A Novel Cost-Efficient Wheelchair Training Roller for Persons with Disabilities in Economically Disadvantaged Settings: Easy Roller

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Barriers to physical mobility in economically disadvantaged settings

4 tracks nationwide

Government support?

>5x monthly income\textsuperscript{1,2}
To design a portable, affordable, and easily manufacturable training system with variable resistance for a variety of wheelchair athletes.
Current wheelchair training devices

Stationary training device, Accra, Ghana.

Bulky (49 lbs.)

Dynolight Rollers, UK.

Expensive (1147 USD)
<table>
<thead>
<tr>
<th>Priority</th>
<th>Constraint/Want</th>
<th>Description</th>
<th>Target Value/Metric</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Safety</td>
<td>Device can hold wheelchair &amp; person</td>
<td>Holds 250lbs</td>
<td>Provided by sponsor</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Safe to get onto device</td>
<td>&lt;170 mm from ground</td>
<td>ASTM F3022-15®</td>
</tr>
<tr>
<td></td>
<td>Originality</td>
<td>Device cannot infringe on existing designs and patents</td>
<td>N/a</td>
<td>N/a</td>
</tr>
<tr>
<td>1</td>
<td>Affordability</td>
<td>Material cost</td>
<td>&lt;$250</td>
<td>Provided by Sponsor</td>
</tr>
<tr>
<td>2</td>
<td>Manufacturability</td>
<td>Design must be easily manufactured in bulk</td>
<td>Est. 20,000 units yearly</td>
<td>Motivation UK</td>
</tr>
<tr>
<td>3</td>
<td>Portability</td>
<td>Weight &amp; dimensions of condensed device</td>
<td>50 lbs, 62 inches combined height + width + length</td>
<td>LuggagePros®</td>
</tr>
<tr>
<td>4</td>
<td>Usability</td>
<td>Ability required to engage in device usage</td>
<td>One person</td>
<td>Benchmark Reviews®</td>
</tr>
<tr>
<td>5</td>
<td>Durability</td>
<td>Units cannot rust and shall maintain usable</td>
<td>Min. 4 years w/o corrosion or fatigue failure or 2.7 million rotations</td>
<td>Sponsor Request</td>
</tr>
<tr>
<td>6</td>
<td>Compatibility</td>
<td>Device must coincide with common characteristics of racing wheelchairs</td>
<td>Front wheel diameter: 0.36-0.46m, Back wheel diameter: 0.61-0.69m</td>
<td>Journal of Rehabilitation Research and Development®</td>
</tr>
<tr>
<td>7</td>
<td>Resistance</td>
<td>Ability to change amount of force required to turn wheels</td>
<td>TBD</td>
<td>Provided by Sponsor</td>
</tr>
<tr>
<td>8</td>
<td>Time</td>
<td>Final prototype must be finished along with drawing package for manufacturing</td>
<td>12/15/2017</td>
<td>Course syllabus</td>
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Design goals

<table>
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<th>Constraint/Want</th>
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<tr>
<td>Affordability</td>
<td>Material cost &lt;250 USD</td>
</tr>
<tr>
<td>Portability</td>
<td>&lt;50 lbs.</td>
</tr>
<tr>
<td></td>
<td>&lt;62 linear inches total^5</td>
</tr>
<tr>
<td>Manufacturability</td>
<td>Est. 20,000 products yearly</td>
</tr>
<tr>
<td>Adjustability</td>
<td>Facilitate various athletes</td>
</tr>
</tbody>
</table>
Design process

Testing at Moss Rehab, PA, USA
Specifications

Material:
• 2x2x1/8” 6061 aluminum square tubing
• Conveyor belt rollers
• U and L brackets

Dimensions:
• 17 x 15 x 3,5”
What makes the easy roller successful?

Pre-fabricated components creatively combined

1. Aluminum frame
2. Raised feet
3. Conveyer belt rollers
4. Inertial weight
5. Variable resistance

The Easy Roller prototype
Final design

*Full set up of the Easy Roller, Newark, DE*
Results

Affordable
- $170 - 200 cost of goods
- Stock materials

Easy to manufacture
- Pre-fabricated components
- TBD further

Adjustable
- Resistance
- Moment of inertia

Durable
- Interchangeable stock materials
  - Withstand 260 lbs.
  - Industry-grade rollers
  - 2.7 million rotations

Portable
- Flat-pack design
  - 34 lbs
  - 42 linear inches
## Results

<table>
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<tr>
<th>Constraint/Want</th>
<th>Target Value</th>
<th>Value</th>
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</thead>
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<tr>
<td>Affordability</td>
<td>Material cost &lt;250 USD</td>
<td>$170-$200</td>
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<tr>
<td>Portability</td>
<td>&lt;50 lbs.</td>
<td>34 lbs.</td>
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<td></td>
<td>&lt;62 linear inches total$^5$</td>
<td>42 linear inches total</td>
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<tr>
<td></td>
<td></td>
<td>Flat pack design</td>
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<tr>
<td>Manufacturability</td>
<td>Est. 20,000 products yearly</td>
<td>TBD</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pre-fabricated components</td>
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<tr>
<td>Adjustability</td>
<td>Facilitate various athletes</td>
<td>Resistance levels</td>
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<tr>
<td></td>
<td></td>
<td>Moment of inertia</td>
</tr>
<tr>
<td>Durability</td>
<td>Min. 4 years w/o corrosion or fatigue failure or 2.7 million rotations</td>
<td>Interchangeable stock materials</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Withstand 250 lbs.</td>
</tr>
</tbody>
</table>
Future directions

• Stabilization of the front part
• Ramp add-on feature
• User-friendly resistance adjustability & numbering
• Performance feedback
  o Accelerometer (speed and distance)
  o Save data connected to an application
• Testing by variety of athletes
• Failure testing & life span
Conclusion

Need to *enhance* the *training facilities* of athletes in socially disadvantaged settings

- Portable
- Affordable
- Easy to manufacture

➢ Variable resistance levels
Potential impact

4 tracks nationwide

Government support?

>5x monthly income$^{1,2}$
References

Thank you

Dr. Yetsa Tuakli-Wosornu (Yale University)
Dr. Jenni Buckley (University of Delaware)
Raphael Botsyo & Maclean Atsu Dzidzienyo – Go Get Dem Wheelchair Racing Club
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MossRehab & Global Abilities (Pennsylvania, USA)
Chapter 126 Sports & Fitness (Connecticut USA)
Dr. Sarah Rooney
Dr. Rory Cooper
Biomedical & mechanical department – University of Delaware