop, as well as other university resources, for all molding and tooling associated with the construction of each piece. No outside manufacturing or professional tooling expertise will be needed.

Table 2 presents the average costs of existing products that were first referenced in section 1.3.1. These existing products do not include any type of biofeedback system, and are not quoted with the price of a lap desk.

<table>
<thead>
<tr>
<th>Product</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Headmaster Cervical Collar</td>
<td>$120.00</td>
</tr>
<tr>
<td>TOT</td>
<td>$50.00</td>
</tr>
<tr>
<td>I2I</td>
<td>$699.00-868.00</td>
</tr>
<tr>
<td>Heads Up</td>
<td>$240.00</td>
</tr>
<tr>
<td>Metalcraft Industries</td>
<td>$99.00-575.00 (individual parts)</td>
</tr>
<tr>
<td>Whitmyer</td>
<td>$180.00-1020.00</td>
</tr>
</tbody>
</table>

_Table 2. Common costs of existing products_

The estimated cost may slightly increase or decrease as design changes are made or market value prices change. The head and neck positioning system will need to be modified and adjusted over time to give the client the best results. The proposed biomechanical feedback system will need to be tested with the client to ensure it functions properly during her everyday environment. These anticipated adjustments are included in the budget for error and waste.

4 Conclusion

The design specifications for this project involve creating a head and neck positioning system to keep Annalee’s head in an upright position with her chin tucked, and create a multi-use table attachable to her power wheelchair. A problem with the current products on the market are that many of them are not custom made, but provide a range of dimensions to fit the needs of most clients. Annelee’s neck support must be custom fit to her exact body dimensions in order to
be most effective in providing comfort and support. In addition, no products on the market currently include a biomechanical feedback system. The integration of this system, along with the use of raw materials to construct the bracketing and mounting system, will make this design new to the market and available for Annalee at a reduced cost. Multi-use desktops are widely available on the market. However, creating this product from raw materials will significantly reduce the cost, and allow for the client’s personal preferences (color, shape, size) to be easily incorporated into the design for her satisfaction.