Delta Horizons

Peace of Mind
Braking System

A Bimodal Braking System that Improves the Safety of Four-Wheeled Walkers

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Engineering for Social Innovation
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Background and Motivation

Delta Horizons has created a novel braking system to improve the safety of four-wheeled walkers. The design features a mechanical system that does not require conscious user input. The brakes are engaged when the walker is unloaded to keep it from rolling away from the user. During normal use, the walker can roll freely. During excess loading, the brakes again engage, creating a stable system.

The Problem

The mission of this project is to improve the safety of four-wheeled walkers, or rollators. While rollators give their users freedom and increased mobility, user input is needed to engage the brakes. Many elderly people (age 65+) experience cognitive decline and forgetfulness as they age. Forgetting to engage the brakes can create an unstable walker that can slip out from underneath the user and lead to serious injury.

Expert Input

The team conducted multiple interviews with potential users and relevant experts. 34 retirees from retirement homes across the front range were interviewed to discuss pain points with their current walkers. 13 relevant medical experts including physical therapists, medical suppliers, and orthopedic surgeons were also interviewed. The consensus of these interviews was that wheeled walkers provide users with better mobility but require the user to properly use the brakes, which is a challenge for those with declining memory. Both sets of conversations were valuable and guided the team to the final design.

Our Solution

The Peace of Mind braking system is a mechanical system that introduces bimodal braking capabilities. When no load is applied to the walker, the Roll-away Brake will be engaged, keeping the walker from rolling away from the user. When a small load is applied, such as the weight of the user's arms during normal use, the Roll-away Brake disengages, allowing for free rotation of the wheels. When a large load is applied to the walker, such as when the walker is used to help the user stand, the Safety Brake will engage, stopping further rotation of the wheels until the load is removed. The design will also allow for the stock manual brakes to be able to function normally. This system has been tailored to the intended user. The purely mechanical design improves durability and removes the need for conscious user input in order to activate the brakes.

Design

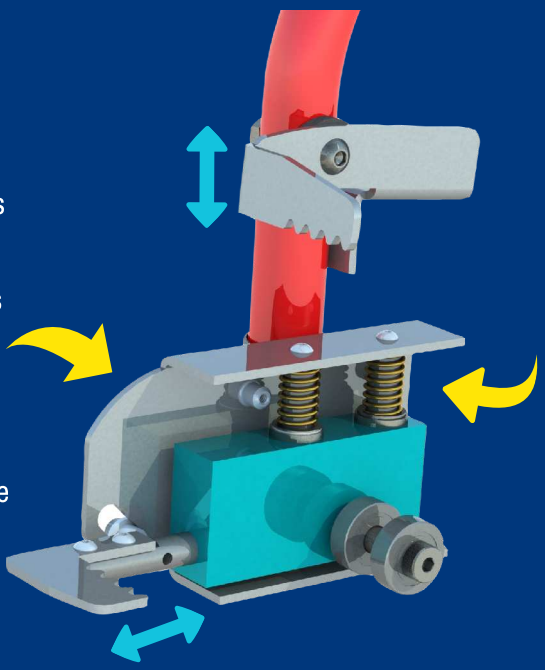
Overview

The Peace of Mind braking system was born out of innovation on simple crank and slider linkage mechanisms. The system is made from a sheet metal cover, a set of two differently sized parallel springs, two vertical linear motion shafts, one horizontal shaft, and a sliding block. The sliding block is rigidly attached to the axle of the wheel. The walker is rigidly attached to the external frame of the P.O.M braking system. Two vertical linear motion shafts attach through the external frame slot of the sliding block and lock it in place. Springs concentric to the vertical linear motion shafts, and in contact with the top face of the sliding block and inside face of the external frame, control the translation of the walker. This allows the Safety Brake to translate up and down. Additionally, an angled slot on the external frame fastened to the horizontal shaft allows left to right translation of the Roll-away Brake, creating two braking modes.

During the first braking mode, the longer spring is supporting the weight of the walker and the Roll-away Brake, held at the bottom of the angled slot, holds the walker in place. When the user places their hands on the walker, the long spring compresses, deactivating the Roll-away Brake and allowing the user to roll the walker. During the second braking phase, the Safety Brake engages when a large load is applied to the walker. The large load compresses the shorter, stiffer spring, bringing the Safety Brake into contact with the wheel. The Safety Brake will stop wheel rotation in the case of a fall, user sitting on the walker, or any other excessive load on the walker. The two-spring system maintains stability during walker use and is designed to last the walker's lifetime.

Sheet Metal Housing

One of the most critical components is the steel sheet metal housing. This material was chosen after calculations for force loading on the system, including a finite element analysis model. In order for the system to be robust and resist deformation, 12-gage steel metal was chosen.



Springs

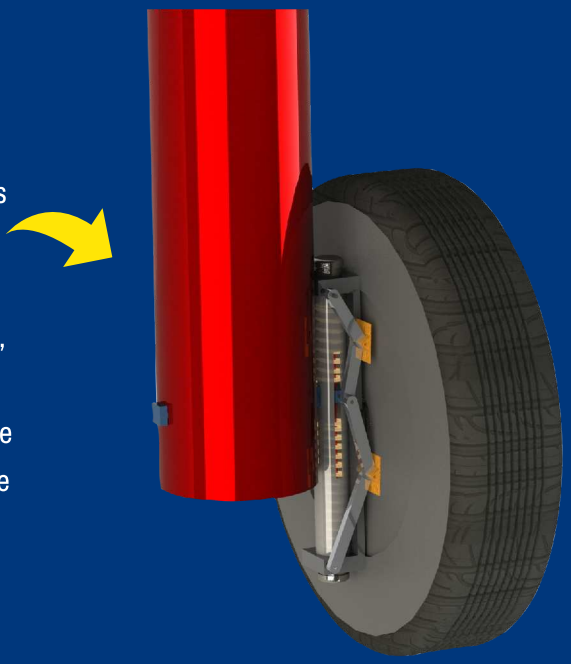
Another crucial component of this braking system is the set of springs. The springs determine what force is needed to engage or disengage the brakes. The springs must have the correct spring constant in order for the system to function properly. Analysis of the system and user testing was used to determine the ideal spring constants of each spring.

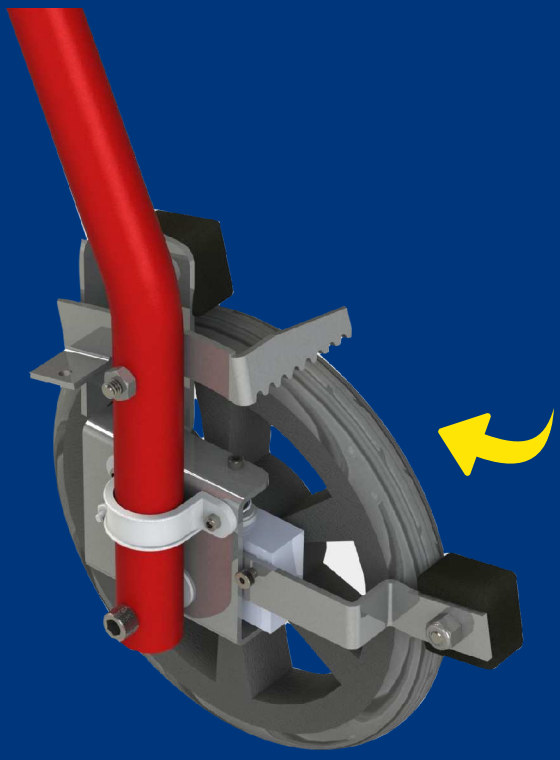
Previous Design Iterations

The previous designs included similar motivations but with different executions.

First Iteration

Initial ideation experimented with utilization of only one additional braking mode, but through client meetings and potential user outreach, two additional braking modes were incorporated in all current designs. Utilizing core concepts from crank and slider linkage mechanics, the team assessed the viability of various potential braking systems. Design 1 includes two springs separated by the axle of the walker leg. The top spring is in tension, and holds the walker up, while the bottom spring is in compression, and determines the maximum loading threshold. Two different rubber brake pads make contact with the inside face of the wheel, at two different instances corresponding to the loading on the walker. This design did not have enough structural integrity nor braking force, so a more robust design was pursued.





Second Iteration

The second design reflects the team's first manufactured prototype. Brake pads were originally used on both the Roll-away and Safety Brake. Through testing, the brake pads were determined to be ineffective. Excessive wear on the pads altered alignments and disrupted the system's ability to brake properly. While the previous design had two springs in parallel like the current design, those springs had the same spring constant. User testing found the system to be "too bouncy" due to spring resonation, making the walker uncomfortable to use. This problem was addressed in the current design where the two springs have different spring constants.

Manufacturing Considerations

Current Design

For the manufacturing of each prototype, the team was constrained by supply chain limitations and on-campus resources. The team had access to waterjet cutting from the Idea Forge shop and sheet metal bending equipment from the maintenance facility, providing a cost and time-efficient way to manufacture the system housing. While the injection molding of this and other components would have made the braking system lighter, funds and resources forced the use of fasteners. All other parts were designed to be manufactured by the on-campus lathe and mill in order to avoid the wait time and costs associated with outsourcing.

Future Design

In future designs, the Peace of Mind braking system will incorporate low-cost manufacturing techniques to reduce per-unit costs. Low-stress components, determined by FEA, will be replaced by injection molded plastic components. Another manufacturing change will be to reduce the machining complexity of the aluminum component by creating metal casting in its rough shape. Lastly, reducing the number of fasteners would reduce the cost and weight of the product. These future iterations work to reduce the overall product cost and weight, thus increasing the profit margin.

Testing and Results

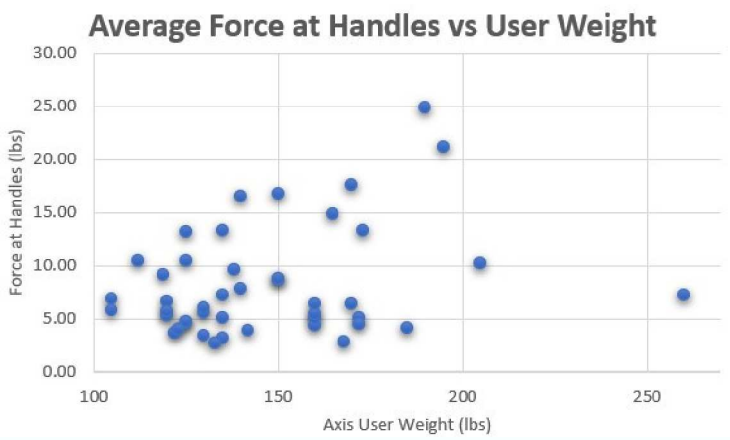
Research Testing and Verification Testing

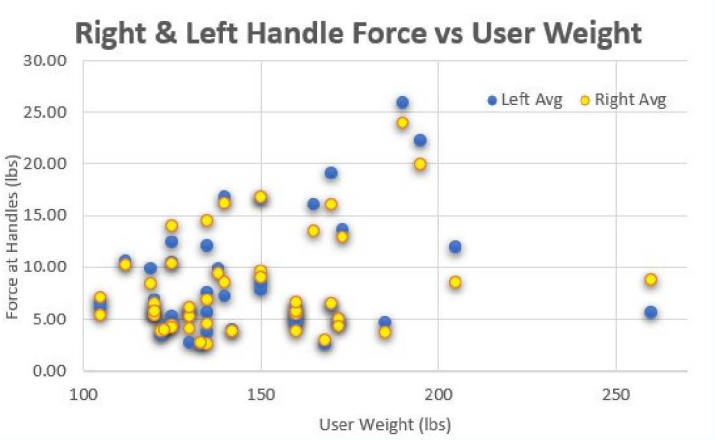
Research Testing

The testing for this project was twofold: research and verification. The research testing involved the team using scales and hand dynamometers to define the relationship between user weight, the weight at the handles of the walker, and the weight distribution through the legs of the walker. For these tests, 6 volunteers acted as users for the Standing Hold Test and 46 volunteers acted as the users for the Seat to Stand Test. In the Standing Hold Test, users were asked to rest their hands comfortably on the handles of the walker to determine the threshold change from Roll-away Brakes to no brake engagement. In the Seat to Stand Test, users were asked to go from a seated to a standing position using the handles of the walker for support to determine the threshold in which the Safety Brake should engage.

Results

While there was no statistical significance in the difference between forces at the handles for the user weights for the weights ranging from 125-170 lbs for the Standing Hold Test, the data is unreliable because 6 subjects is not a large enough sample to draw conclusions. After performing analysis for the 46 data points for both the right and left hands results for these two different tests showed that there was no statistically significant difference in the weight distribution at the handles of the walker even with outliers at 260 lbs. The spread of the data for users ranging from 100 to 260 lbs is displayed below. From this analysis, the range of threshold forces for the different brake engagements of the walker were determined.





Verification Testing

The following verification tests will be performed in April of 2022:

- Spring Fatigue: Determining that rate of fatigue of the springs
- Maximum Load on Assembly
- Assembly Fatigue
- Vibration & Terrain Testing
- Day in the Life Tests

Business and Market Considerations

Market Size

This product lies within the walking aid market. The total addressable market is the global walking aid market, valued at 2.5 billion USD [1]. The serviceable addressable market is the global walker market, valued at 810 million USD [2]. Refining this space provides the global four-wheeled walker market, valued at 110 million USD [3]. This four-wheeled walker market is the serviceable obtainable market. With market valuations this high, there is clear potential to leverage the competitive advantage of the Peace of Mind braking system and generate a profit.

Competition

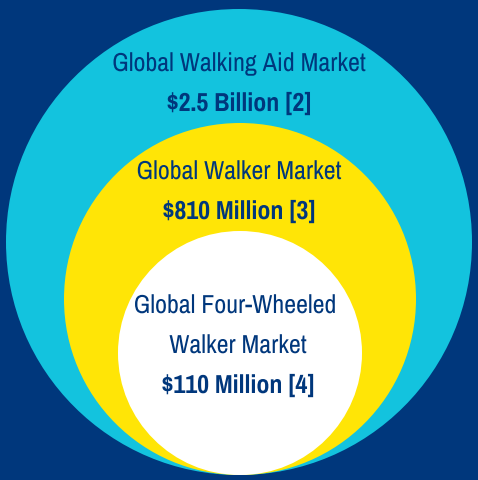
Delta Horizons is competing with other walker brands and products in the walking aid space. The main competition comes from other four-wheeled walkers. Drive Medical has the largest market share in this space. Their four-wheeled mobility walker is the best-selling walker, and therefore the largest competitor. It should be noted that while Delta Horizons is competing with all other four-wheeled mobility walkers, the Peace of Mind braking system is completely innovative and unique. This gives Delta Horizons a clear competitive advantage and motivates a higher price point.

Revenue Streams

The business plan for Delta Horizons revolves around the direct sale of walkers equipped with the Peace of Mind braking system. Penetrating the beachhead market of local physical therapists, retirement communities, and medical suppliers is the primary source of revenue. To this end, connections have been established with local medical experts to help generate early sales. After establishing credibility in the medical industry with direct sales, Delta Horizons will pursue product licensing with existing walker manufacturers as an additional revenue stream.

Company Traction

Delta Horizons won the 2022 CU Boulder New Venture Challenge Cross-Campus Specialty Competition and was a semifinalist in the main round of New Venture Challenge. Combined with company outreach, expert interest, and GetSeed funding from CU Boulder, Delta Horizons is set to expand and generate profits.



Market Breakdown

Delta Horizons is a diverse team of engineers working to create safe, credible, and innovative walking aid devices.

Conclusion

After discovering a lack of innovation within the mobility industry, Delta Horizons has created a novel braking system to improve the safety of four-wheeled mobility walkers. Notable progress has been made in multiple areas of this product. There have been numerous design iterations, with clear improvements made each time. User testing and product analysis have generated key insights, leading to a useful and successful product that directly addresses user pain points. Business development has provided capital for the company, both through CU Boulder's GetSeed fund and the prize money from winning the Cross Campus New Venture Challenge competition.

Through intense customer development, design analysis, prototyping, and business expansion, the Peace of Mind braking system is ready to disrupt the mobility industry.

References

[1]“Walking AIDS market research report by type, by application, by region - global forecast to 2026 - cumulative impact of COVID-19,” Yahoo!, 13-Oct-2021. [Online]. Available: https://www.yahoo.com/lifestyle/walking-aids-market-research-report-072700883.html?guccounter=1&guce_referrer=aHR0cHM6Ly93d3cuZ29vZ2xlLmNvbS8&guce_referrer_sig=AQAAAGDRE4WrHvHvtnXFBwzvV9YtzReHZcFZdOmwTErPCvxg1VF8bv3RP8_WKuRo83uCt1CEBll0VKfpHjAVVQprZQSd5UgUCQAZ_cUU6xvhWaq5Y1pAVXG_90WMDDG7_gPGaJ8s1eL4EVvv_G5WrOtvtnGqBLROHsxJxaQbRT0asx9v. [Accessed: 17-Mar-2022].

[2]“Medical walker market: Global industry analysis and Forecast (2021-2027),” MAXIMIZE MARKET RESEARCH, 07-Feb-2022. [Online]. Available: https://www.maximizemarketresearch.com/market-report/global-medical-walker-market/84285/. [Accessed: 17-Mar-2022].

[3]A. More, “Rollator Walker market share 2021 global growth, trends, industry analysis, key players and forecast to 2027,” WICZ, 16-Nov-2021. [Online]. Available: https://www.wicz.com/story/45299741/Rollator-Walker-Market-Share-2021-Global-Growth,-Trends,-Industry-Analysis,-Key-Players-and-Forecast-to-2027. [Accessed: 17-Mar-2022].

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