Assistive Jumping Device

For Trampoline

By:
Caitlin Martin
Kelly Valentine
&
Blaine Ericson

Client Contact:
Brenda Stenglein
Ashford, CT
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Executive Summary

Until now, jumping on a trampoline has been limited to individuals with normal statute and strength. Those with physical disabilities have been forced to watch this entertaining pastime rather than participate in the fun. This is completely unacceptable. Everyone should be able to partake in the joys of trampoline jumping.

The Assistive Jumping Device (ADJ) will enable those with physical disabilities to use a trampoline. It will provide the bodily support needed to make jumping independently possible in a safe and controlled manner. The following proposal will address the specifications, given by a client with physical disabilities, for the assistive device. It will expand on the ADJ’s preliminary design, similar products, and budget requirements.

1 Introduction

1.1 Background

With the recent improvements in medical care, physical disabilities are becoming less of a limitation and more of an inspiration to accomplish all life has to offer. The stigmatism behind a disability is slowly dying and the world of today has become accessible to everyone. The increasing awareness towards accommodation has allowed more to become physically active. Unfortunately, however, some areas remain to be untouched. Many activities have yet to be modified to assist those unable to use the equipment as initially intended. The desire continues to remain for the disabled to participate in these certain physical activities.

More exclusively, a specific disabled client has expressed the hope to jump on a trampoline “like everybody else.” The client has a severe case of cerebral palsy. The inability to maintain an upright position (due to his flared rib cage and lack of abdominal muscle strength) has made jumping independently impossible. While the leg muscles can support the body, the stability and balance needed to stand and jump alone are not there. An assistive device would be needed for the client, as well as many others disabled clienteles, to be able to experience the joys of trampoline
jumping. This device would be crucial for the client or more generally, anyone, child or adult, to benefit from the fun and exercise of jumping.

1.2 Purpose

The AJD will allow people with cerebral palsy and similar conditions to independently jump on a trampoline. It will be implemented by a harness system to be placed onto the user for the needed support of the torso. The ADJ will enable the user to safely jump on a trampoline in a controlled, stabilized manner. It must also take into consideration other non-device users on the trampoline. Since the trampoline is located outdoors, the ADJ must withstand weather conditions and natural wear. It is essential for the safety of the user that the ADJ furthermore withstands the repetitive motion of jumping and multiple usages of the trampoline.

1.3 Previous Work Done by Others

1.31 Products

The National Science Foundation Engineering Senior Design Projects for Persons with Disabilities (NSF) has provided funds for student engineers at universities throughout the United States to create custom designs for individuals with disabilities. All of the funded designs are located on the NSF website (http://nsf-pad.bme.uconn.edu/). Several of these projects have similarities to the ADJ.

The first of which is the Dancer Assist (Fig. 1). It was created in 2004 by Devin Slesicki and Thomas Wang of Duke University. The device was designed for the client, a professional dancer, with post-polio syndrome to lessen the weight of her legs while on stage. Its structure consists of a lightweight mobile frame with a harness attached through a spring suspension. The Dancer Assist enables the user to perform aerial maneuvers, such as jumps, that could not previously be done before. The support frame glides on the stage during usage. It can easily be disassembled and is portable.

Another project with much similarity to the ADJ was the Recreational Child Jumper (Fig. 2). It was constructed by Jennifer Glasgow and Thomas
Meese of Duke University in 2001. The device was created for a five year old girl with cerebral palsy to recreationally jump safely and comfortably. It was implemented using swing-quality bungee cords to provide the vertical jumping motion and a padded seat to support the user. The Recreational Child Jumper is attached to the ceiling and nylon straps allow for adjustable height.

Furthermore, the NSF funded a project called the Jumping Apparatus (Fig. 3) in 1990. The device was created by J. Baumgardner, K. Cartier, and S. Robertson of New Mexico State University for a small boy to aid in his coordination. The child had difficulty in coordinating movement involving multiple motor skills at a time. The apparatus allowed the user to jump from a standing position and a low stool with minimal risk of injury. The design consisted of a portable framed housing unit with an attached adjustable denim harness. Springs, plastic coated cables, and straps of nylon webbing aided in the jumping motion.

In addition to the NSF funded projects, there are also many similar devices on the commercial market for sale as well as for rental usages. These products are for fun and recreational operation without a custom design for a person of disabilities.

Trampoline spotting rigs are found at gymnastic supply wholesalers. The system comes in a portable as well as an attached variety. The portable system consists of a freestanding steel construction with a harness and pulley system. The attached overhead spotting rig has tubular steel sections that attach to the frame of the trampoline and consists of a rope and pulley system. These designs are used during gymnastics training and each includes pulley systems for the instructor to aid the user in height and motion.

Also, a company called The Trampoline Thing sells an extreme sport bungee cord system to safely propel the user to jump up to 24 feet in the air. It is marketed towards Olympic trainers, home parties, parks, and fairs. There are two models produced; the M20 and the M30. The M20 is the stationary trampoline thing and consists of two upright poles with bungee cords and a harness attached. There is a stationary base and stairs to get the user to the harness. The M30 is the portable trampoline thing. The dual upright poles are attached to a wheeled trailer for transportation. The system folds up during travel.
1.32 Patent Search Results

The following patents relating to the design, implementation, and overall function of assistive jumping device were found using the Google Patent Search engine (http://www.google.com/patents):

- Patent 3937461: Exerciser for Aerial Calisthenics (Fig. 4)

The exerciser for aerial calisthenics is used to lift and suspend an exercising person in midair for aerial exercises. A belt is used to secure the person around the lower torso. The design uses a pulley system to lift the user into the air with the aid of another person. The harness consists of a pair of small rings secured to two diametrical sides of a belt that is then securable around the lower portion of the torso. There is also a pair of Y-shaped straps secured to the belt of the harness.

- Patent 5788606: Adjustable Trampoline Support (Fig. 5)

The adjustable trampoline support is designed with the purpose to limit the safety concerns of trampoline jumping. It enables the user to use a trampoline as safely as possibly. The structure consists of a trampoline with a frame and adjustable support to hold the user of the trampoline. The support includes an adjustable tower to change the dimensions of the frame as well as an adjustable harness attached to the tower to carry to user. The height of the tower can be changed to fit the user.

- Patent 6638199: Collapsible Structure Device for Practicing Elastics-Assisted Trampoline, an Activity Called “Acro-Bungy” (Fig. 6)

This collapsible structure device is used for practicing elastics-assisted trampoline, an activity called “acro-bungy.” The practice enables the user to be fixed above a trampoline through a harness and a group of fixed elastics. The user can then jump with the elastics accelerating the upward travel and decelerating the downward travel for the purpose of the sensation felt during these movements. The structure mainly consists of a central mast that can move vertically while being actuated through mechanical means with a possibility of being locked in an upper position.
- Patent 6554747: Exercise Device and Method of Use Thereof (Fig. 7)

The exercise device allows the user to perform functional tasks during training or exercise. It also can aid the user during rehabilitation exercises and training. It consists of a housing structure and harness assembly that is adapted to be worn by the user. The harness is located within the housing.

- Patent 5178590: Aerial Exercise Assembly (Fig. 8)

The aerial exercise assembly enables human users to bound, swing, and flip. It comprises of a set of swing members (straps) to be used for support that could potentially be coupled to a single strap or a rope for hoisting the user to a desired exercise position. The feet of the user are stabilized with foot engaging elements (loops or footboards) provided at the lower ends of the support straps. A pelvic harness is used with a pair or harness pivot straps for lateral positioning and complete 360° movement.

- Patent 7325254: Cross-Over (Fig.9)

The “Cross-Over” is a portable and lightweight vest utilized during basketball training. Its purpose is to help a person develop ambidexterity during the game of basketball. The “Cross-Over” is made with a hybrid material consisting of a Neoprene (polychlorine) base. There are six velcro straps to fit the vest snugly to the user. An arm sleeve has two bungee cords for the right and left arm. Each cord is attached to the vest by two D-Rings on both the front and the back. There are also elbow straps with D-rings connecting to the right and left arms.
2 Project Description

2.1 Objective

The Assistive Jumping Device will be similar in design to many of the products and patents listed above. However, there will be some key differences between the ADJ and the products on the market currently. The ADJ must take into account these designs, but modify them to fit the needs of the client. It will provide the user will much more support and stability than the other designs. The usage of the ADJ will be milder and less extreme than the previous designs that enhance speed and height while jumping. The design of the ADJ must also take into consideration other, non-device using jumpers on the trampoline both at the same time as the ADJ user and during separate usage.

The Assistive Jumping Device must accomplish the following:

1. Maintain support of the torso and upper extremities of the user while allowing full motion of the legs to jump.
2. Maintain stability of the user while jumping in the device and to withstand the repetitive motion and usage.
3. Framework must be sturdy and withstand the forces of usage
4. Withstand the outdoor elements (rain, snow, wind, lightning, etc.)
5. Provide for the safety of the user as well as for other people on trampoline not using the device.
6. Consider the growth of the user in future usage.

These goals will be accomplished by implementing the following:

1. A harness around the torso will be used to hold the user upright. An opening around the legs will allow for a no constricting of the jumping motion.
2. The user will be attached to the system by a set of spring and bungee cord system to control and stabilize the jumping motion.
3. The system will be constructed from a metal with strong and sturdy characteristics. The design of the base will provide for maximum structural stability.
4. Pieces affected by such weather conditions will be detachable from the system. The framework structure will also be portable for indoor storage as well as an exterior coating to protect from the elements.

5. The structure will provide for head clearance of the user while jumping as well as a design to minimize the amount of possible contact during usage. The side structures will be padded in case of any contact. It will again, also be portable, as to remove the device if other jumpers need full access to the trampoline without the use of the assistive device.

6. The framework will consist of adjustable poles to create a taller structure when height increases. The harness will be portable to adjust or possibly replace when the user becomes larger. The design of the bungee/spring system will take into account future usage with a larger user.

2.2 Methods

The harness will be created to support an individual with limited abdominal control and pelvic stability. The harness will thus have to include a vest or shoulder straps, with additional pelvic support and straps. The harness design should not compromise comfort, and therefore must be easily adjustable. There are many different harnesses on the market for a range of tasks from construction to mountain climbing, and can be modified to fit the assistive jumping device. The harness will be secured to the bungee cords or spring by carabineers.
Fig. 10: Abdominal and Pelvic Support Harnesses on the Market

The user and harness will attach to the assistive jumping device frame by bungee cords or springs. An elastic material will provide the proper support while allowing the user to jump with their body strength. The tension will have to be great enough to support the upper body of an individual with limited abdominal strength, which will be determined by the individual’s specific needs. In order to accomplish this task, the vertical component of the tension in the bungees must exceed half of the difference between the user’s weight and the spring force applied by the trampoline while the jumper is in contact with the trampoline. This point is illustrated in the free body diagram featured in figure 11 below. Another factor to keep in mind is the tension in the cord while the user is no longer in contact with the trampoline. Bungee trampoline systems on the market are designed to propel the jumper and therefore apply much greater tension forces than needed in this design. Excessively high bungee tension would be dangerous for a jumper with limited physical abilities. In order to maintain safety, the bungees should become slack while the jumper is no longer in contact with the trampoline so that gravity is the only force acting on them, as shown by the free body diagram in figure 12.
Fig. 11: Free Body Diagram of person standing on a trampoline using assistive harness, where $F_s$ is the spring force applied by the trampoline, $mg$ is the weight of the user, and $T$ is the tension in the bungees.

The system in figure 11 can be described by the following equations:

While in contact with the trampoline acceleration in the y-direction ($a_y$) will be zero:

$$\sum F_y = m \times a_y = 0 = 2T\Theta - mg + F_s \quad \text{(Eq. 1)}$$

$$T > \left(\frac{mg - F_s}{2\sin \Theta}\right) \quad \text{(Eq. 2)}$$
The system in figure 12 can be described by the following equations:

\[ \sum F_y = -m \cdot ay = mg \quad \text{(Eq. 3)} \]

\[ ay = -g \quad \text{(Eq. 4)} \]

Therefore, the person will accelerate downward at the rate of gravity.

The bungee cords will be fastened to a large metal frame to support the jumper and bungee system. Considering the cyclic loading of the frame, metal would be the best material due to its high strength and durability. The base of the stand would need to support the weight of not only the structure, but the user and the additional forces due to the jumping motion. This may be implemented by size and/or supporting beams connecting the main frame to the base as shown in figure 13.
The height of the metal frame will be adjustable to assure the safety of the trampoline users. The arms that extend over the trampoline must be high enough to provide the proper head clearance and the width of the structure must be wide enough as to not disturb other users. Bungee cords and springs used will provide enough tension and slack for the user to jump most effectively without a dramatic increase in speed. This is also done to limit the impact of landing on the trampoline.

The metal framework will be padded in all areas where contact may be likely. This will increase the safety of all users, whether in the ADJ or not.

The frame will be located in an outdoor environment. Protective measures will be taken to minimize the corrosive effects of weathering. The framework structure will be portable so that it can be stored indoors when not in use to again for protection. This will be accomplished by making the frame capable of being partially disassembled, making the framework manageable for movement. The framework will also have a protective coating to provide a barrier for the metal from the elements. These efforts should successfully reduce corrosion of the frame and therefore help maintain its structural integrity.

The design of the Assistive Jumping Device must be able to adapt to the physical growth of the user. Over time, the user, especially our
specific ten year old client, will grow both taller and heavier. The ADJ’s ability to adjust prolongs the duration of usage.

The design of the framework will bear in mind the increase in height and weight of the user. The structure of the framework will be created using telescoping poles. The poles will be able to slide to extend or shorten the length of the rod and thus creates a structure with the ability to vary in height. A pin and locking system will lock the poles to safely secure the framework.

The harness will also need to accommodate the growth of the user. It must either be adjustable to fit the size of the user or have to option to purchase a larger vest support when the user outgrows the previous. Since the harness will be removable, the user can fit the harness to oneself prior to attaching to the ADJ and using the trampoline. It will also make it easier to replace the vest if necessary.

3 **Budget**

At this point, the budget is based upon several preliminary designs. These designs have taken into account the specifications of the client as well as additional design constraints. The parts are the basic components of the assistive device and additional parts may be needed as the design becomes finalized and implemented. Prices of the parts were found by an internet search. Many of the parts and prices come from hardware stores while others are from specialty gymnast supplies and trampoline wholesalers.
### Part List

<table>
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<th>Part</th>
<th>Individual Price ($)</th>
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<tr>
<td>Structural Carbon Steel Pipes (Width: 1.5-4 inches, Height: 10-21 feet)</td>
<td>70.00-300.00 each</td>
</tr>
<tr>
<td>Contour Post Padding</td>
<td>6.50-8.00 per square foot</td>
</tr>
<tr>
<td>Carabineer</td>
<td>7.95-34.95 each</td>
</tr>
<tr>
<td>Harness</td>
<td>40.00-163.00</td>
</tr>
<tr>
<td>Bungee Rope</td>
<td>1.00-40.00 per foot</td>
</tr>
<tr>
<td>Spring</td>
<td>1.00-5.00 each</td>
</tr>
<tr>
<td>Flat Heavy Duty Nylon Strap (Length: 2-30 feet)</td>
<td>2.85- 7.61 each</td>
</tr>
<tr>
<td>Metal D-Ring</td>
<td>0.25-0.55 each</td>
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Table 1: Estimated Total Expense

The relating products noted previously were of assistance in developing a preliminary basic design of the ADJ. The materials used in such devices were noted and expanded upon. The prices of these projects were also taken into account to understand the standard overall cost for the general design of a trampoline jumping apparatus. The portable spotting rigs range from $1100-1395. The spotting rigs that are permanently attached to the trampoline range from $685 - $995. Overhead suspension rigs, which would not be acceptable for the ADJ’s design since the trampoline is located outdoors, range in price from $408 to $848.

### 4 Conclusion

Even with the recent advancements in product adaptations for the physically disabled, there are still some areas that remain untouched. Jumping on a trampoline is still impossible for those with these limitations. An assistive jumping device is critical to aid those that want to participate in this activity. Not only would such a device allow for the disabled to enjoy the fun of jumping on a trampoline but it would provide exercise and the muscle stimulus of physical therapy and rehabilitation.

The development of the Assistive Jumping Device, as specifically demonstrated by the client, would fulfill the particular requirements to facilitate the disabled to effectively use a trampoline. It will fully support the user to safely and securely jump. The ADJ’s easily removable parts
and the portability of the framework structure make the design simple for all to use. The Assistive Jumping Device will take into consideration the physical abilities of a disabled clientele, while still remaining marketable to a wide range of consumers.