

Johnson Health Tech: Adaptive Indoor Rower for Wheelchair Users

Product Design Specifications

October 10th, 2022

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Function:

Individuals with injuries or disabilities have trouble utilizing typical workout machines due to a lack of exercise equipment that is accessible to them. One of these affected groups are individuals who require the use of a wheelchair. People require wheelchairs for a multitude of physical disabilities or injuries to the brain, spinal cord, or lower extremities. The majority of exercise machines are not designed for wheelchair use, and thus exercise options for wheelchair users are limited. In order to solve this issue, modifications need to be made to current manufactured machines. A standard Matrix rowing machine will be adapted to accommodate individuals who require the use of a wheelchair [1], but will retain the ability for someone not in a wheelchair to easily use the machine. The Adaptive Rower will secure the wheelchair/user to the rowing machine, preventing the user from both tipping backwards and falling forwards out of the wheelchair during the workout. This modified design will increase the accessibility and ease of use of a rowing machine by individuals in wheelchairs while allowing the user to maintain proper rowing form, and will help to improve their overall well-being through exercise.

Client Requirements:

- A magnetic rowing machine will be built to better understand how the overall assembly fits together. This will aid in the design of optimized adaptations to the current assembly process.
- The adapted rowing machine should allow individuals in wheelchairs to easily fit into the machine and use it properly. The machine should be accessible to both wheelchair and non-wheelchair users.
- Users with varying sized wheelchairs should be able to adjust the equipment to still be able to use the rower comfortably.

- Individuals in wheelchairs will be able to lock themselves into a stabilization frame without assistance. Individuals will also be able to change the resistance, view the display console, and grab the handlebar without external assistance.
- The rowing machine will be user-friendly and alterations to the rower will not hinder the rowing motion.
- The rowing machine will be used several times in a day, and components will not degrade over a short period of time.
- The rowing machine will have a mechanism to reduce excessive recoil force to prevent users from tipping backwards in the wheelchair.
- The user will remain in their wheelchair for the duration of the exercise.
- The added components to the current rower will be made out of metal to ensure a professional finish.

Design Requirements:

1. Physical and Operational Characteristics

a. Performance Requirements:

- i. The modified rower will enable people in wheelchairs to use the machine. The user will be able to easily secure/unsecure themselves to/from the modified rower. The attachment to the rowing machine should keep the wheelchair from tipping over backwards and will prevent unnecessary chair movement during the rowing motion.
- ii. The modifications made, to allow for attachment of the user/wheelchair, should remain intact and not break with repeated use of the rowing machine.
 1. The modifications used for the attachment should be able to resist and endure stresses caused by a pulling force up to 1050 N [2].
 2. The modifications made to the machine should be able to endure the fatigue due to the repetitive rowing cycle.
- iii. The user will grip the handlebars to complete rowing movements. The wheelchair and the adaptive rower machine will remain stationary during rowing.
- iv. The device will be used daily.
- v. The transition of the handle and rope from the original configuration to the adapted side should be easily carried out by all users, including those in wheelchairs.

b. Safety:

- i. The modifications made to the rowing machine will not pose any biological hazards to the user.

- ii. Any modifications made to the rower will be filed and made smooth in order to prevent sharp points that could harm the user. Additionally, all modifications will be reviewed to make sure that no pinching/excess pressure is felt by the user during exercise.
 - iii. The modifications made to the rower will ensure that the user is securely stabilized to the rower and will not be ejected from their wheelchair during use of the rower.
 - iv. Electrical components incorporated into the design will be covered to prevent harm to the circuit and/or user (i.e. water damage or electrocution).
- c. *Accuracy and Reliability:*
- i. The adapted rowing machine should accurately simulate the feeling of a traditional rowing machine for the user's upper body by producing a force per pull between 100-350 N. This range accommodates for the different resistance settings.
 - ii. The loading and recoil motions should accommodate pulling the handle bars back to approximately one arm's length and should be smooth and absent of excessive friction.
 - iii. In order to prevent backwards tipping, a mechanism should be included that provides a downward reaction force to counteract the maximum backward force of 1050 N with a safety factor of two [2]. The reaction force output by this mechanism should not cause forward tipping. The force output necessary to prevent tipping should be repeatable given a certain force input from the rower.
 - iv. Once the adapted fixtures are designed, proper tolerances will be assigned to each of the components to ensure proper assembly and functionality of the adapted rowing machine.
- d. *Life in Service:*
- i. The modifications and attachments added to the rowing machine should last for the same duration the rowing machine typically lasts. The lifetime of a rowing machine is categorized a few different ways. The modifications made should last:
 - 1. At least 10 years [3]
 - 2. At least 8 million meters [3]
 - ii. The product will be able to be used for at least 10 years and withstand normal wear and tear from the user.
 - 1. Weight placed onto the product from the user
 - 2. Friction applied by the user
 - iii. All modifications will provide the user with a stable and safe rowing experience for the 10-year period.

1. This includes preventing the user from tipping over while using the machine.
2. A safe locking system that ensures the wheelchair does not move during use.
3. Support the user's body to ensure security.

e. *Shelf Life:*

- i. The product will be stored in an environment that minimizes external loads placed onto the rower. This includes when it is being manufactured overseas, while shipping, and during storage in various facilities. Maximum external loads applied will be limited to 158.76 kg [1].
- ii. The temperature range for the manufacturing, shipping, and storage process should be maintained within -20°- 45°C (-4°-104°F).
- iii. When stored at a facility, the product will remain functional for a minimum of 30 years.

f. *Operating Environment:*

- i. Ideal temperature range for the machine is 5°-35°C (41°-95°F). Temperatures exceeding 95°F/35°C might lead to the device warming up, causing discomfort for the user.
- ii. No large water sources should be used near this device. The LCD display relies on a power generator and water could destroy internal components of the rower.
- iii. The device will allow a wheelchair user to attach the chair to the device.
 1. All forces applied by the wheelchair onto the rower will not hinder the machine's ability to perform at its optimal level.
 2. Forces will be minimized by the use of harnesses and supports.

g. *Ergonomics:*

- i. The user will secure themselves to the adaptive rower. This action will utilize only hands and arms and will be possible in an upright sitting position.
- ii. A locking support system will ensure the user will not move during rowing.
- iii. External additions to the rower will not inhibit comfort to the user. Stability measures will not inhibit the rowing experience for wheelchair users.
- iv. After the user is secured into the machine, only the upper body will be used to complete the rowing motion. In addition, the user will be in an upright position.
 1. No leg movements will be required during the use of the machine.
- v. Users will not need to reach more than 70 cm (1.8 ft) from the front of the wheelchair to grab the handlebar [4].

- h. *Size*
 - i. Additions will extend from the device by a maximum amount of 1.6067 m (3.5 feet). This will be measured by taking the distance perpendicular from the points of addition. The current dimension of the device is 223 cm x 55 cm x 97 cm [1].
- i. *Weight*
 - i. The current weight of the design is 158.76 kg/350 lbs [1].
 - ii. A maximum of 40 kg (approximately a fourth of the rower's weight) of mass will be added to the existing rower. This is to ensure the rower can still easily be moved via its transportation wheels if necessary.
- j. *Materials:*
 - i. When possible, adaptations will be fabricated out of clean, polished, or painted metal for support and durability.
 - 1. Common materials used for exercise equipment include steel and aluminum due to high durability and strength [5].
 - ii. Materials that have a high degree of flexibility should not be used for the stabilization structure. However, cushioning materials may be used where this structure contacts the user for added comfort.
 - iii. Plastics used will have a high degree of strength and durability.
 - iv. After application of 1050 N [2] (safety factor of 2) onto the plates supporting the additional pulley is applied, a maximum deformation of 1.5 mm will be allowed. The pulley plate material will be able to withstand these typical operating conditions.
- k. *Aesthetics, Appearance, and Finish:*
 - i. Adaptations made to the machine will have a smooth finish to prevent abrasions or lacerations to the user.
 - ii. Welds will be smooth.
 - iii. If time permits, adaptations will be painted black to match the rower.

2. Production Characteristics

- a. *Quantity:*
 - i. One rowing machine will be constructed and modified to accommodate the inclusion of a wheelchair during use.
- b. *Target Product Cost:*
 - i. A budget of \$500 will be used for development of the fixtures to the rowing machine structure for both the Fall and Spring semesters.

3. Miscellaneous

- a. *Standards and Specifications:*

- i. The International Organization for Standardization (ISO) entry 20957-7:2020 stipulates the safety requirements for rowing machines, specifically rowing machines within classes H, S, and I and classes A, B, and C for accuracy. Entry 20957-1 describes the general safety requirements for stationary workout equipment. Entry 20957-1 covers the safety requirements for any additionally provided accessories to be used in conjunction with the rowing machine [6].
 - ii. This product does not require FDA approval as it does not fall under any of the FDA regulated products such as pharmaceuticals, medical devices, medical biologics, food, products that contain tobacco, supplements, cosmetics or electronic products that emit radiation [7].
- b. *Customer:*
- i. The adapted rowing machine should be functional for individuals in wheelchairs, but ideally should be able to function as a standard rowing machine as well.
 - ii. The client prefers to have the rowing machine fully built into one assembly rather than broken up into several components that need to be attached each time the rowing machine is used.
- c. *Patient Related Concerns:*
- i. The rowing machine will need to be sterilized between uses to remove debris and sweat from previous users.
 - ii. The added adaptations to the rowing machine should be able to accommodate a range of wheel thicknesses and wheelchair widths up to 3 inches wide.
 - iii. The added adaptations to the rowing machine should not cause overuse injury to other parts of the users body, such as hands and arms.
 1. The user should be thoroughly taught how to properly use the machine to reduce risk of misuse or injury.
 - iv. If the use of patient data is deemed necessary to construct specific adaptations to the rowing machine, it should be kept secure and confidential.
- d. *Competition:*
- i. There are currently a plethora of adapted rowing options for wheelchair users available on the market. One of these options is an adapted rowing machine seat that is easily switched with a standard seat and is more accessible to get in and out of for paralyzed users [8].
 - ii. Adapted rowing machines such as the AROW (Adapted Rowing Machine) by BCIT REDLab [9] utilize an adapter and a stabilizer to isolate the rowing motion to the upper body of the user while keeping their chair in place.

1. These adaptations were designed specifically for the Concept 2 rowing machine.
- iii. There are also existing patents for adapted rowing machines, including patents specific to wheelchair users. One such patent describes a machine that includes a unit for fixing the upper half of a user's body to the machine, straps to keep the user's legs stabilized, and a pulley system to create the rowing motion for the upper body [10]. Many of these patents appear to require an additional person to assist the user onto the machine or the user to move themselves from their chair to the machine - both scenarios that have been deemed undesirable for this project by the client.
 - iv. There appears to be a gap in the market for a rower that can be converted between an adapted and standard model. This interconvertibility is something that the client expressed interest in and is a unique deliverable for this project.

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