Gait Trainer With Treadmill

Final Report

Fall 2025 BME 200/300 Lab 302

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Step Masters

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Abstract

A woman with a significant mobility impairment and seizure disorder relies on a gait trainer to ambulate during her daily strength and conditioning walks. During the winter months, she requires a safe way to use her gait trainer on her treadmill. Unfortunately, the dimensions of her gait trainer are incompatible with her current treadmill, making them unable to be used together as is. Commercially available devices that allow a gait trainer to be used with a treadmill are costly and often require replacing existing equipment. To address this, our solution features a low-cost, compactable ramp and adjustable track system that allows the gait trainer to be wheeled securely onto the treadmill and remain stable during use. This solution enables continued use of current equipment, reducing financial burden, while ensuring accessibility and safety.

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Introduction

More than 25% of adults in the United States have a disability, 35 million of whom are women. According to the CDC, these 35 million women are three times more likely than their non-disabled counterparts to be diagnosed with conditions like heart disease, stroke, diabetes, or cancer [1][2]. Even though it has been proven that daily physical activity can help reduce the impact of chronic diseases, improve mobility, reduce muscular atrophy, increase community involvement, and improve mental health, less than half of all adults with disabilities report engaging in leisure time aerobic physical activity [3][4]. For disabled women especially, this is concerning as the lack of musculoskeletal stress puts them at an increased risk for bone conditions such as osteoporosis, which exacerbates the severity of injuries from falls [5]. This discrepancy in physical activity is largely due to limited resources and appropriate access to accessible aerobic exercise. Currently, there are few accessible aerobic-equipment options for individuals that use mobility devices. However, the majority of these devices are intended for wheelchair users, or to be used in a professional therapy setting, making them unrealistic for everyday use in a home setting.

Background

Client Information

The client, Amanda Pajerski, is an Occupational Therapist representing her patient who is a woman with a mobility impairment and seizure disorder. This patient cannot ambulate independently and uses a Rifton Pacer Gait Trainer with the assistance of caregiving staff. To maintain her strength and conditioning, she goes on daily walks around her neighborhood with her caregivers. However Wisconsin weather is often unpredictable, and particularly during the winter months, Mrs. Pajerski's patient is unable to get the daily exercise she needs to stay healthy. Therefore, Mrs. Pajerski is seeking to have a transfer device fabricated that will allow her patient to use her gait trainer on the 2012 Horizon T101 Treadmill that her patient owns. This project is a continuation of a Fall 2024 project, and builds off of the previous team's work, with improvement input from the client, the patient's family, and caregiving staff.

Previous and Competing Designs

When Amanda Pajerski initially recommended her patient use a treadmill for her daily exercise, she intended for her patient to have a Rifton Pacer Gait Trainer with a Treadmill Base that featured a wide base, and was designed to fit around a standard treadmill (similar to the K650 XL model available for Youth sized Gait Trainers) [6]. Unfortunately, soon after the decision was made, this base was discontinued. Therefore, the client's patient instead ordered the Rifton Pacer Gait Trainer with the K640 Large Utility Base (Figure 1) [7]. While this base is still wider and more durable than the standard base frame, it is too narrow to fit around the treadmill, and too wide for the wheels to fit on the treadmill track. In Fall 2024, a transfer device (Figure 1) was fabricated for the client by a UW-Madison BME design team [8]. This transfer device, while functional, was heavy and bulky, making it difficult for caregiving staff to maneuver. The C-Clamps that functioned to secure the ramp and side tracks were also difficult to utilize. Therefore, this device has not been used by the client's patient.

Figure 1. The Fall 2024 fabricated design features wooden side tracks for the gait trainer to rest on top of with a wooden ramp leading up to the treadmill. The images above feature the patient's Rifton Pacer Gait Trainer with the K640 Large Utility Base. The wooden side tracks are built to rest above the side of the treadmill and laterally extend the usable area for the Gait Trainer to rest.

There are a few designs available commercially that integrate gait training with a treadmill. Apart from the treadmill-specific base that Rifton previously manufactured, other solutions included gait-training-specific treadmills that have built-in assistive functions for wheelchair transfers and attached postural support [9]. These treadmills are expensive, and are rarely seen outside of professional therapy settings because they are impractical for private use. Another competing design includes a partial weight bearing vertical post, such as the LiteGait models that have a sling and wide base (Figure 2) [10]. Unfortunately, LiteGait's system is not universal to other brands of treadmills.

Figure 2. The LiteGait 4 Home Adult partial weight-bearing system features a sling, support bars, and a wide base to accommodate treadmill use. This model is compatible with LiteGait manufactured treadmills [9].

Design Specifications

This design is a transfer device that allows the user to utilize her Rifton Pacer Gait Trainer on her treadmill. The transfer device will consist of a ramp system, and over-the-treadmill tracks that support the gait trainer while the user is on the treadmill. The ramp should be compliant with ADA guidelines to ensure user safety and accessibility [11]. The ramp and track system must be able to bear a combined weight of 173.6 kg during daily use of up to 15 minutes, which includes the weight of the user, one of her caregivers, and the weight of the gait trainer. The dimensions of the device should be adjustable to fit other treadmills in case the user must purchase a new treadmill. The device will be easy for users to set up for use and put away for storage, taking no more than 5 minutes to complete either of these steps. In addition, per NIOSH lifting guidelines, the device should require a lifting force of less than or equal to 23 kg during the storage process [12]. For safety, the device should feature an anti-slip ramp surface. Side guards between 3.8 and 6.3 cm in height will attach to the tracks to prevent the wheels of the gait trainer from rolling off the sides. To ensure a maximum life in service, the device should be stored in temperatures of less than 55℃ at less than 70% humidity to maintain the structural integrity of the device and ensure user safety [13][14]. A full description of the product design specifications can be seen in Appendix A.

Preliminary Designs

Design 1: Telescoping Ramp

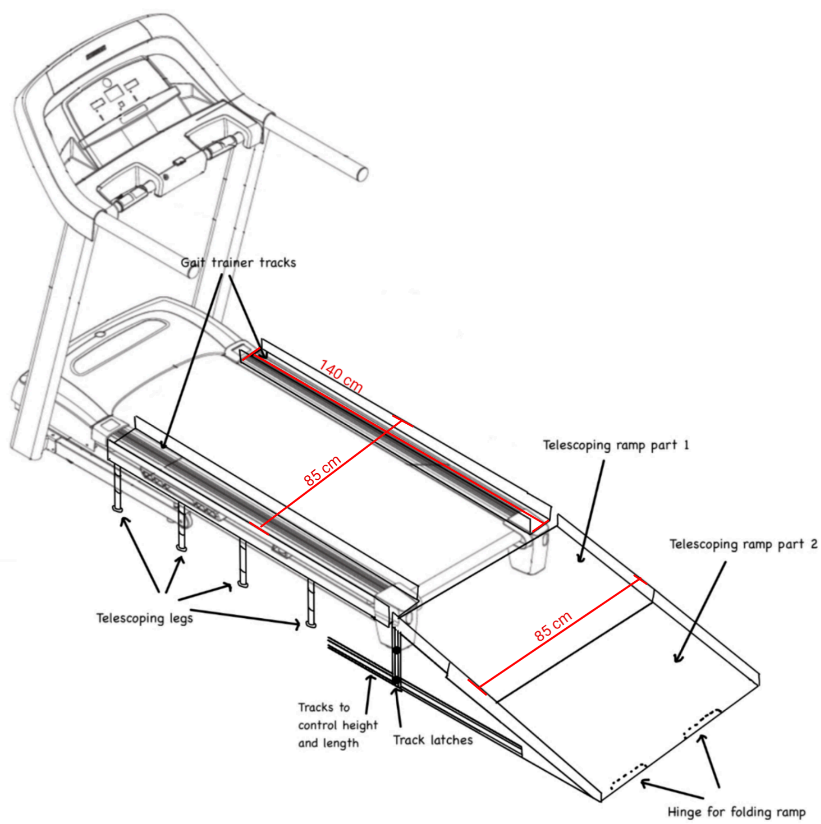


Figure 3. Telescoping Ramp Design Sketch

The telescoping ramp design (Figure 3) has tracks that are able to control the height and length of the ramp to be ADA compliant if the client would need to adjust to another treadmill with different dimensions in the future. The adjustment tracks are held in place by a screw clamp. There is a hinge at the bottom and the tracks are open to allow the ramp to fold fully flat. The gait trainer tracks are also removable and have telescoping legs that allows the ramp height to be adjusted to other treadmills. The tracks are secured to the treadmill with toggle clamps.

Design 2: Suitcase Ramp

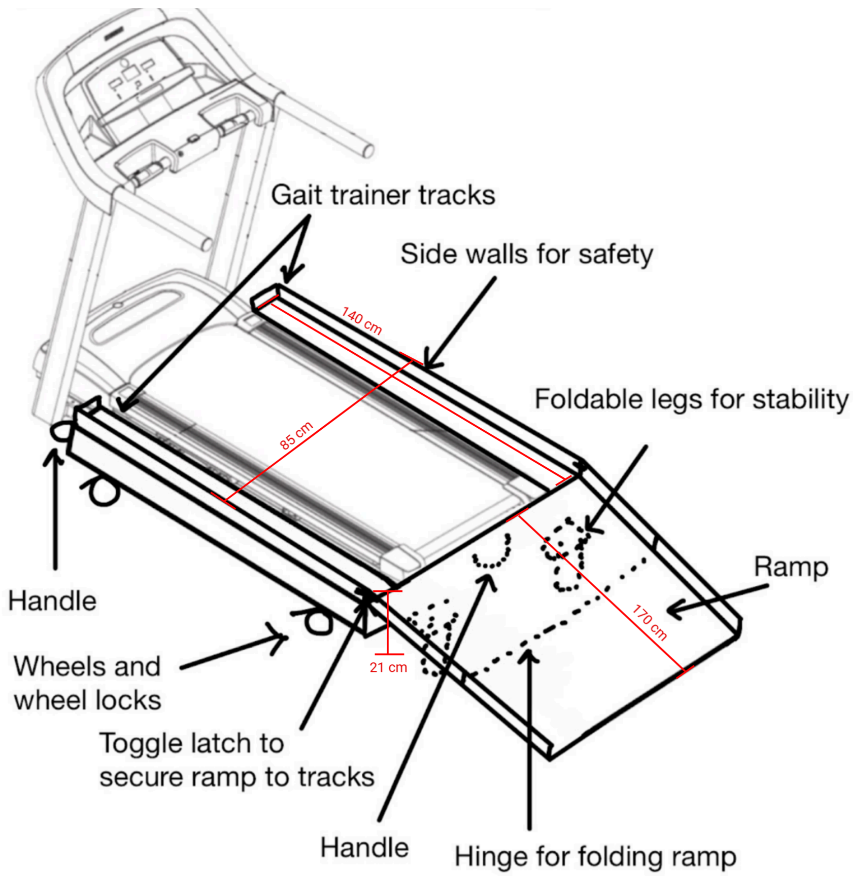


Figure 4. Suitcase Ramp Design Sketch

The suitcase ramp design (Figure 4) has three separate, detachable, components that can all be removed from the treadmill and easily transported to a new location for storage when the treadmill is not in use. The tracks will each be made from a lightweight wood and have wheels that will lock the tracks in place while in use. There will also be handles on the end of the tracks to allow caregiving staff to easily wheel the tracks away like a suitcase. The ramp will be made from aluminum with supporting legs underneath that can fold for when the ramp is stored and not in use. The ramp will have hinges horizontally along the center of the ramp so that it can be folded in half to take up less space while not in use. There also will be handles for easy transport. Additionally, the side walls on the ramp will attach to the side walls of the tracks via a toggle latch for stability of the entire three part system.

Design 3: Folding Ramp

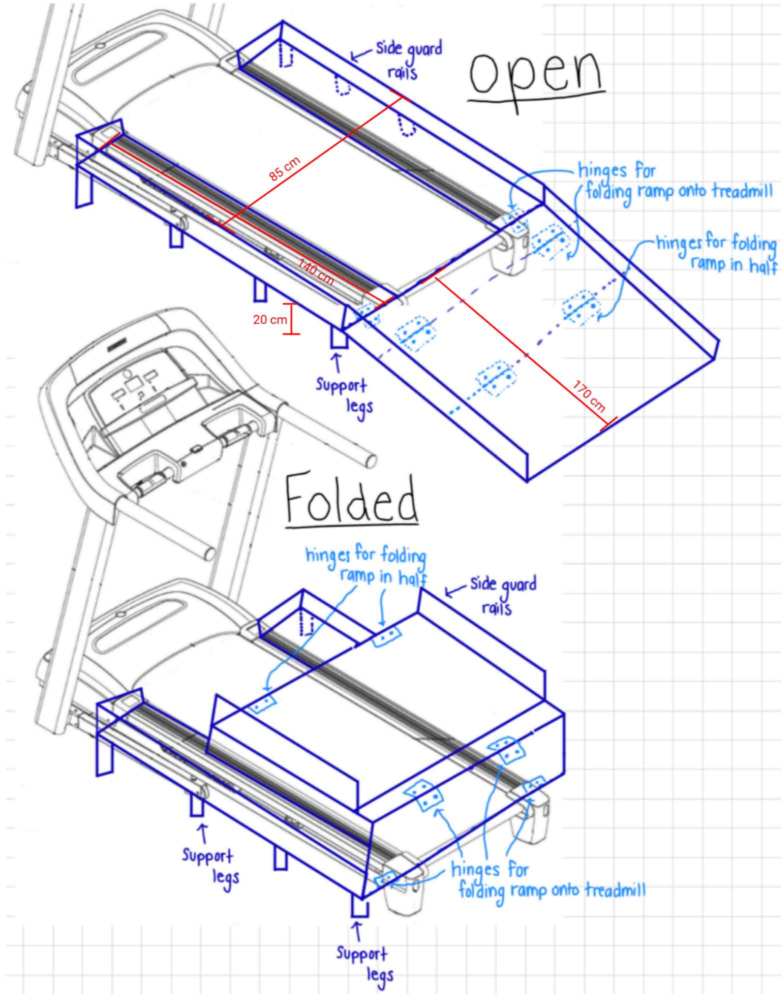


Figure 5. Folding Ramp Design Sketch

The folding ramp design (Figure 5) has tracks along each side of the treadmill that partially rest on the treadmill edge and partially hang over supported by 4 legs. These tracks will be made of wood and permanently attached to the treadmill. Each track has a guard rail on the outer edge and on the front. At the back of the track, there are hinges that connect the tracks to the ramp, allowing the ramp to fold onto the treadmill. There is another hinge on the ramp that allows the ramp to fold back onto itself. The ramp also has a guard rail on each outer edge and will be made of aluminum to ensure it is lightweight for folding.

Preliminary Design Evaluation

Design Matrix

To thoroughly assess each preliminary design, a detailed design matrix was developed (Table 1). This matrix evaluates multiple aspects of the designs based on specific criteria. Each design received a score from 1 to 5, where 1 represents an unsatisfactory rating and 5 represents a very satisfactory one.

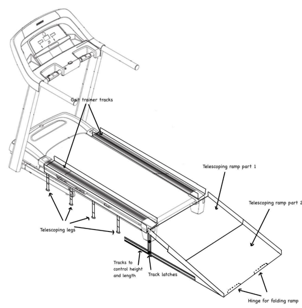
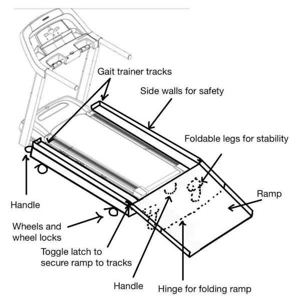
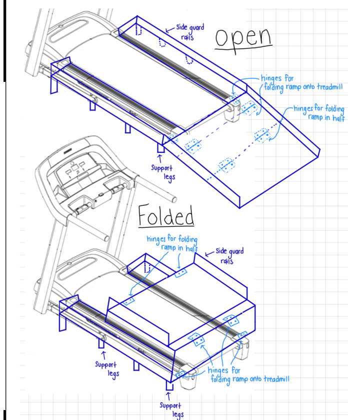
		Design 1: Telescoping Ramp 		Design 2: Suitcase Ramp 		Design 3: Folding Ramp 	
Criteria	**Weight**	**Score**	**Weighted Score**	**Score**	**Weighted Score**	**Score**	**Weighted Score**
Safety	**25**	**3/5**	**15**	**4/5**	**20**	**4/5**	**20**
Ease of Set Up	**25**	**3/5**	**15**	**3/5**	**15**	**3/5**	**15**
Weight of Device	**15**	**3/5**	**9**	**4/5**	**12**	**3/5**	**9**
Compactability	**15**	**4/5**	**12**	**4/5**	**12**	**4/5**	**12**
Ease of Fabrication	**10**	**3/5**	**6**	**4/5**	**8**	**3/5**	**6**
Adjustability to Other Treadmills	**5**	**4/5**	**4**	**2/5**	**2**	**2/5**	**2**
Cost	**5**	**2/5**	**2**	**4/5**	**4**	**3/5**	**3**
Total	**100**	**63**		**73**		**67**	

Table 1: Design Matrix for Preliminary Designs

Summary of Design Matrix

The evaluation criteria and how each design earned their score are as follows:

Safety (25%) - Safety is the highest priority, as the device must prevent any risk of injury to the user, earning it a 25% weight. The design must support both the user and gait trainer, while keeping the trainer's wheels securely in place, even during a seizure. All three designs provide similar safety mechanisms through track supports and locking attachments. Design 1, however, is rated slightly lower due to a bump in the telescoping ramp that could catch the gait trainer or cause the user to lose balance.

Ease of Set Up (25%) - Ease of setup is critical because the previous prototype was rarely used due to difficulty moving and attaching it with C-clamps, earning it a 25% weight. Each design requires adjusting tracks on and off the treadmill and engaging ramp attachments for each use. While none completely eliminate setup steps, designs that simplify attachment improve usability. All designs perform similarly, with minor differences in attachment mechanisms that could make setup slightly faster.

Weight of Device (15%) - Weight is an important factor because the previous wooden prototype was too heavy to move easily, so the weight of the device was given a 15% weight in the matrix. The device should ideally weigh under 23 kg. Design 3 ranks highest, as its built-in wheel locking mechanism allows the tracks to be made from lightweight materials while maintaining stability. Design 1 is heavier due to additional tracks needed to support the ramp, and Design 2 falls in between.

Compactability (15%) - Compactability measures how easily the device can be stored or folded to save space. Compactibility is weighted at 15% because the clients also stressed the importance of it being able to fit in their living space. Design 1 ranks highest, as it can fold fully flat and shorten the track legs. Designs 2 and 3 are tied; design 2's ramp folds but wheel height remains fixed, while Design 3 folds onto the treadmill, reducing footprint but preventing the treadmill itself from folding.

Ease of Fabrication (10%) - Ease of fabrication considers material accessibility and manufacturing complexity. There is considerable access to materials and resources for fabrication plans, so it is only weighted at 10%. Design 2 ranks highest, as it requires fewer custom parts and many components (such as wheels and locks) can be purchased. Designs 1 and 3 are more complex in that Design 1 requires precise fabrication of the telescoping ramp mechanism, and Design 3 needs accurate measurements for compact placement on the treadmill without interfering with the tracks.

Adjustability to Other Treadmills (5%) - Adjustability measures how easily the device can fit other treadmill sizes if a treadmill replacement becomes necessary. Functionality is more important than adjustability, so this category is only weighted at 5%. Design 1 ranks highest, as its adjustable length and height meet ADA guidelines and allow compatibility with multiple treadmills. Designs 2 and 3 are limited because their ramp heights are fixed, though they still accommodate the client's gait trainer.

Cost (5%) - Cost evaluates material and fabrication expenses, which the client is flexible on so it is ranked at 5%. Design 2 is the most cost-efficient, requiring fewer materials and simpler mechanisms. Design 1 is the most expensive, due to additional ramp materials, while Design 3 is moderately priced because of extra folding hardware.

The winning design was the suitcase ramp. This design scored highest in five of the six scoring criteria categories. The wheels on this design make the set up and storage processes easier as the device can be wheeled onto the treadmill. The handle also contributes to the ease of set up, making it easier to maneuver. The foldable legs underneath the ramp portion of the device provide added safety and stability to this design. Although the suitcase ramp design is the winner based on the design matrix, the proposed final design combines elements from all three of the preliminary designs.

Proposed Final Design

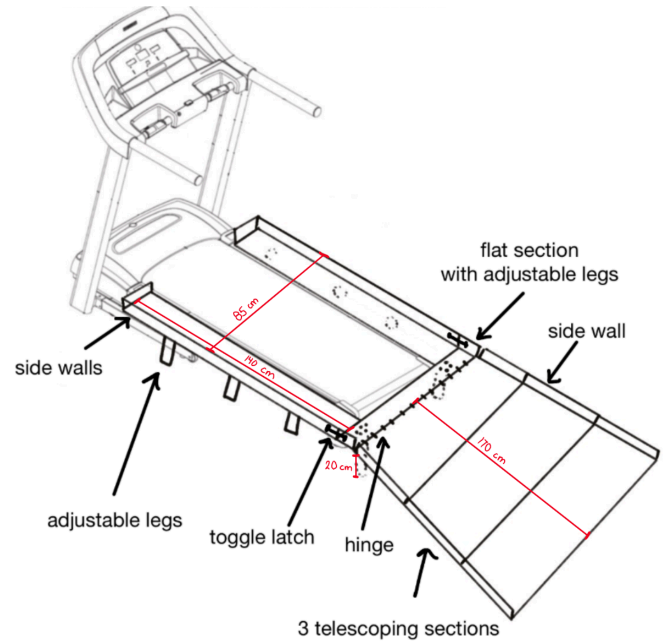


Figure 6. Proposed Final Design Sketch

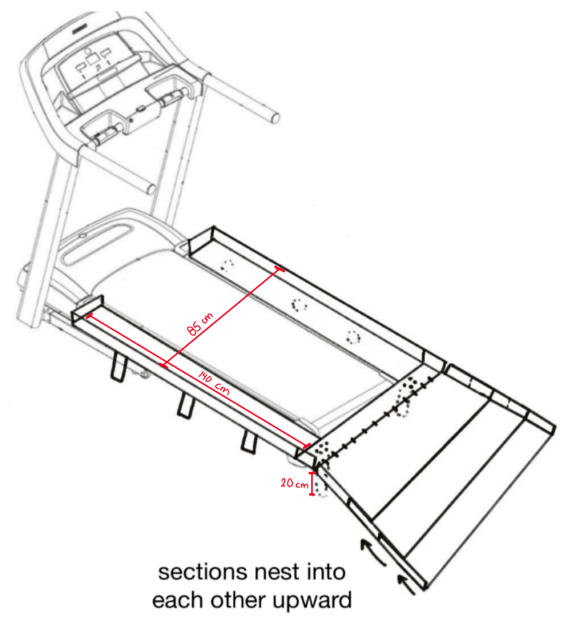


Figure 7. Telescoping ramp nesting into each other

Figure 8. Adjustable legs to be implemented in the final design [15]

After reviewing the three preliminary designs, it was decided to combine aspects from all three designs as well as add adjustability elements for the proposed final design (Figure 6). This design combines telescoping elements of Design 1 along with folding elements from Design 2 and Design 3. This design has aluminum tracks, supported by adjustable legs (Figure 8). This allows the tracks to change height if a different treadmill was used with the design. At the end of the treadmill before the start of the ramp, there is a flat section also supported by adjustable legs. This section is connected to the tracks by a hinge. The purpose of this flat section is to provide a way for the ramp to be supported by adjustable legs without the legs being impacted by the ramp angle. After the flat section is an aluminum telescoping ramp. The ramp is telescoping, meaning that portions of the ramp can nest inside one another to compact the ramp for folding (Figure 7). It is made of aluminum to keep it lightweight and durable. This ramp is also connected to the flat portion by hinges to allow it to fold onto the treadmill when compacted. Overall, by combining elements of all the designs, the ease of setup, compactability, and adjustability to other treadmills can be maximized.

Final Design

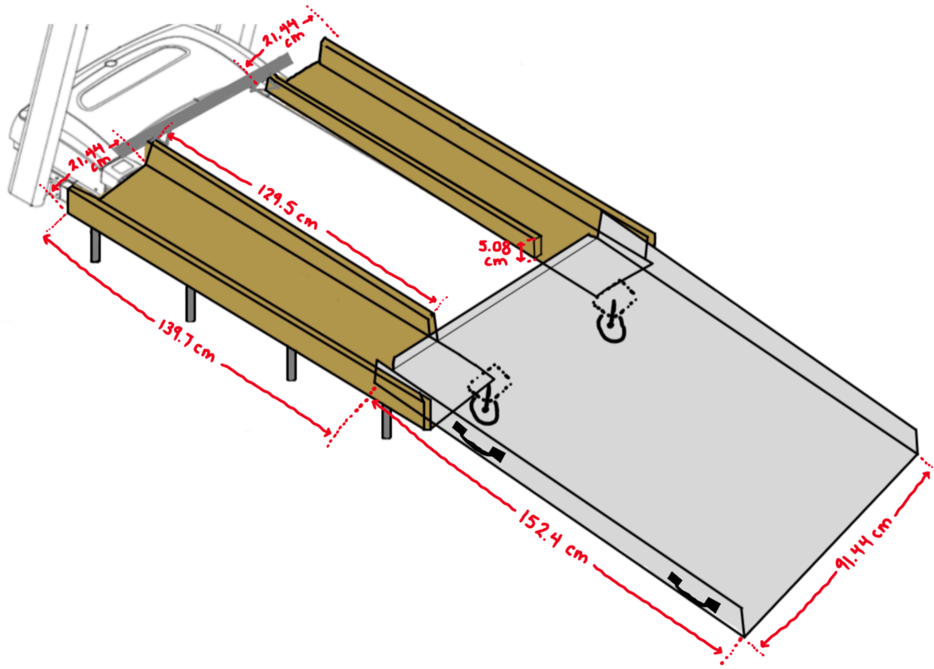


Figure 9. Final Design with ramp extended

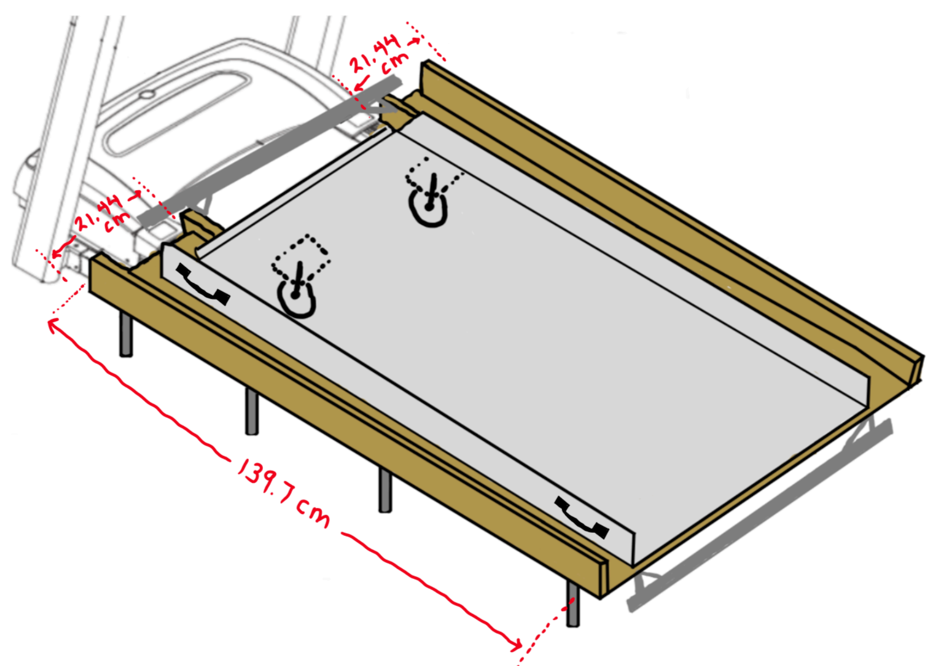


Figure 10. Final Design with ramp compacted

The final design builds upon the proposed final design with similar aspects of the side tracks, a different ramp design, and additions for increased stability (Figure 9). The side tracks are wooden with guard rails on both the inside and outside. The inner guard rail is 10.2 cm shorter than the outer guard rail to allow the ramp to rest on the back of the side tracks. On the outer edge of each side track, there are 4 evenly spaced adjustable legs (Figure 8). The inner edge of each side track rests on the plastic side edges of the treadmill.

The ramp design from the proposed final design was changed to a pre-fabricated aluminum ramp setup. When in use, the front of the ramp is placed at the back of the side tracks, just behind the end of the treadmill belt (Figure 9). For easy storage, the ramp has one wheel on each side, screwed into the bottom of the ramp. When the front of the ramp is lifted, the wheels are set onto the side tracks. Then, the back of the ramp is lifted, allowing the ramp to roll forward on the wheels along the side tracks to a compacted position (Figure 10). To make the lifting process user-friendly, handles are screwed onto the guard rails of the aluminum ramp on both sides at the front and back of the ramp.

To increase stability and safety, adjustable supports connecting the side tracks to each other are also added. These adjustable supports are made of 80/20 aluminum, allowing the horizontal spacing between the side tracks to be changed. This system is screwed at both the front inside and back inside of the side tracks. Additionally, a non-slip and scratch resistant material is added onto the bottom of the ramp where it meets the hardwood flooring to increase friction and reduce scratching to the flooring.

The final design fits the specifications by being safe, easy to set up, lightweight, compactable, possible to fabricate, adjustable, and in-budget. Since safety is a top priority, the

80/20 supports ensure that the device is stabilized during walking, as well as entering and exiting the device. The pre-fabricated ramp also guarantees safety of the user and allows an efficient set up using wheels. This design maintains an adjustability to other treadmills, featuring adjustability to both the height and width of the device. For these reasons, aspects of the proposed final design were altered to create this final design that meets the design specifications.

Fabrication

Materials

A lightweight, yet durable, material is needed to hold the gait trainer, the user, and another caregiver if applicable. Following these guidelines the team used the prefabricated Aluminum Threshold Ramp from Silver Spring because its properties fulfill these requirements [16][17]. The lowest yield strength of available aluminum alloys is 34.47 MPa, which is able to hold the combined weight of 173.6 kg that could be placed on the device [18]. The pre-fabricated ramp is stated to have a maximum capacity of 363 kg, which is more than double the expected load [19]. To make storage easier, 7.62 cm wheels were added to the bottom of the ramp and kayak handles were added to the sides to allow caregivers to maneuver the ramp more easily. In addition, a non-slip and scratch resistant material was added to the bottom of the ramp to ensure the ramp stays in place when walking on it, and to not scratch the client's floors. Rubber caps were also added to the screws to reduce the sharp edges on the device. The team selected southern yellow pine for the base of the sidetracks because of its classification as a hard softwood which was lightweight but was also durable compared to other softwoods. Similarly, the team chose aspen wood for the sidewalls of the sidetracks to comply with the client's requests. The adjustable legs that were incorporated into the design are made out of cold rolled steel chosen for their durability [15]. Across the front and back of the sidetracks, the team added angle brackets and 80/20 T slot structural framing to have a rigid support that can adjust the horizontal distance of the sidetracks. Complete documentation of the materials used can be found in Appendix B.

Methods

The team began by sourcing wood for the sidetracks. The team cut the wood to the correct length of 129.5 cm and 139.7 cm using the miter saw, and the correct width using a SawStop table saw. The team used a Jet 12” jointer/planar to make the boards smooth and finished. The team attached the pieces of wood for the walls of the sidetrack to the base boards by using wood glue and clamping the sidetracks together (Figure 11), with the side boards attached .635 cm from the bottom of the base boards to ensure they would not hit the belt of the treadmill.

Figure 11. Sidetracks glued and clamped together

The sidetracks were further secured together by using 6.99 cm wood screws spaced 2.54 cm from the edges and then equidistance along the boards. The team used Minwax stain in the color Red Mahogany on the wood side tracks to give the design a more finished look. Next, the adjustable legs were attached to the sidetracks by 2.54 cm screws using a Milwaukee impact driver equally spaced (Figure 12).

Figure 12: Finished sidetracks with Red Mahogany stain and adjustable legs attached

After testing, the team decided to add more rigid supports to the front and back of the sidetracks that also allowed horizontal adjustment. The team achieved this goal by drilling holes using a 7mm drill bit and a Milwaukee cordless drill, then by attaching angle brackets into the side tracks with .794 cm-18 X 3.81 cm screws with bolts for the front end of the side tracks. For the bottom end of the side tracks, the angle brackets were screwed in using 3.81 cm wood screws and a Milwaukee impact driver. These angle brackets had built-in attachments that allowed a 78.74 cm piece of 80/20 T slot structural framing to slide back and forth and secure by tightening bolts that fit an allen key (Figure 13). The complete fabrication protocol for the sidetracks can be found in Appendix C.

Figure 13. Sidetracks with 80/20 attached in the front with angle brackets

For the ramp, holes were drilled using a Milwaukee cordless drill with a letter O drill bit at a distance of 7.62 cm and 12.7 cm from the side of the ramp and at a distance of 22.23 cm and 28.58 cm from the top of the ramp for each of the above horizontal distances. These holes let 2 #10-32 3.175 cm L socket button head bolts with #10 1.27 cm washers and 5.715 cm-20 3.175 cm L socket button head bolts attach a wheel to the ramp. This process was repeated for both sides of the ramp for a total of two wheels attached to the underside of the ramp (Figure 14).

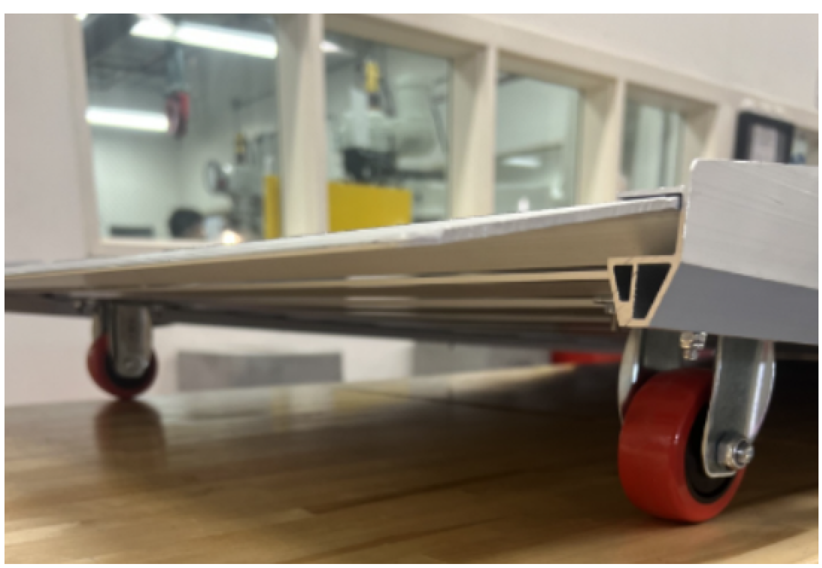


Figure 14: Wheels attached to the ramp

On the sides of the ramp, two kayak handles were attached by using a 1.96 cm drill bit with a Milwaukee cordless drill to drill holes spaced 22.9 cm apart, right as the slope of the siding flattened (Figure 15). The handles were secured by using #8-32 1.59 cm L phillips head bolts and #8 .635 cm washers.

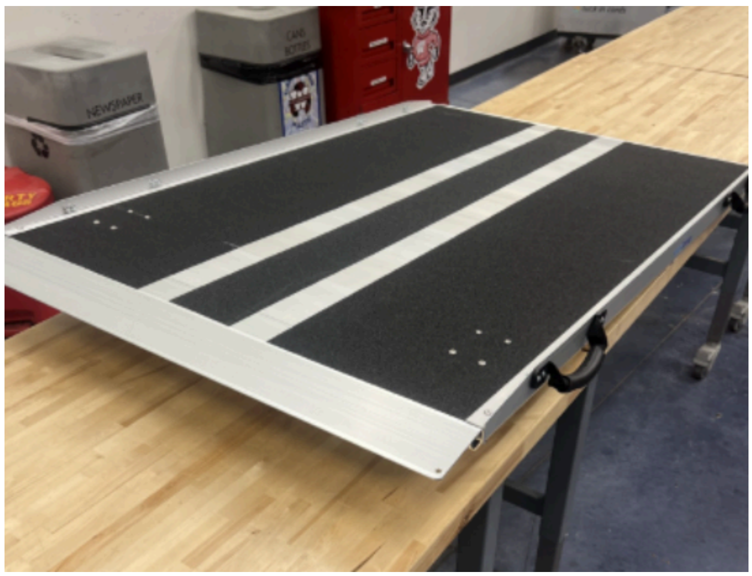


Figure 15. Kayak handles attached to ramp

The team used 120 grit sandpaper to rough the bottom of the ramp and used alcohol to clean the surface. The rougher and clean surface allowed the non-slip and scratch resistant material to stick better to the ventral surface of the ramp. For the final touches, the team added rubber caps cut to 0.635 cm in length to the ends of the bolts located along the ramp.

Final Prototype

Figure 16. Side view of the storage position of the final prototype on the treadmill

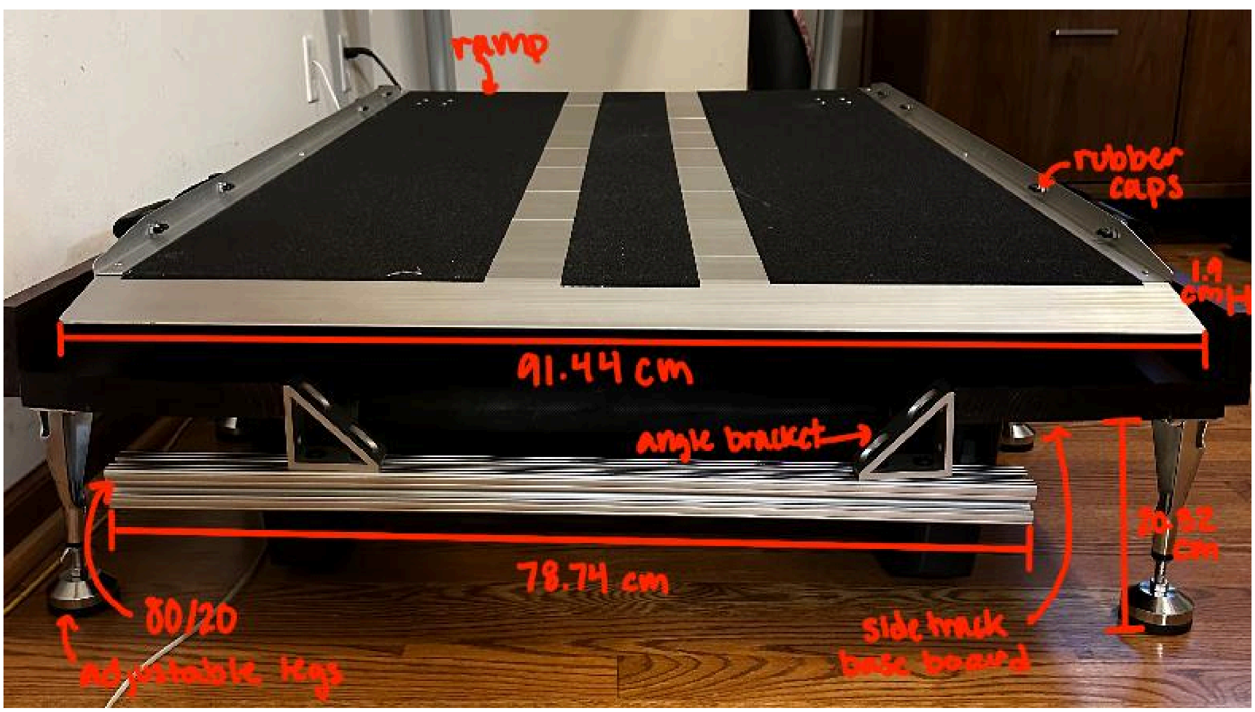


Figure 17. Front view of the storage position of the final prototype on the treadmill

Figure 18. Assembly of the final prototype with the gait trainer on the treadmill in ready-to-use position

Testing and Results

Solidworks FEA Simulation Testing

The Solidworks Finite Element Analysis (FEA) Simulation tool was used to determine the structural integrity of the side tracks (Appendix D). These simulations will provide insight into potential critical stress regions and will determine if the side tracks meet performance requirements as outlined in the PDS. To mimic the expected weight of the user, gait trainer, and an additional care giver, a load of 1703 N was distributed along the top face of the side tracks. Although, in practice, the load will not be evenly distributed, and the treadmill will bear some of the weight, this loading condition will provide conservative results for how the device may deform under maximum conditions. For materials, the adjustable legs and treadmill support were modeled as 1020 cold-drawn steel, and the platform was modeled as pine wood to most closely resemble the true device. As illustrated in Figure 19, fixtures were applied to the adjustable legs and treadmill support assuming that there will not be any slipping. Additionally, the legs and treadmill support are bonded to the platform under the assumption that the legs will remain screwed into the platform, and there will not be any slipping.

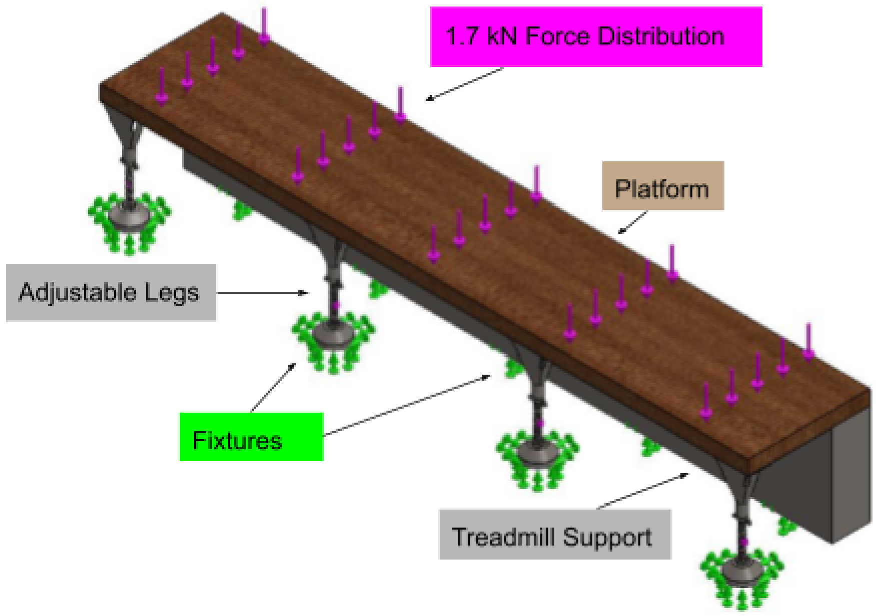


Figure 19. Model of side tracks analyzed in Solidworks FEA Simulation tool. Bodies analyzed include the platform, adjustable legs, and treadmill support. The purple arrows show the 1.7 kN force distribution and the green arrows indicate fixtures.

The analysis yielded a minimum factor of safety of 25.68 which exceeds recommended values ranging from 1.3-4.0 [20]. Additionally, the maximum displacement was only 13.7 µm. A full description of testing and results can be found in Appendix D. Although the model does not exactly reflect the true loading conditions, the assumptions made and the conservative modeling give an acceptable understanding of how the side tracks are expected to deform while in use. Ultimately, the analysis indicates minimal concern regarding the device's ability to withstand the expected loading conditions.

Stability Testing

In order to determine the overall stability of the device, the team evaluated its movement every 30 seconds while in use with the 80/20 horizontal bars and without them (Appendix E). Prior to testing, the team marked the initial position of the device on the floor and measured the displacement that occurred every 30 seconds during the testing period. The length of the testing period depended on the endurance of the patient. The device will be considered stable if the displacement is less than 1.0 cm and if there is no observable rocking, tipping, or progressive drift.

For stability testing without the horizontal bars, the testing period was only 1.5 minutes due to the patient's endurance level. As seen in Figure 20, the maximum displacement during this trial was 1.4 cm exceeding the acceptable displacement. With the horizontal bars, the testing period was 7 minutes, but for statistical analysis purposes, only the first 3 recorded values were analyzed. There was no displacement of any of the legs throughout the trial. After performing a t-test between the groups, it was found that there was no statistical significant difference. However, because the displacement without the horizontal bars exceeded the displacement threshold of 1.0 cm, the horizontal bars can be concluded as necessary for maximum stability of the device. In order to provide more statistical evidence, additional testing should be performed in the future, with a larger sample size.

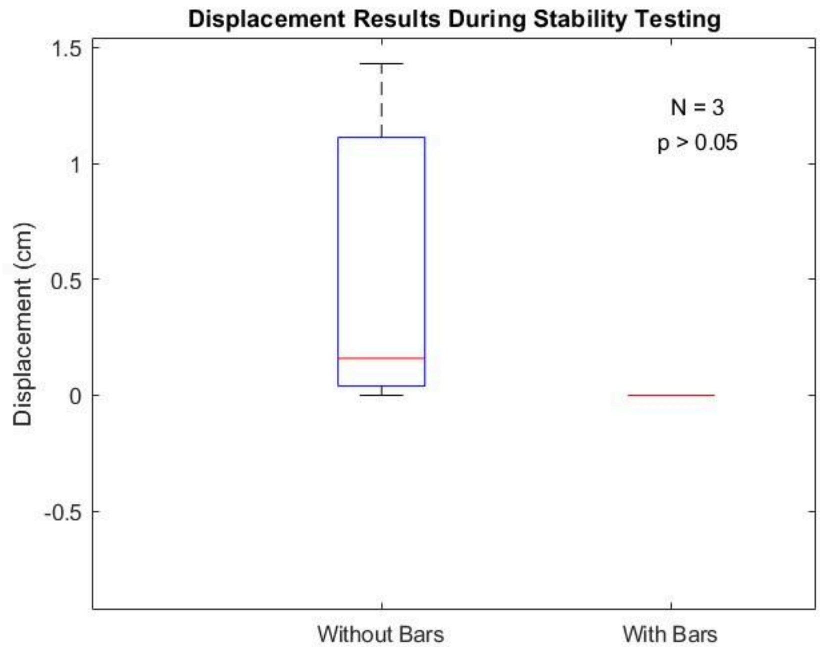


Figure 20. Comparison of displacement results during stability testing without and with the horizontal bars of sample size N = 3. Mean values are 0.53 and 0.0 cm respectively, p value = 0.36 (> 0.05).

Ease of Use Testing

In order to determine the ease of use of the device, the team measured the time required for setup and storage (Appendix F). To meet product design specifications, the setup and storage time must not exceed five minutes. Prior to data collection, each subject group completed three practice trials to become familiar with the procedure to accurately reflect the performance of care-givers who will be accustomed to operating the device. The first group tested consisted of three variants of a two-person team, while the second group was conducted with a single person to evaluate the effect of group size on the time.

For the set-up testing, the mean value for the two-person team was 11.5 and 11.4 seconds for one person, both under the 5 minute threshold as seen in Figure 21. The t-test concluded that there is no significant difference between the group sizes, indicating that the set up procedure can easily be done by one caregiver. For the storage testing, the mean value for 2 people was 13.1 and 19.1 seconds for one person, both again under the 5 minute threshold as shown in Figure 22. Additionally, another t-test was performed and concluded that there is no significant difference between the group sizes. Ultimately, reducing the steps needed to set-up and store away the device makes it easier and quicker to use whether it is done by one or two caregivers.

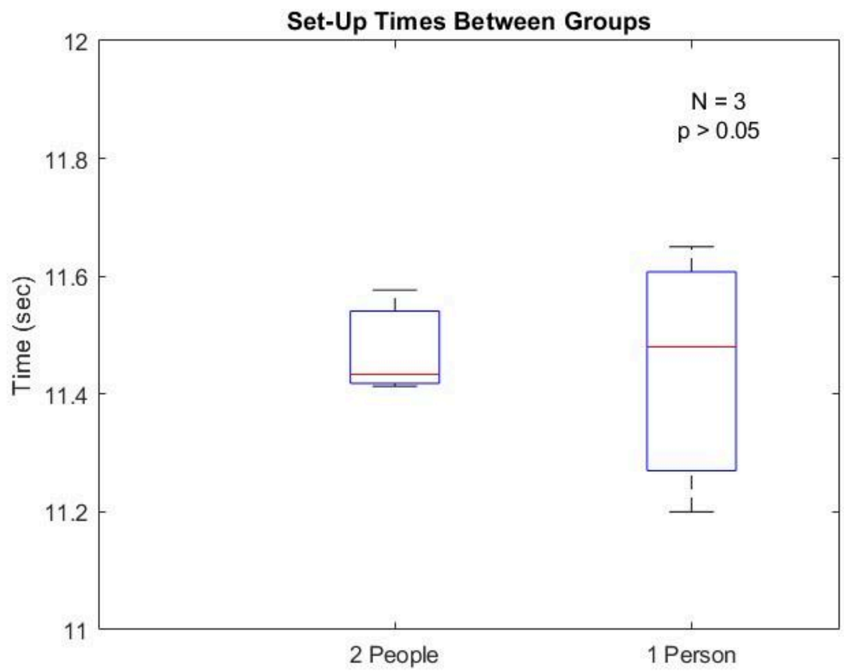


Figure 21. Comparison of set-up time results during ease of use testing between the mean values of 2 people and results from 1 person of sample size N = 3. Mean values are 11.5 and 11.4 seconds respectively, p value = 0.79 (> 0.05).

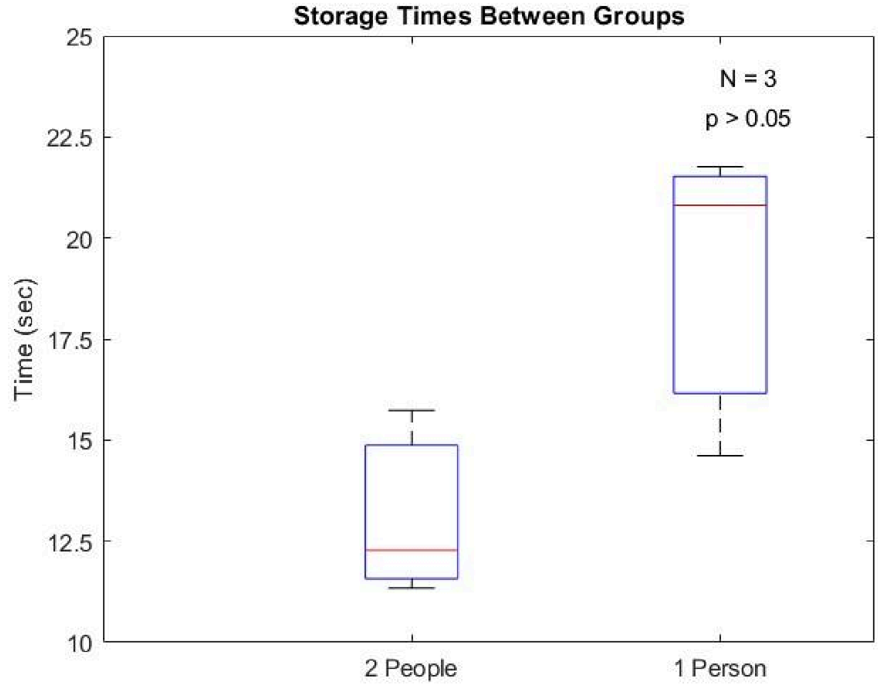


Figure 22. Comparison of storage time results during ease of use testing between the mean values of 2 people and results from 1 person of sample size N = 3. Mean values are 13.1 and 19.1 seconds respectively, p value = 0.08 (> 0.05).

Discussion

The Solidworks FEA Simulation and stability testing results are in alignment with the designs' intended use and client requirements. Furthermore, testing found the prototype to have a high factor of safety [20] with a large margin between the maximum expected load and the maximum load capacity. This load capacity margin and high stability results creates added security and peace of mind for caregiving staff and allows caregivers greater access to the user in the case of a medical emergency.

While the ramp system features a durable construction, anti-slip surfacing, and edge-protection, the slope of the ramp does not align with the ADA standard of 1.0 inch rise for every 12.0 inches of ramp length [11]. This deviation was approved by the client as her patient had the ability to navigate a steeper slope and because the patient's home does not have the functional space for an 8 foot long ramp. While our client favored this modification for her patient, other users of this system with different mobility limitations could find this increased slope difficult to navigate and may require a longer ramp and/or greater assistance from caregiving staff.

It is important to note that this ramp and track system was designed to be compatible specifically with the Rifton Pacer Gait Trainer with the K640 Large Utility Base. Therefore, the use of this system with other models of gait trainers or other mobility aides is not guaranteed as-is, and will likely require dimensional adjustments. Despite this, the 80/20 horizontal adjustment bars and the adjustable legs allow this system to be used with standard-sized treadmill models. This is because the horizontal adjustment bars accommodate for 15.5 centimeters of horizontal variability and the adjustable-height legs allow range between 18.288 and 37.592 centimeters.

In regards to ethical considerations, it is important that all materials used are sourced from responsible vendors, and that any wood treatments used such as stains and lacquers are used responsibly in well-ventilated areas, with the use of N-95 masks and gloves when applicable. For this project, the Minwax Red Mahogany stain [21] was used to treat the wood. Minwax, a subsidiary of Sherwin Williams, engages in environmentally-responsible practices that aim to reduce environmental impact. Despite this, it should be noted that the safety data sheet for this product states that it is considered hazardous by the OSHA Hazard communication standard as this stain is a category three flammable liquid, category two carcinogen, and rated category three for organ toxicity for single exposure and category one for repeated exposure.

Additionally, all physical testing of the design was performed under the supervision of a licensed occupational therapist, and with the assistance of trained caregivers. Prior to the patient testing out the system herself, testing was conducted first with just the gait trainer, and then subsequently by the design team members and caregiving staff. The caregiving staff and the occupational therapist assessed the safety of the system before the patient herself used the ramp and track system.

Sources of error during the fabrication and testing process include frequent conversions between the U.S. Customary Measurement System and S.I. Units. This was due to the fact that the hardware and lumber used are sold in U.S. Customary Units of Measurement, and that many of the shop tools used in fabrication use the U.S. Customary Measurement system. This is significant because frequent conversions can lead to measurement discrepancies. Additionally, during fabrication almost all measurements and drilling were done by-hand, again introducing the possibility of slight discrepancies.

Computer-generated models such as Solidworks FEA assume idealized versions of all materials used. In real-life, materials such as wood naturally deteriorate and warp over time and feature imperfections such as knots that can affect their behavior and performance. Additionally, pine was used in testing simulations for the side track base boards instead of the stronger southern yellow pine that was used for fabrication. Therefore it is likely that the maximum weight capacity determined through the Solidworks FEA model is lower than the actual capacity, and that the strength of these sidetracks is not uniform throughout the entire structure.

Finally, testing was reliant on human use. For ease-of-use testing, design-team members were used. For a more accurate representation, caregiving staff should have been included in testing. Furthermore, displacement testing was reliant upon the health and ability of the client's patient which varies day-to-day, and led to discrepancies between trials. These discrepancies include length of trial, speed of walking, number of seizure episodes, and level of caregiver intervention. It is hard to idealize this testing as this product is highly specific to the patient's circumstances. However, to increase the reliability of these results, future improvements could include a greater number of trial days to see how the design performed under a greater number of uses.

Conclusions

Gait trainers are used to help those with limited mobility navigate their surroundings. Physical activity is important for maintaining muscle strength and improving one's mood, but unpredictable winter weather can limit the ability to use a gait trainer outdoors. The final design includes two wooden side tracks that attach to a modified pre-fabricated aluminum ramp. The side tracks are adjustable in height via the legs that support them, and adjustable in width via two pieces of 80/20 aluminum that connect the side tracks to each other. These adjustable features ensure that the device could be used on treadmills of varying dimensions. The ramp includes handles on the sides, as well as two wheels, which help to move the ramp into the storage position on top of the side tracks.

Prior to fabricating the device, the design was modeled and tested in SolidWorks to ensure the client's needs would be met, especially ensuring the design was safe for patient use. SolidWorks testing revealed that the design was extremely durable and safe, having a maximum displacement of 13.7 micrometers and a factor of safety of 25.7. After fabrication, the physical prototype was tested. After implementing the 80/20 aluminum bars in the design, it was found that the side tracks did not move while the device was in use, further enforcing the stability of the design. The device also meets the criteria of being able to be easily set up for use and taken down for storage as revealed in the ease of use testing.

While the final prototype is functional and meets all safety and client criteria, future work can be made to improve the safety and security of the system. Due to time restrictions, the team was unable to install a secondary attachment mechanism between the side tracks and aluminum ramp. While the aluminum ramp was designed to be free-standing, a large, atypical backwards force could displace the ramp from its resting position on the side tracks. This is not a concern for when someone is standing on the ramp (as their body weight creates a strong downward force), but for when the treadmill is in use. Therefore, to prevent unintended movement, pins or toggle latches could be applied.

Another feature to add in future work would be a secondary locking mechanism to more strongly secure the gait trainer in place. This was not a concern for our client, but was an area of improvement noted by the design team. Currently, caregiving staff use the gait trainer's wheel locks while the patient is on the treadmill. These wheel locks prevent a great deal of movement, but not all, so caregiving staff also physically hold the patient in place. Ideally, a mechanism would be added to the side tracks to either help secure the wheels in place, or to help secure the frame of the gait trainer to the treadmill frame.

Additionally, future work includes improving the material of the side tracks to a material that is more durable, but still lightweight. Wood was chosen for the material of the side tracks because of cost and ease of fabrication considerations. However, wood can become warped and degraded over time which would make this design unsafe. Research should be conducted to determine a material that could be used in place of wood that would remain durable over a long period of time, while also being lightweight to allow the device to be easily removed from the treadmill if necessary.

Finally, future work includes the creation of a more compact storage process. The current design requires that the treadmill belt stays in the down position when the device is in the storage position, which takes up more room in the patient's home. Ideally, a system would be created to easily remove the side tracks from the treadmill when not in use, allowing the treadmill to fold up and minimizing the space taken up in the patient's home.

The final prototype satisfies the client's needs, providing the patient with an easy way to move their gait trainer onto a treadmill. The device is secure and stable, while also being adjustable to other treadmills and easy to set up or store.

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Appendix

Appendix A: Product Design Specifications

Problem Statement:

A woman with a significant mobility impairment due to a seizure disorder requires support while walking because of seizure risks and poor postural strength. She has a Rifton Pacer Gait Trainer which has allowed her to resume walking outdoors; however, it is unsafe to use in winter. It is crucial for her to be able to use the gait trainer for daily walks in order to maintain her muscular strength and mental health. The solution is to design a transfer device that will allow her to use her gait trainer on a Horizon T101 treadmill to give her the opportunity to maintain her muscle conditioning when weather conditions are not favorable. The transfer device will need to allow the gait trainer to be wheeled onto the treadmill and secure the wheels in position so it cannot fall off the side while she's walking. It will need to hold the weight of the gait trainer, the user, and one caregiver, totaling to 173.6 kg. It will need to be easy for caregiving staff to use, taking no more than 5 minutes to assemble, under 23 kg, and have the ability to fold in order to maintain the functionality of her living environment.

Client requirements:

- One transfer device that can repeatedly attach or permanently attach to the client's treadmill
- Easily fold for transfer with a handle or fold with the treadmill
- Withstand the weight of the gait trainer, user, and staff

- Be durable to withstand the usage needs of the client
- Have a smooth finish with no sharp edges
- Be slip-resistant to prevent falls
- Have safety guards to prevent the wheels from sliding off of the device while in use

Design requirements:

1. Physical and Operational Characteristics

a. **Performance requirements**

i. The device must be able to transfer the client and her gait trainer from the ground to her treadmill platform. The device should be able to sustain the weight of both the client and her gait trainer, as well as the weight of an additional caregiver (approximately 173.6 kg). The device should be able to withstand daily use of about 10-15 minutes, and have the ability to easily fold into a compact shape. For storage, the device must follow NIOSH lifting equation guidelines in order to allow caregivers and family members to move it independently without strain [1]. For ease of use, the device will allow the gaitwalker to work seamlessly with the treadmill, and not hinder the user's movement.

b. **Safety**

i. Due to the nature of the client's seizure disorder, the device should secure the gait trainer to the treadmill during exercise, to reduce the chance of the client falling off the treadmill. In addition, the locks securing the gait trainer should be easy for caregiving staff to remove and engage, to ensure that they have quick access to the client in the case of a medical episode. In the case of a medical episode, the device must be stable enough to bear 173.6 kg. That being said, the device must be less than 23 kg in order for caregiving staff to reasonably move without fearing strain and possible back injury per NIOSH guidelines. For transfers, the surface of the device should be even, smooth to the touch, and slip-resistant. Furthermore, the device should be flush with the treadmill belt so that the wheels and client's clothing do not get caught during the transfer process.

c. **Accuracy and Reliability**

i. The client should be able to use this device up to seven days per week, at intervals of 10-15 minutes without device failure. With the help of two caregiving staff, the client should be able to complete her transfer onto the treadmill and secure her gaitwalker in five minutes or less. Similarly, when disembarking from the treadmill, the client and two caregiving staff members should be able to unlock the device and transfer back to the floor in five minutes or less. When the device is no longer needed, its storage process should take no longer than five minutes for a single user. Correspondingly, when needed, the device set up process should take no longer than five minutes for a single user to complete.

d. **Life in Service**

i. The device must remain functional for the entire lifespan of the client's current treadmill as it will be fitted to the treadmill's specific dimensions. It should be able to withstand regular usage by the client, including sessions of 10-15 minutes multiple times a week, with the possibility of increased use during the winter months. Both the weight of the client and the weight of the gait trainer must be supported by the device for the duration of use, meaning the device must be extremely durable. The shelf life of the device should be approximately 15 years [2].

e. **Shelf Life**

i. The device should be stored inside when not in use. To ensure a maximum life in service, the device should be stored at temperatures of less than 55℃ and in an area with less than 70% humidity to maintain structural integrity and ensure client safety [2] [3]. With proper storage conditions, the shelf life should match the life in service of approximately 15 years.

f. **Operating Environment**

i. The device should properly function while attached to the treadmill within the client's home, where it will be positioned on top of hardwood flooring. Ideally, the device should fold to be less than 85 cm wide and 170 cm long to minimize the space needed for storage within the home. The device also needs to be compatible with the client's gait trainer which will simultaneously be used with the treadmill.

g. **Ergonomics**

i. The device should be easily moved by the client's staff, and by their family. In addition, the clamping mechanism used to secure the device to the treadmill should be operable with little to no exertion, either through a one-time attachment for permanent attachment, or a method that is easily repeatable.

h. Size

i. The device should have a width of at least 86.5 cm which is the width of the Horizon T101 treadmill to prevent the Rifton Pacer Gait Trainer from falling off the treadmill [4]. The length will depend on the height of the treadmill for the client's set up to be compliant with ADA guidelines for ramps [5]. Guardrails should be added on the side of the ramp and should be at least 2.54 cm above the surface of the ramp.

i. Weight

i. The device should be able to support the weight of the client which is around 79.4 kg and in some instances, a caregiver which is also around 79.4 kg. The device also needs to support the client's Rifton Pacer Gait Trainer which has a total weight of 14.8 kg which includes the K640 model with the utility base [6]. In total, the device needs to support 173.6 kg. The device itself should weigh under 23 kg, the typical weightlifting job requirement following NIOSH lifting model [7].

j. Materials

i. The materials used for the device should be lightweight, yet durable enough to withstand the weight of the pacer, the client, and another caregiver if necessary. Aluminum is a good option for this device due to its rigidity and the weight of the material itself in comparison to other similar materials [8]. In addition, considering the available alloys and tempers of aluminum, the lowest yield strength is 5 ksi which would support the aforementioned expected load [9].

k. Aesthetics, Appearance, and Finish

i. The Gait Trainer with treadmill device should be lightweight, durable, and easy for caregiver staff to use. The device will consist of a ramp, two tracks for the gait trainer wheels, and four wheel locks to hold the wheels in place. The device will be easily compatible with the Horizon T101 treadmill and Rifton Pacer Gait Trainer. The ramp will be slip-resistant by having a coating such as the ResuGrip Non-Slip Floor Coating by Sherwin Williams which is designed to follow ADA guidelines [10]. The ramp should have a shallow incline following ADA guidelines, and lead onto tracks that start out wider and lead to a narrower fit. The tracks should have a smooth finish to let the wheels easily get to and from the locking device. All of the components should be black to blend in with the treadmill, with the exception of the start of the tracks, which should be yellow for an easy guide onto the tracks.

2. Production Characteristics

a. Quantity

i. This project consists of making one device compatible with the client's T101 Horizon treadmill including a ramp, two wheel tracks, and four wheel locking mechanisms. Considering mass production, the quantity would need to meet market demands among the population of people who would benefit from using a gait trainer with a treadmill. The gait trainer market is expected to grow significantly in the next 10 years due to an increasing elderly population, prevalence of mobility disorders, and need for rehabilitation devices [11].

b. **Target Product Cost**

i. The initial budget for this project is $500; however, the budget is flexible. The client is willing to increase the budget if the device is functional and meets all specifications. The budget will need to cover all material costs for prototyping, testing, and final fabrication.

3. Miscellaneous

a. **Standards and Specifications**

i. The ramp will need to follow ADA Guidelines 405.2 and 405.4 for Ramps and Curb Ramps. The slope ratio of the ramp must not exceed 1:12, 1 unit of height per 12 units of length. The run and landing surfaces must be firm, stable, and slip-resistant [6].

b. **Customer [12]**

i. This ramp and platform device's target audience is for individuals who require a gait trainer to walk and benefit from treadmill walking, but do not have a compatible gait trainer and treadmill system that allows the patient to be supported at the height of the treadmill. This particular product is specified to the patient's gait trainer and foldable treadmill style.

ii. The ramp must be either permanent and foldable with the treadmill or detachable but lightweight to save space.

iii. The device must be easy to maneuver in small spaces, lightweight, and user friendly for the caregivers or nurses to set up.

iv. The platform must have a locking and securing mechanism for the wheels so they cannot fall off the side while walking, but also have the ability to unlock seamlessly in the case of an emergency.

v. The device must abide by ADA safety guidelines (see section 3a. *Standards and Specifications*).

***c.* Patient-related concerns**

i. The ramp and platform system must be designed for the customer's specific gait trainer model by accommodating 20.32 centimeter front casters and 29.21 centimeter back wheels [13].

ii. The device must abide by the customer's safety needs.

1. The ramp and platform must have a minimum of 2.54 centimeter guard rails (preferably 2.54-5.08 centimeters).

2. The device must be able to stay secure on the platform in the case of a patient seizure.

3. The device must be capable of supporting at least 173.6 kg: the weight of the individual using the gait trainer (79.4 kg), the gait trainer base (8.8 kg), the dynamic upper support (6.1 kg) and one caregiver/nursing staff who may need to step on (upwards of 79.4 kg), in the case of a seizure.

***d.* Additional optional patient requests**

i. The device should have the option to allow use with a new treadmill in the case that the current treadmill stops working.

e. Competition

i. Rifton Gait Trainer Treadmill Base [14]

1. Rifton offers a treadmill base for their gait trainers that is wide enough to fit around the width of a treadmill.
2. The gait trainer has a lever to raise and lower the harness to adjust the harness height with the treadmill height which allows the system to work across different treadmill models.
3. This system allows the use of a gait trainer with a treadmill at home.
4. Drawbacks: This system requires the purchase of a new gait trainer base. The base is wider and the lever system makes the gait trainer bulkier. For practical use, this gait trainer base may be too large, meaning that a person may need two gait trainer bases: one for everyday use and one for the treadmill. This is not cost effective and would require switching from one gait trainer base to another.

ii. LiteGait for Adults [15]

1. LiteGait has an overhead harness system that supports the user while on the treadmill.
2. There is a base of 2 beams that span the length of the treadmill, allowing for stabilization and a bar in the front that connects the stabilization beams. The front bar has a large vertical beam attached. This beam has arm supports in front of the user and holds up the harness.

3. Drawbacks:

    a. The device is meant for clinical usage and therapeutic exercise, not for at home.

    b. The device contains many electronic features beyond what our client needs, making this option not cost effective.

    c. The device would only be used for treadmill walking, meaning that the patient would need to transition from their current gait trainer to the LiteGait for each treadmill usage.

iii. Body-Weight Support Treadmill Gait Training System [16]

1. Sunshine Medical has an overhead harness system designed for treadmill walking, similar to the LiteGait.

2. The device has a base constructed with two beams that span the length of the treadmill, two front cross bars connecting the base beams, and a vertical column that has two hooks at the top holding up the harness.

3. This device provides significant body-weight support, which would help Nadine's caregivers in assisting her walking .

4. Drawbacks:

    a. This device is made for Sunshine Medical Treadmills, which are not foldable.

b. The device would require the user to transfer from their current gait trainer to the gait trainer treadmill system for every treadmill session.

iv. HCI Fitness Wheelchair Ramps [17]

1. The HCI wheelchair ramp utilizes a 2 part ramp and platform system that allows wheelchair users to safely roll up and enter certain HCI equipment such as rehabilitation devices and medical exercise machines.
2. Drawbacks:
   a. There are no guard rails on the sides of the ramp and platform.
   b. Since this device is specialized for wheelchair users, the ramp does not extend the full width of the product. When using a gait trainer, the middle of the ramp height needs to be the same as the sides to keep the user's feet and gait trainer at the same level.
   c. The product is designed for use with HCI equipment and may not be compatible with a treadmill.
   d. The product's ramps and platforms are not foldable, meaning they would take up a large amount of space in a home.

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Appendix B: Materials and Expenses

Item	Description	Manufacturer	Mft Pt#	Vendor	Vendor Cat#	QTY	Cost Each	Total	Link
Final Design Materials									
80x20	Cut into two 77.5 cm long parts. Used for horizontal adjustment system and added rigidity between side tracks.	80/20	1515-LS-72	Grainger	5JTC0	1	$77.35	$77.35	Here
Inside Corner Brackets	For added rigidity between side tracks while simultaneously allowing lateral adjustment.	80/20	40-4336	Grainger	5JRU1	4	$14.14	$56.56	Here
Corner Bracket Hardware	5/16 inch bolts, nuts, and wood screws for attaching the inside corner brackets.	N/A	N/A	DI Lab @ ECB	N/A	N/A	$3.00	$3.00	N/A
Rubber End-Caps	20-pack; to cover exposed ends of screws from handles. Cut into 0.635 cm long units.	DMiotech	N/A	Amazon	B0B59MCLHN	1	$5.03	$5.03	Here
Handle Hardware	#8-32 5/8 L phillips head bolts and corresponding nuts; #8 1/4 in washers; for attaching kayak handles.	N/A	N/A	DI Lab @ ECB	N/A	N/A	$8.80	$8.80	N/A
Wheel Hardware	#10-32 1-¼ in round head machine screws (Qty 4) and 1/4"-20 1-1/4 in round head machine screws (Qty 4) for attaching	N/A	N/A	DI Lab @ ECB	N/A	N/A	$3.30	$3.30	N/A

	wheels to the ramp.								
1/2 in. Zinc Flat Washer	For use with the securing the "small holes" of the wheels to the ramp. (30-pack)	Everbilt	825221	Home Depot	1006540097	1	$1.47	$1.47	Here
Felt Furniture Pads	To line the bottom edge of the ramp.	VOCOMO	N/A	Amazon	B0C814K7QW	1	$9.99	$9.99	Here
Kayak Handles	4-pack: Double Hole Nylon Rubber Kayak Carry Handles	HDCBMCDDM-US	DF25FED	Amazon	B08RWMXQ7S	1	$11.59	$11.59	Here
Wood Glue	For use with securing the side rails to the side track base.	Franklin Adhesives & Polymers	S-25894	DI Lab @ ECB	N/A	1	$6.00	$6.00	Here
Wheels	3" Steel Rigid Caster Plate	Everbilt	4120424EB	Home Depot	1010895538	2	$11.37	$22.74	Here
1x4 - 18ft Lumber	Two 55" and two 52" Aspen boards for side track walls	N/A	207059054	Home Depot	1000005744	18	$2.17	$39.06	Here
2x10 - 8ft Lumber	Premium Southern Yellow Pine for side track base	N/A	852481	Home Depot	852481	2	$8.35	$16.70	Here
Ramp	5' L x 36" W Aluminum Threshold Ramp (10” max rise)	Silver Spring	N/A	Discount Ramps	STR-536	1	$329.99	$329.99	Here
Adjustable Leg Supports	Black Full Size Adjustable Height Center Support Leg Bed Frame (Set of 3) 3 in. L x 2 in. W x 7-14 in. H. Screws included.	Porohom	765420143323	Amazon	B0946P92KZ	3	$35.05	$66.59	Here
1.25" Wood Screws	Used with the lumber to create the track base frame (1/8" no threads, 11/64" thread diameter)	N/A	N/A	DI Lab @ ECB	N/A	16	N/A	$2.50	N/A
							Total:	**$660.67**	

Appendix C: Side Tracks Fabrication Protocol

Materials

- 5.08 cm × 25.4 cm × 243.8 cm wood (2 quantity)
- 2.54 cm × 10.16 cm × 142.2 cm wood (2 quantity)
- 2.54 cm × 10.16 cm × 132.1 cm wood (2 quantity)
- Adjustable legs (8 quantity)
- 3.18 cm screws (16 quantity)
- 2.54 cm screws (32 quantity)
- Wood glue
- Wood stain
- 4 angle brackets with corresponding bolts and screws

Equipment

- Table saw
- Jointer / Planer
- Clamps
- Impact driver
- Cordless drill

Procedure

1. Measure and mark a line 139.7 cm from the end on each 5.08 cm × 25.4 cm board.
2. Cut each board to a length of 139.7 cm using the miter saw.
3. Measure and mark a line on each board to make it 22.07 cm wide.
4. Using the table saw, cut each board at the line marked in the previous step.
5. Run each board through the planer to ensure a smooth finish, ensuring the final thickness is 3.18 cm.
6. Run the boards through the jointer to achieve squared edges on each side.
7. On the two 2.54 cm × 10.16 cm × 142.2 cm boards, measure and mark a line 139.7 cm from one end (outer side walls).
8. On the two 2.54 cm × 10.16 cm × 132.1 cm boards, measure and mark a line 129.5 cm from one end (inner side walls).
9. Cut the boards to length using the miter saw. This will result in two boards at 139.7 cm and two boards at 129.5 cm.
10. On each board, measure and mark a line on the 10.16 cm wide face that is 7.62 cm from one end.

11. Cut each board at the marked line using the table saw. This results in two strips measuring 2.54 cm × 7.62 cm × 139.7 cm and two strips measuring 2.54 cm × 7.62 cm × 129.5 cm.
12. On each side rail, pre-drill four holes using a 0.238 cm drill bit. Holes should be 2.54 cm up from one long edge and spaced approximately 30.5 cm apart.
13. Glue one long side wall and one short side wall onto each outer side of the larger bottom board, ensuring the side rails are raised 0.64 cm from the bottom to prevent contact with the treadmill belt.
14. Use clamps to secure the glued pieces.
15. Insert 3.18 cm screws into the 16 pre-drilled holes to secure the side walls using an impact driver.
16. On the bottom of each side rail assembly, mark locations for adjustable legs. Each side track uses four legs, evenly spaced approximately 35.6 cm apart.
17. Stain the side tracks with Red Mahogany wood stain.
18. Using 2.54 cm screws, secure the adjustable legs by drilling through the pre-drilled leg plate holes into the base. A total of 32 screws are required.
19. Pre-drill holes on each side track to attach angle brackets in the desired positions.
20. Attach angle brackets using appropriate bolts and screws.
21. Side track fabrication is now complete.

Appendix D: Solidworks FEA Simulation Testing

Procedure:

1. Open the updated sidetracks Solidworks model
2. Open the add-on Simulation Tool
3. begin a new study
4. apply AISI 1020 Steel material to the adjustable legs and treadmill body
5. apply pine wood material to the side walls and sidetrack body
6. apply fixtures to the bottoms of the legs and treadmill body
7. apply bonded connections:
    a. side walls - main body
    b. main body - legs
    c. main body - treadmill body

8. apply load distribution to main body (1703 N)

9. create mesh and run simulation

10. analyze the results

Results:

Name	Type	Min	Max
Displacement1	URES: Resultant Displacement	0.000e+00mm Node: 130	1.371e-02mm Node: 62845

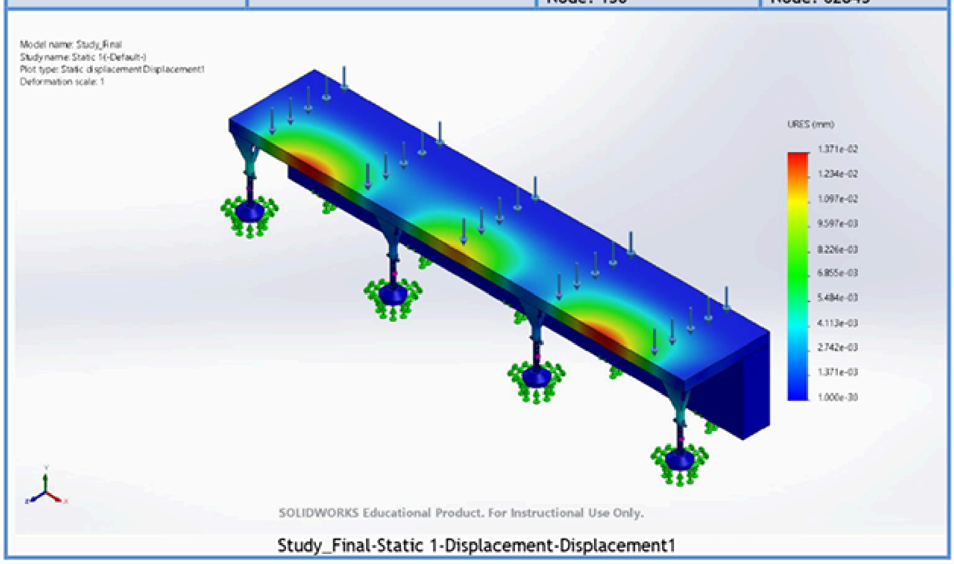

Figure D1. Displacement results for Solidworks FEA Simulation.

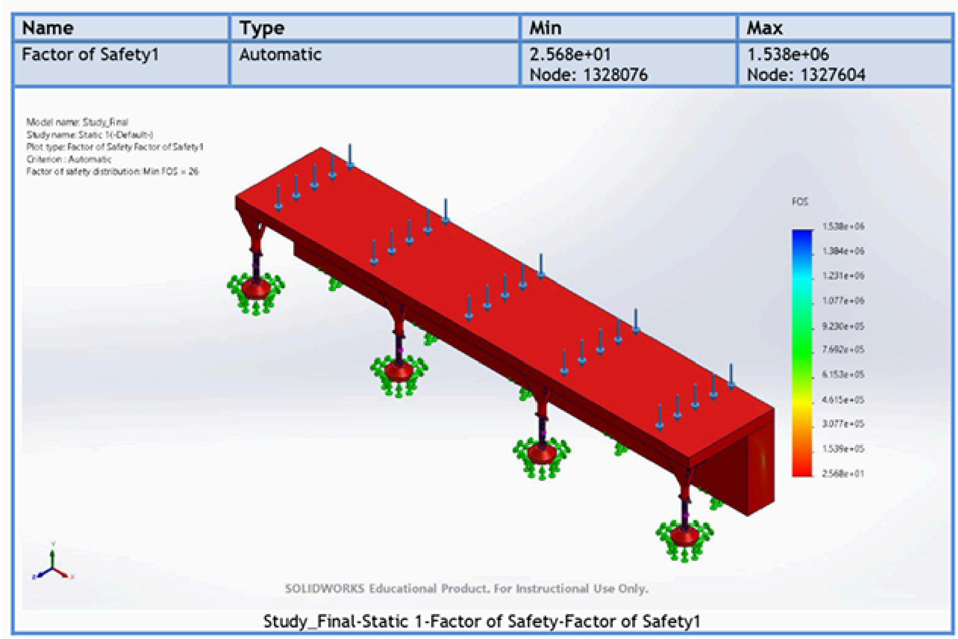

Figure D2. Factor of safety results for Solidworks FEA Simulation.

Appendix E: Stability Testing

Materials:

Side tracks, ramp, gait trainer, treadmill, tape, timer

Procedure:

1. Place tape at each corner of the side tracks and the ramp
2. Begin operating conditions set up
    a. Caregivers wheel patient onto the ramp
    b. Turn on treadmill
3. Set a 30 second timer
4. Measure the displacement of the side tracks and ramp from the tape
5. Repeat steps 2-3 for the duration of the trial period
6. Conduct steps 1-5 again, but with the 80/20 horizontal bars in place

7. Analyze results between the different conditions

Results:

Trial	Displacement (cm)	Observations
1	1.43 cm left back side to side	Caregiver was walking with gait trainer, only the back seemed to move with the side to side movement - could be due to kick back of caregiver and the ramp moving as a result
2	0.16 cm slightly shifted forward in both sidetracks	Nadine on the treadmill - not picking up feet as normal, feet do not go back far enough to kick ramp
3	0 displacement	Sierra walking on treadmill and purposely trying to create movement of tracks by bouncing and pounding on the treadmill while walking, tracks securely set up, movement on treadmill does not seem to affect it - only pressure on sidetracks from the gait trainer

Table E1. Displacement results of legs during treadmill usage without the 80/20 horizontal bars.

Trial	Displacement (cm)
1	0.0
2	0.0
3	0.0
4	0.0
5	0.0

Table E2. Displacement results of legs during treadmill usage with the 80/20 horizontal bars.

Stability Testing MATLAB Code:

```
clear; clc; close all;
groupA = [1.43, 0.159, 0];  % without bars
groupB = [0, 0, 0];  % with bars
[h, p] = ttest(groupA, groupB);


meanB = mean(groupB);
meanA = mean(groupA);


figure;
hold on
boxplot([groupA'; groupB'], [ones(3,1); ones(3,1)*2]);
ylabel("Displacement (cm)");
xticklabels({'Without Bars', 'With Bars'});
yticks(-0.5:0.5:1.5);
text(2, 1.25, 'N = 3');
text(1.95, 1.1, 'p > 0.05');
title('Displacement Results During Stability Testing')
hold off
```

Appendix F: Ease of Use Testing

Materials:

Side tracks, ramp, Gait trainer, treadmill, stopwatch

Procedure (Set-up):

1. Before recording perform 3 practice trials to become familiar with the set up process
2. Begin with ramp wheeled on top of the treadmill
3. Record the time it takes to wheel the ramp into position at the end of the treadmill
4. Repeat step 2-3 for a total of 3 trials

Procedure (Storage):

1. Before recording perform 3 practice trials to become familiar with the storage process
2. Begin with the ramp at the end of the treadmill
3. Record the time it takes to wheel the ramp to on top of the treadmill (in storage position)
4. Repeat step 2-3 for a total of 3 trials

Results:

Trial	**Time for setting up ramp (seconds)**	**Time for putting ramp in storage position (seconds)**
1	12.08	15.97
2	12.44	16.61
3	9.72	14.64
Avg	11.413	15.74

Table F1. Ease of use testing results for Sierra and Grace.

Trial	Time for setting up ramp (seconds)	Time for putting ramp in storage position (seconds)
1	12.89	11.59
2	13.16	11.91
3	8.68	13.33
Avg	11.57	12.27

Table F2. Ease of use testing results for Sara and Katie.

Trial	Time for setting up ramp (seconds)	Time for putting ramp in storage position (seconds)
1	12.61	11.56
2	11.66	11.40
3	10.03	11.06
Avg	11.43	11.34

Table F3. Ease of use testing results for Sierra and Katie.

Trial	Time for setting up ramp (seconds)	Time for putting ramp in storage position (seconds)
1	11.48	20.81
2	11.65	21.76
3	11.10	14.61
Avg	11.41	19.06

Table F4. Ease of use testing results for Sara only.

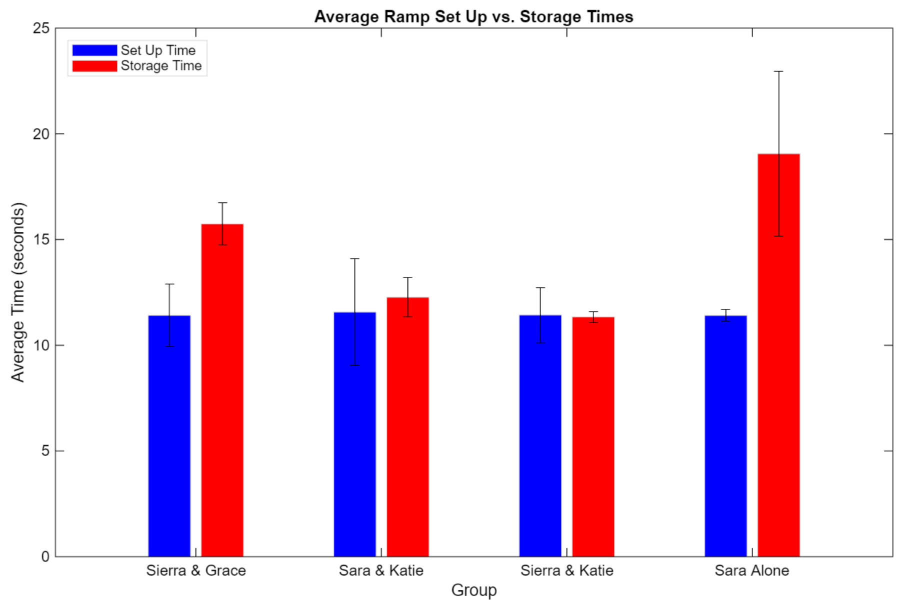

Figure F1. Comparison of average times during ease of use testing for each group.

Ease of Use Testing MATLAB Code:

```
groupA = [12.08, 12.44, 9.72];
groupA2 = [15.97, 16.61, 14.64];
groupB = [12.89, 13.16, 8.68];
groupB2 = [11.59, 11.91, 13.33];
groupC = [12.61, 11.66, 10.03];
groupC2 = [11.56, 11.40, 11.06];
groupD = [11.48, 11.65, 11.20];
groupD2 = [20.81, 21.76, 14.61];

group = [mean(groupA), mean(groupB), mean(groupC)];
group2 = [mean(groupA2), mean(groupB2), mean(groupC2)];
mean_g = mean(group)
mean_g2 = mean(group2)
mean_d = mean(groupD)
mean_d2 = mean(groupD2)


[h, p] = ttest(group, groupD);
[h2, p2] = ttest(group2, groupD2);

figure;
```

```
hold on
boxplot([group'; groupD'], [ones(3,1); ones(3,1)*2])
ylim([11 12]);
yticks(11:0.2:12)
xticklabels({'2 People','1 Person'});
text(2, 11.9, 'N = 3');
text(1.95, 11.85, 'p > 0.05');
ylabel('Time (sec)');
title('Set-Up Times Between Groups');
hold off

figure;
hold on
boxplot([group2'; groupD2'], [ones(3,1); ones(3,1)*2])
ylim([10 25]);
yticks(10:2.5:25);
xticklabels({'2 People', '1 Person'})
text(2, 24, 'N = 3')
text(1.95, 23, 'p > 0.05')
ylabel('Time (sec)');
title('Storage Times Between Groups');
hold off
```