Adaptive Paddleboard Seat

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Problem Statement

It is estimated that about 66% of individuals in the spinal cord injury (SCI) population are overweight or obese because of a sedentary lifestyle following injury. The SCI population is therefore at high risk for developing forms of cardiovascular disease and other related health issues. It is in the best interest of the health-promotion community to provide a plethora of activities to remediate the physical inactivity often experienced within this population. One such emerging recreational activity is paddle boarding. Paddle boarding is an outdoor watersport that requires trunk rotation, shoulder flexion, elbow extension, and elbow flexion. This activity would be particularly beneficial to this population because it can provide a workout that will help strengthen core muscles and the upper extremities, which tend to be weak due to an acquired lack of use post-injury. Unfortunately, this sport is not readily accessible to people with spinal cord injuries. There is a significant need for a device that would help enable people with poor lower trunk extremity control, particularly those who have injury at the T1 level or below, to sit securely on a paddle board. By expanding the range of physical and recreational activities that are accessible to SCI populations, it will become easier to promote healthy and fulfilling lifestyles.

Background

After a person experiences a Spinal Cord Injury (SCI), the body undergoes changes to metabolism and general composition. These changes coupled with the decline in energy expenditure and physical activity cause a high prevalence of obesity and obesity-related conditions in persons with an SCI. The prevalence of overweight and obese individuals in the SCI population is estimated at 66%. Furthermore, circulatory diseases (including Cardiovascular disease or CVD) are the leading cause of death in individuals with SCI age 60 or 30 years after injury.[5] In the general population, the connection between physical activity and risk of obesity and CVD is well established. One study demonstrated that physical activity among SCI individuals results in functional effects such as the increase of strength, mobility and coordination, as well as social and psychological effects such as an increase in self-confidence, self-concept or mental state.[1] In a qualitative study analyzing the barriers to everyday physical activity among person with an SCI, inaccessibility of facilities and lack of equipment suited to their needs were among the highest barriers to participation in physical activity.[4] We aim to alleviate these challenges by designing and adaptive seating device that would enable persons with spinal cord injuries to participate in paddle boarding

The new paddle board seat is designed for those with complete spinal cord injury at the T1 level and lower, or diagnoses that present similarly. Individuals with a T1 or lower injury will experience paraplegia with limitations to lower extremity muscles and postural support muscles below the mid chest level (Figure 1). Paddle boarding would be beneficial to these individuals to work on impaired core muscles, posture support muscles, back muscles, and to help maintain arm strength (Figure 2).[7]

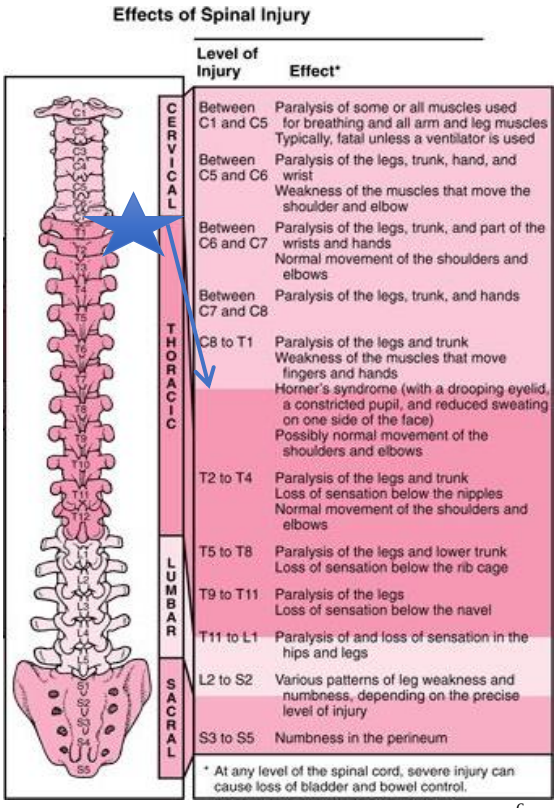

Figure 0: Effects of Spinal Injury with T1 Level Starred[6]

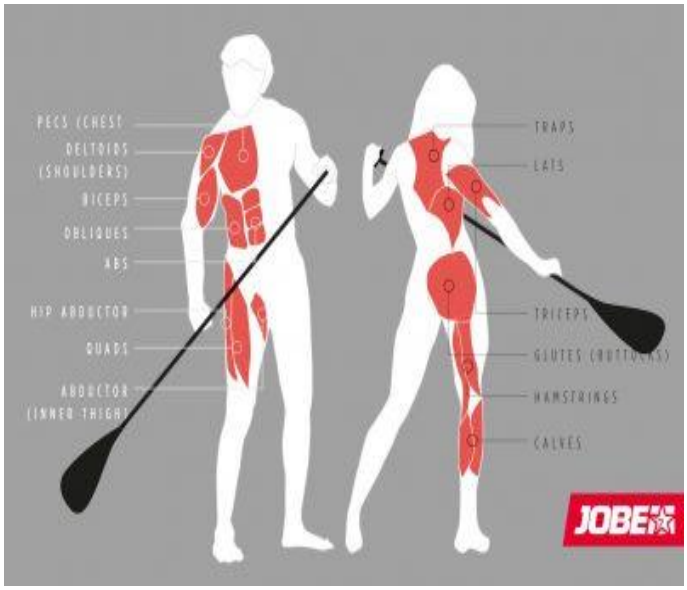

Figure 2: Muscle Groups Activated by Typical Stand up paddle-boarding[7]

Need and Purpose of Device

To utilize a paddleboard, one must have the ability to stand up and exhibit dynamic standing balance, or at minimum, strong dynamic sitting balance to use the board from a seated position. Thus, the use of paddleboards is restricted to those with strong core and postural support muscles. Depending on level of injury, people with an SCI at the may be able to pull themselves onto the board and be on their stomach or onto their knees. These individuals will not be able to fully stand and paddle, however they can still reap the benefits to their arm strength, sitting balance, trunk control, and core stability by using this device from a seated position. By creating a seating system on the paddle board, the sport would be opened to those with less postural control and upper body strength.

Design Objectives

The following device design objectives were identified through research and potential consumer interviews to guide the design of the device. They aim to complete the statement, "Our device will," and are listed in Table 1 below.

Table 1: Objectives in Ranked Order of Importance

Our adaptive paddle board seat will …			
1.	Authentic	6.	Comfortable
2.	Physically Engaging	7.	Universal
3.	Safe	8.	Intuitive
4.	Adjustable	9.	Affordable
5.	Durable	10.	Aesthetically Pleasing

In summary, the sport of paddle boarding has exclusive benefits that other water sports do not. Paddle boarding engages the core and strengthens muscles of the upper extremity. At the same time, it provides greater challenge to vestibular systems and refines motor output in ways that other water sports do not. Our initiative is to create a device that can serve as modification to paddle boards already commercially available, and will allow individuals with disabilities to be securely seated. While there are current designs that enable participants to be seated while paddle boarding, none of these modifications are designed for people whose disabilities limit their sitting balance while at the same time are able of being moved from one paddle board to the next. Our goal is to open access to paddle boarding for a wider range of people.

Design Concept Selection

After conducting secondary research, interviews with potential stakeholders, and a group brainstorming session, the team developed over 100 concept sketches followed by multiple rough design mock-ups that represented different concepts for an adaptive paddle board seat. The team then met with two potential users and two experts at the Adaptive Sports Connection (ASC), a local organization that provides adaptive recreational opportunities for those with disabilities. In these meetings, the mock-ups were presented and comments were welcomed on the features of the design. In terms of seat attachment, the discussion was centered around the permanence of the chair on the paddle board. A ratchet straps concept was appealing because it did not require permanent alteration of the paddle boards. To the potential users, both stability and *perceived* stability of the paddle board and adaptive seat were important factors. Therefore, removable commercial paddle board stabilizer bags (Figure 3) were added to the design to give users the option of adding increased stability while paddle boarding.

Figure 3: Inflatable Stabilizers

Discussion of perceived safety also impacted potential users' feedback on the authenticity of the adaptive paddle boarding experience. Although elevation of the chair above the board would best mimic an authentic and traditional standing paddle board experience, this elevation was concerning to potential users. This discussion influenced the elimination of a foot support on the adaptive seat, and instead the design will have height adjustability to allow users of varying leg lengths to position their feet flat on the paddle board surface. The potential users also emphasized that the lateral stabilizers should not impede the paddling motion.

Description of Final Design

After group discussions and a consultation meeting with ASC, some design features were given higher priority than others. These features included 1) the ability to easily attach and remove the adaptive seat from a paddle board (i.e ratchet straps), 2) the addition of optional lateral supports for stability (i.e. inflatable stabilizers), 3) vertical height adjustability within the adaptive seat, and 4) the allowance for full range of motion of the users' arms while paddling. As a result, the original concepts and mock-ups were re-analyzed and combined in the final design to ensure the users' needs were appropriately incorporated (Figure 4).

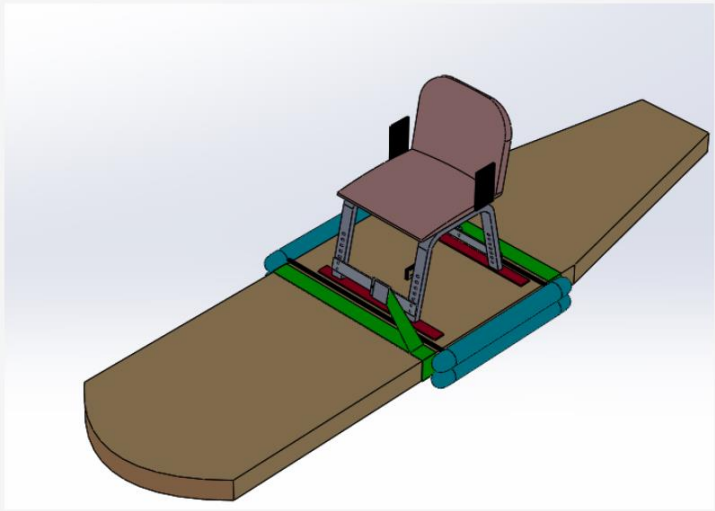

Figure 4: Solidworks Model of Final Design.

This adaptive paddle board seat is secured to the paddle board through the use of the ratchet straps, therefore allowing easy installation and removal of the seat without permanent alteration or damage to the paddle board. There is padding between the chair legs and the paddle board to provide additional protection from scratching the board, as well as prevent the chair from slipping or moving while the seat is in use. The chair also includes lateral supports to hold the user's hips in place and help prevent them from sliding off the chair. The seat's back is purposely designed with a low profile to allow for a full range of movement of the arms while paddling. The seat legs are also adjustable in height to allow for users of different leg lengths to comfortably rest with their feet on the surface of the board.

Device Testing and Outcomes

The team tested the adaptive paddle board seat for usability, ease of installation, and safety in a local indoor pool (see attached video). Different members paddled around the pool to test for any obstructions to movement, uncomfortable points, and general balance of the board. The team tested with and without the stability bags and found that they made a considerable difference to the balance and made the board much harder to tip. The team also tested the set up and take down time of the chair from the board and found the whole apparatus could be prepared in less than 90 seconds. No scratches were seen on the board during the test. The final test completed was to have different team members fall off the board and get back on without using their legs. This test was a complete success as all team members who attempted to get back into the chair from the water succeeded.

Figure 5: Photo of the Adaptive Paddle Board Seat being tested by one of the design team members.

The team also distributed a survey to potential users, which asked questions about the comfort and perceived safety they felt during a dry land test of the board. Due to university liability restrictions, the team was unable to permit users to test the paddle board device on water.

Cost

The total cost of materials used to create the prototype was approximately $240. This materials estimate was made using products which were bought from other companies and was not completely made up of custom-made materials. The final design will have custom made manufactured parts which will be created as per custom drawings. As a result, the final product will cost more than the cost of the initial prototype. The team is estimating the final cost to be between $300-$350. This only includes the cost of the adaptive paddleboard seat and not the paddleboard itself. However, the seat is designed to be compatible with any paddleboard.

Significance

This product will allow for those with T1 and lower spinal cord injuries (SCI) to partake in the sport of paddle boarding. This is an activity that was requested by the patrons of the community partner Adaptive Sports Connection (ASC), and is a requested activity at many other locations around the world. Other products exist to meet this need, but none are popular because of the need for permanent modification to an expensive paddleboard or the purchase of a custom paddleboard. The Adaptive Paddleboard Seat is designed to meet the needs of those with SCI in an affordable, safe, and physically engaging. Additionally, it requires no permanent modifications to the paddleboard itself. This product is also extremely marketable since it can be sold to other demographics as well. This is not simply a device for people who cannot paddleboard without it, it is a device for anyone who wants to paddleboard from a comfortable seat. The Adaptive Paddleboard Seat will open up the experience of paddle boarding to all audiences in a way that is both safe and exciting.

Acknowledgments

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References

1. Anneken, V., A. Hanssen-Doose, S. Hirschfeld, T. Scheuer, and R. Thietje. Influence of physical exercise on quality of life in individuals with spinal cord injury. *Spinal Cord* 48:393–399, 2010.
2. Bryant, A. Wheelchair users try adaptive paddleboards at Frenchtown Pond before SUP Cup | Local | missoulian.com. , 2014.at <http://missoulian.com/news/local/wheelchair-users-try-adaptive-paddleboards-at-frenchtown-pond-before-sup/article_a1262a32-0d4d-11e4-b9ef-0019bb2963f4.html>
3. iRocker. Kayak seat for SUPat <https://irockersup.com/product/irocker-kayak-seat/>
4. Levins, S. M., D. M. Redenbach, and I. Dyck. Individual and societal influences on participation in physical activity following spinal cord injury: a qualitative study. *Phys. Ther.* 84:496–509, 2004.
5. Martin Ginis, K. A., S. Jörgensen, and J. Stapleton. Exercise and Sport for Persons With Spinal Cord Injury. *PM&R* 4:894–900, 2012.
6. Rubin, M. Overview of Spinal Cord Disorders
7. 4 REASONS TO EASILY GET FIT WITH THE JOBE SUP 2017 COLLECTION
8. Swivel Seat Fishing Rig w/ Scotty® Rod Holdersat <https://www.seaeagle.com/Accessories/seats/universal-swivel-seat-fishing-rig>
9. Paddle Board Size and Weight Chartat <https://www.islesurfandsup.com/sup-101/paddle-board-size-and-weight-chart/>
10. Best SUP for big guys (and ladies, too!)at <https://www.wavesweekender.com/standup-paddleboard-heavy-guys/>
11. Onit Ability Boardat <http://www.accessrevolution.com/products-1/adaptive-paddleboard>
12. Why we need standardsat <https://www.iso.org/standard/61406.html>
13. ISO 25649-7:2017. Floating leisure articles for use on and in the water – Part 7: Additional specific safety requirements and test methods for Class E devicesat <https://www.iso.org/standard/61406.html>
14. Stainless Steel Vise, C clamp, Locking Clamps.at <http://www.steritool.com/tools/viseandclamp.htm>
15. Time-Sert 10124 M10X1.25X16.0MM Metric Stainless Steel Insert - 10 Packat <https://www.walmart.com/ip/Time-Sert-10124-M10X1-25X16-0MM-Metric-Stainless-Steel-Insert-10-Pack/148412399?wmlspartner=wlpa&selectedSellerId=10152&adid=22222222227107730191&wl0=&wl1=g&wl2=c&wl3=233315547996&wl4=pla>
16. GOODE 3M Interloc (per Foot)at <http://store.goode.com/goode-3m-interloc-per-foot/>
17. 2 Inch Ratchet Straps with Flat Snap Hooksat <https://www.cargoequipmentcorp.com/2-Inch-Ratchet-Straps-with-Flat-Snap-Hooks-p/57xx63x-12.htm>
18. The Hillman Group 1/4 in. x 2 in. Wire Round Lock Pinat

<https://www.homedepot.com/p/The-Hillman-Group-1-4-in-x-2-in-Wire-Round-Lock-Pin-5-Pack-882693/204726206>

19. Airhead® AHSUP-A006 - SUP Training Wheels Setat <https://www.carid.com/airhead/sup-training-wheels-set-mpn-ahsup-a006.html?view=000589&gclid=CjwKCAiApJnRBRBlEiwAPTgmxPN-oiQ7raMfYAWZsKNGY6-wU9KROoLwvMJ7_wQZT0jivKIXvply5BoCek8QAvD_BwE>
20. Moen Home Care Glacier shower chair -- DN7100 -- Moenat <http://www.moen.com/products/Moen_Home_Care/Moen_Home_Care_Glacier_shower_chair/DN7100>
21. ANSI Z50.1. Safety Standards 4. Machine Principles of Design <http://www.asbe.org/assets/1/7/4-mchnprincdesgn.pdf>