STAIR CHAIR

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Problem Statement

A mechanically powered stair climbing device must be created to help temporarily disabled patients at Encompass Rehabilitation Hospital with stair negotiation during their non-weight bearing period of recovery. Crutching up stairs is not feasible for elderly patients, and large electric stair climbing devices are beyond the budget of many patients. The device should be able to fit between 3-5 stairs and withstand average outdoor weather conditions in the state of Wisconsin.

Motivation & Background

- Stair negotiation is difficult for elderly patients at Encompass Rehabilitation Hospital
  - One million Americans each year are treated for complications from falls while using stairs [1]
- Completely healthy older adults (>55) are at a greater risk for falls [2]
  - 42.1% of stair related injuries impact lower extremities [1]
  - Older adults are more prone to fractures than younger adults [1]
- Electric stair climbing devices can cost at a minimum $3000 [3]
  - Design must be mechanically powered to be cost effective
- The full scale design uses a winch to allow user to generate mechanical input
- Women aged 70 and older an average can generate 45% of the power 20 year old women can [4]
- Young women maximum power output tends to be about 86 Watts [5]
  - Braking winch selection can be tuned to the power output of old women

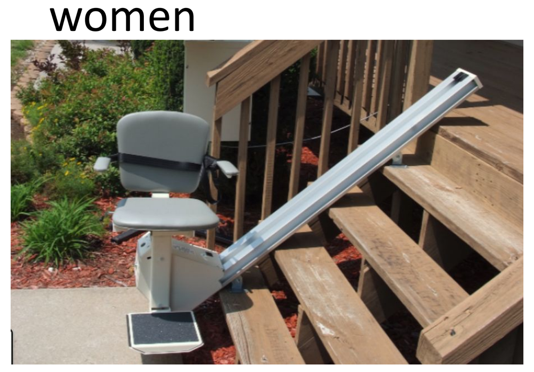

Figure 1: Electric Stair Lift [6]

Figure 2: Braking Winch [7]

Design Specifications

- Mechanically powered stair climbing device
  - Can ascend and descend between 3-5 stairs
  - Can withstand up to 140 kg to account for variable masses of users
- Weight of the device must not exceed 30 kg
- Can be used frequently for up to 26 weeks
- Appropriate safety measures to fulfill ISO standards of performance and quality for medical devices [8]
- Expected life in service of up to 5 years, per Durable Medical Device (DME) requirements [9]
- Generate a proof of concept for possible further exploration

Final Design

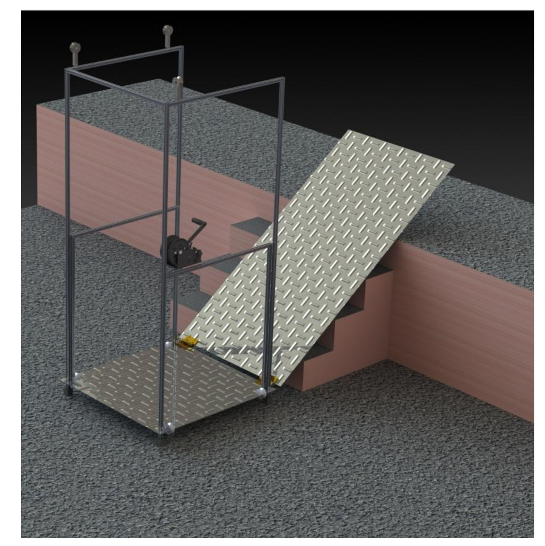

Figure 3: SolidWorks Model of Final Design at Lowered Position

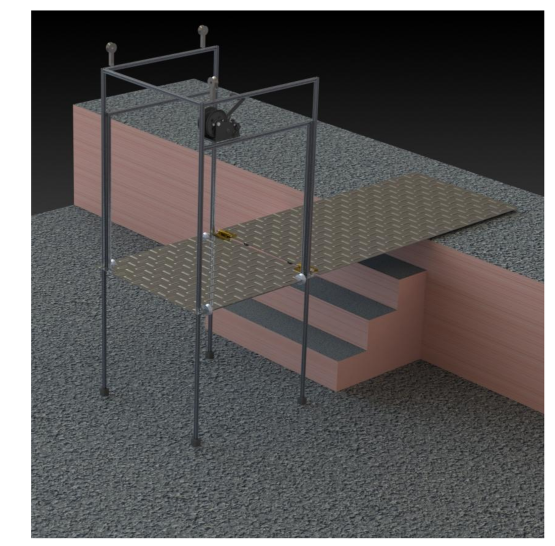

Figure 4: SolidWorks Model of Final Design at Top Position

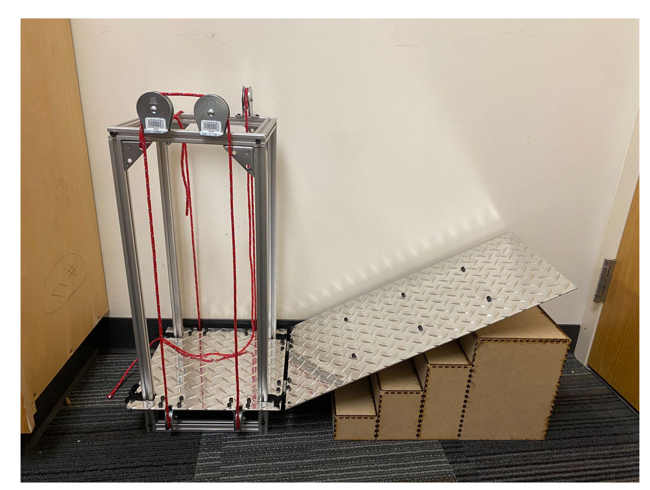

Figure 5: 3:1 Scale Model at Lowered Position

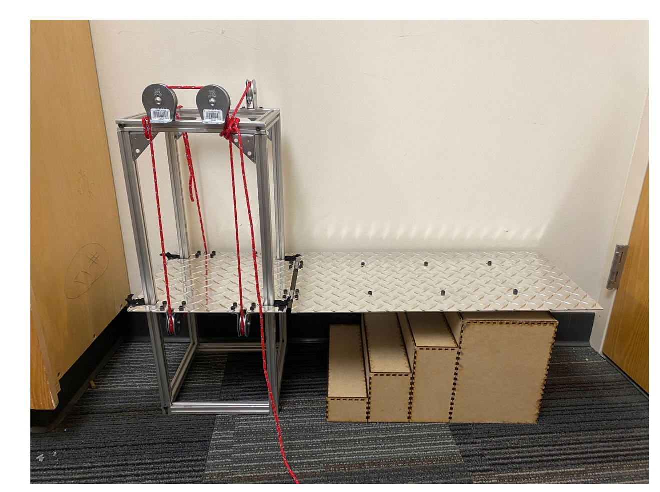

Figure 6: 3:1 Scale Model at Raised Position

Testing

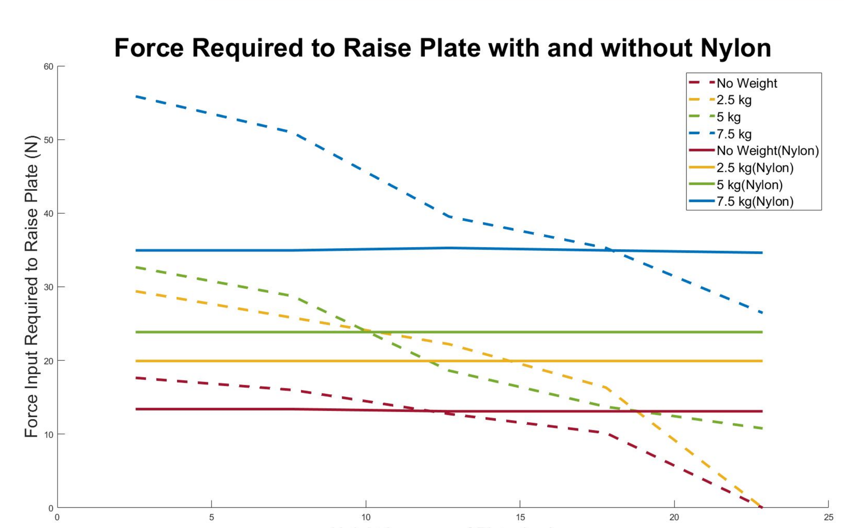

Figure 7: Force Required to Raise Lift with and without Nylon

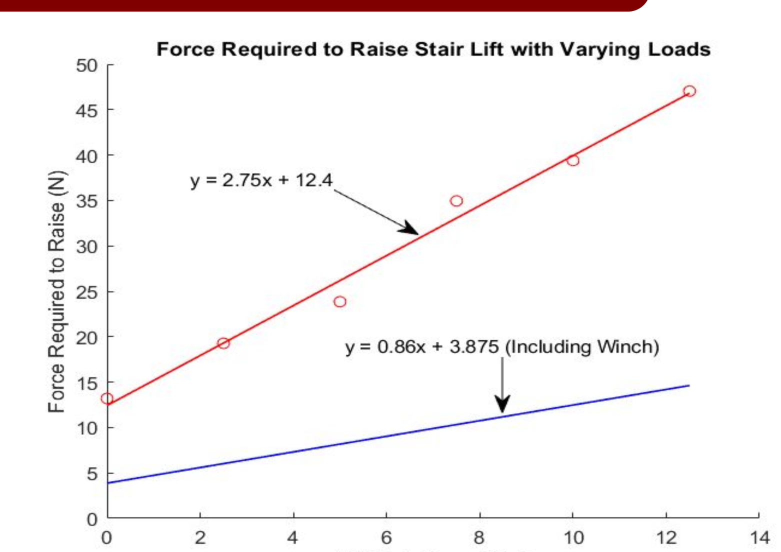

Figure 8: Force Required to Raise Lift with Varying Loads

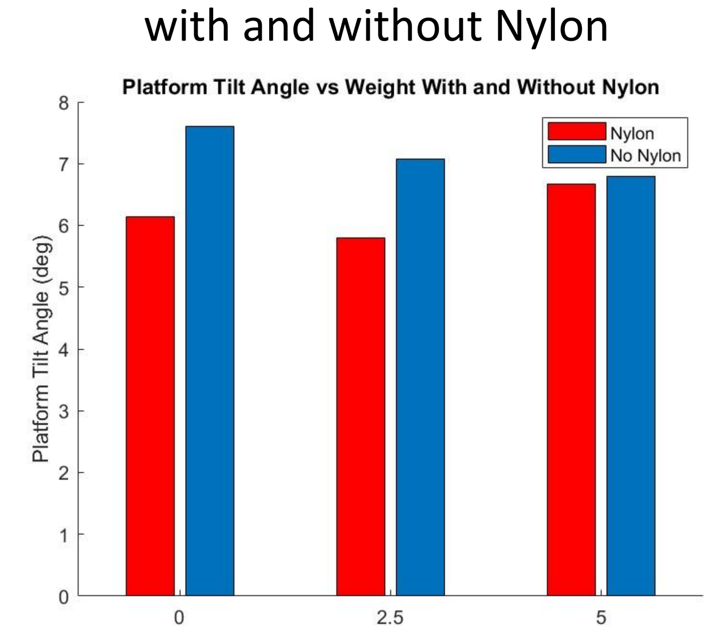

Figure 9: Average Platform Tilt Angle While Raising Platform With and Without Nylon

Figure 10: Testing of Required Force and Platform Angle With 7.5 kg Load and Nylon

Results

- Force Required to Raise Lift
  - Constant throughout ascent with inclusion of nylon to the plate
  - Scales linearly with an increased load by 2.75 N per 1 kg added
  - With addition of a winch, the force required would scale down by 3.2 times
- 12 N*m of work needed to raise 17.3 kg up the lift (⅓ of average mass of elderly woman)
- Assuming this work increases linearly with a scaled up design, an elderly woman could raise a full scale lift in 10 seconds at 10% of their peak power output potential
- Without nylon, the average platform tilt angle decreased with added weight, stopping after 5 kg due to friction preventing movement. With nylon, the tilt angle decreased by nearly one degree and was minimized with 2.5kg
- Platform tilt would be remedied further by the use of T-slot bearings and more precise machining
- Final 3:1 scale model weighs 6.8 kg. Full scale apparatus is estimated to weigh about 37kg

Discussion & Future Work

- Benefits of Current Design
  - Design is free standing, adaptable to varying heights, and functional at scale loads congruent with expected loads on full sized prototype.
- Issues With Current Design
  - Platform tilts during ascent, creating friction with the vertical frame.
  - Platform is not balanced well and friction greatly slows descent at high loads.
- Future Work
  - This design proved the feasibility of this type of device, allowing for a full size prototype to be built that would include the following:
    - A winch to lower force requirements
    - Bearings to guide plate up the lift, reducing tilt
    - A railing on the platform and ramp for safety
  - Failure tests need to be done to verify the safety of the device with much greater loads

References

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[3]"2023 Stair Lift Cost & Prices | Chair Lift Cost," Arrow Lift. https://arrowlift.com/stair-lifts/stair-lift-prices/
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