Unpowered Assistive Knee Brace for Sit-to-Stand Transition

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The Decreasing Sit-to-Stand Ability

The International Classification of Functioning, Disability, and Health lists mobility, management of domestic tasks, and engaging in activities like employment as some of the most critical categories for consideration when assessing disability and impairment. All of these actions either require or incorporate the use of the Sit-to-Stand transition process, and therefore can suffer as an individual ages.

Average Sit-to-Stand Transitions, per Day, by Age Group

<table>
<thead>
<tr>
<th>Age Group</th>
<th>1960 Census</th>
<th>2015 Census</th>
<th>2060 Est.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Young Adults/Independent Living</td>
<td>4.5%</td>
<td>4.0%</td>
<td>3.5%</td>
</tr>
<tr>
<td>Elderly Persons, in Assisted Living</td>
<td>7.5%</td>
<td>8.5%</td>
<td>9.5%</td>
</tr>
</tbody>
</table>

The United States population over the age of 65; 1960, 2015, and 2060 projected.

Existing Solutions & the Need for Improvement

There are three main types of existing devices to assist with the Sit-to-Stand Transition: push-support, such as Spring Chairs; lift-support, such as hospital Lift Stands; and upper-body assistance, such as Handheld Canes. Each type fails to address one or more key areas of need for an assistive device.

<table>
<thead>
<tr>
<th>Device</th>
<th>Cost</th>
<th>Portable</th>
<th>Affordable</th>
<th>Effective</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lift Stands</td>
<td>$500-$10,000</td>
<td>-</td>
<td>-</td>
<td>X</td>
</tr>
<tr>
<td>Spring Chair</td>
<td>$100-$2,000</td>
<td>X</td>
<td>X</td>
<td>-</td>
</tr>
<tr>
<td>Handheld Cane</td>
<td>$15-$500</td>
<td>X</td>
<td>X</td>
<td>-</td>
</tr>
</tbody>
</table>

Design Requirements

Project Goals and Objectives

Assistive Structure

Provide an assistive force or moment to the subject in order to improve their ability to perform the Sit-to-Stand transition.

Safety and Lifestyle Integration

Perform the intended function without interfering with other day-to-day activities such as walking, running, kneeling, sitting, and standing.

Economic Viability

Minimize the complexity of the design in order to reduce its unit cost, without sacrificing reliability or functionality.

Design Specifications

Mechanical Advantage

Target the knee joint moment, between phases 2 and 3. Deliver an additional 0.2 Newtons per Kilogram.

Cost to Consumer

Limit cost to $300, undercutting Spring Chairs and Lift Stands.

Safety Parameters

Continuous operation for six months, or eleven thousand cycles.

Mechanism Evaluation

SOLIDWORKS 2016 Finite Element Analysis Simulation

Simulated using 3D Printed ABS Plastic and a 0.45Nm torque applied about the central axis.

Result: less than 0.004mm deflection on all surfaces.

Physical Prototype Testing

Physical testing of a preliminary prototype using 3D strength springs performed as expected. Estimate that the size could be reduced by 40% if machined steel was substituted for the ABS.

Citations

http://www.rehabmart.com/category/standing助理


data: 19 Nov. 2016.


Final Design

The full truss assembly and final components are included in for clarity, but the truss assembly itself has not been evaluated to ensure that it meets design requirements, beyond basic dimensioning. The mechanism shown in the entirety of this project’s final design and has been evaluated to ensure that it meets the design parameters.

A. Upper truss attachment cable
B. Structural bolt that both holds the mechanism together and acts as the rotation shaft for the ratchet levers
C. Linear ball-bearing embedded into the central cam disk allows it to slide along the Lateral axis
D. Central shaft, oriented along the lateral axis
E. Central cam disk interfaces the cables, ratchet mechanism, and drive spring
F. Cable guide along the outer diameter of the cam-disk to help prevent wear
G. Ratchet lever arm for interfacing with the cam-disk ratchet teeth
H. (Not Shown) Torsion spring inside the ratchet lever arm supplies the spring-back force
I. Lower truss attachment cable, attached to the drive spring
J. Primary drive spring for supplying the assistive moment