Brace to Facilitate Increased Mobility and Improved Posture for Patients Suffering from Spinal Abnormalities

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Abstract

Camptocormia is defined as a forward bend in the thoracic or lumbar region of the spine of at least 45 degrees when upright which dissipates in the supine position. The cause of the condition is unknown and the market for treatment devices is limited. A mobility brace has been developed to facilitate an upright stance and increased mobility, including the ability to bend forward and perform daily tasks. Relevant calculations to understand the dynamics of the condition and the forces which needed to be produced by the brace were performed. Patient and device testing was performed to determine the needs of the patient and capacity of the device. After analysis of three design alternatives, a cam mechanism yielded the highest score in the design matrix, due to functionality and self-operability. After producing a model of the brace in SolidWorks, the team fabricated and tested the final design.

Background

Figure 1: Camptocormia behavior[1]

Camptocormia
- Forward bend in thoracic or lumbar region of spine exceeding 45° when upright, but dissipates in supine position[2] (Figure 1)
- Often accompanies Parkinson's disease
- Cause Unknown: may be physiological or neurological[2]

Spine Brace Market
- None tailored to unique moment at hip
- Currently uncomfortable options focused at preventing bending in the mid-lower back[3]

Design Specifications
- Hold upright yet allow range of motion
- Weight less than 44.8 N, comfortable for all day use
- Self-Operable, quick & simple application/removal
- "Not a robot"

References

[1] http://www.parkinsonnet.nl/media/1004438/doherty_lancet%20neurology%20(2011)%20postural%20deformities.pdf

[2] Doherty (2011). Postural Deformities in Parkinson's Disease. The Lancet Neurology , 10 (6), 538-549.

[3] Overcoat, V. 2005). By fitting leather corset postures camptocormiques. Annals of Physical Medicine and Rehabilitation , 48 (8), 603-609.

Final Design

Reference Number - Design Component	
1	Upper anchoring ring
2	Upper lever arm
3	Corset
4	Lower lever arm
5	Lower anchoring ring
6	Cam rotational pieces
7	Elastic cam band
8	Michelle

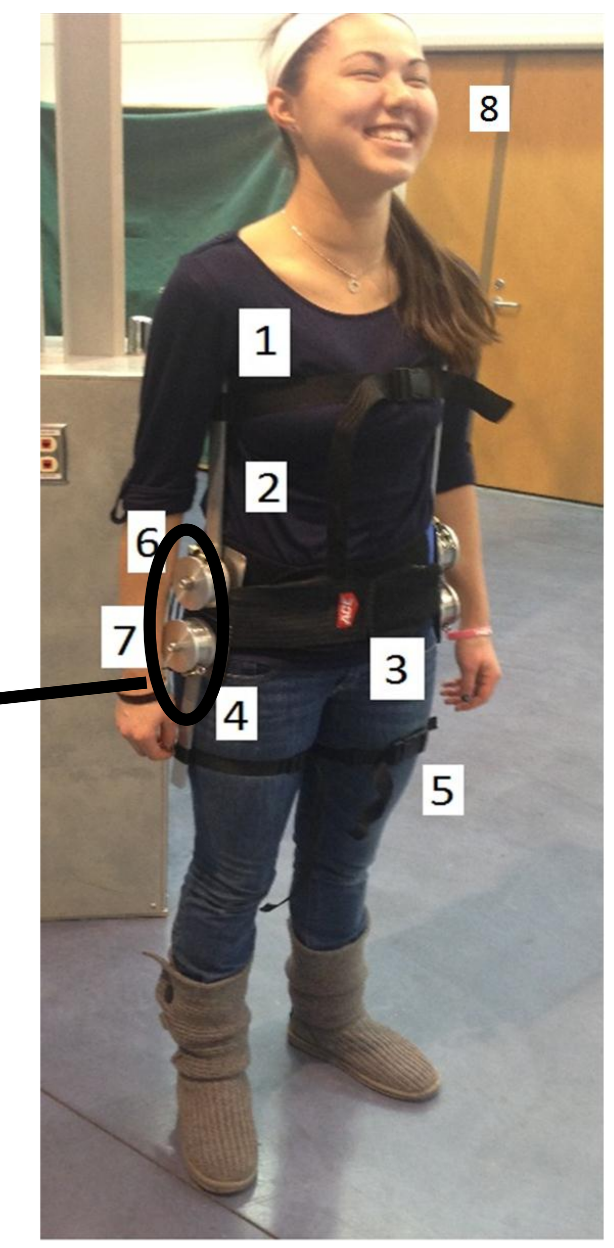


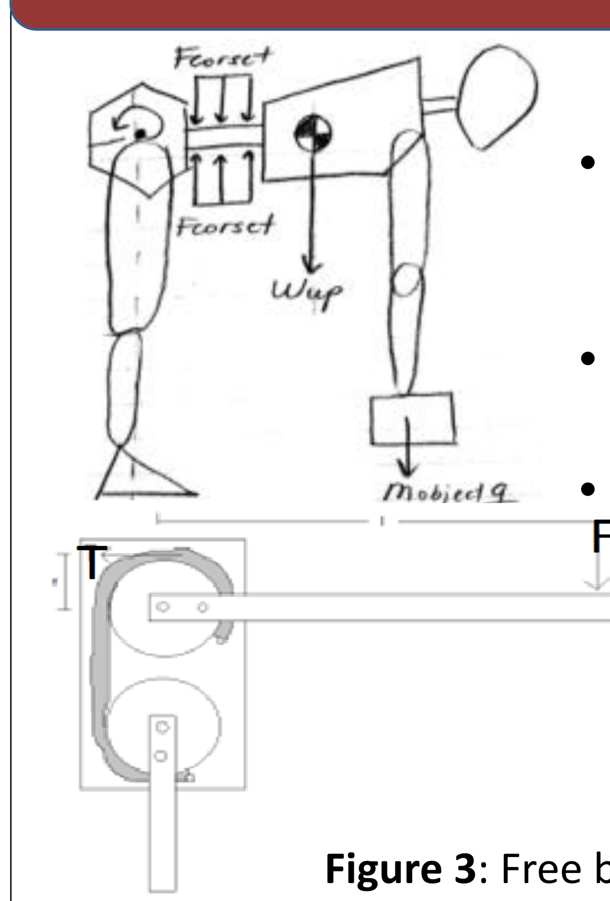
Figure 2: Final design

Cam Mechanism (Figure 2 - 6)
- Wheels rotate independently with torso and leg bend- induced resistance via connected elastic material
- Fabricated from aluminum and affixed to an aluminum plate
- Cams attached to back brace for support and adhesion at hips

Frame (Figure 2 – 2 and 3)
- Anchors above breast, at hips, and at mid-thigh to provide dynamic counterforce against disease-induced moment about hip

Specifications
- Aluminum, steel, bungee cords
- Weight: 26.7 N (<44.8 N)

Calculations



- Moment at hip: camptocormia, moments due to weight of body and objects held (Figure 3)
- When bending, elastic region must withstand force applied from body
- Determine max loading of elastic region

$$T = \frac{Fl}{2r} = \frac{160\ N * 0.3175\ m}{2 * 0.0381\ m} = 667\ N$$

Figure 3: Free body diagrams of patient and device

Testing and Results

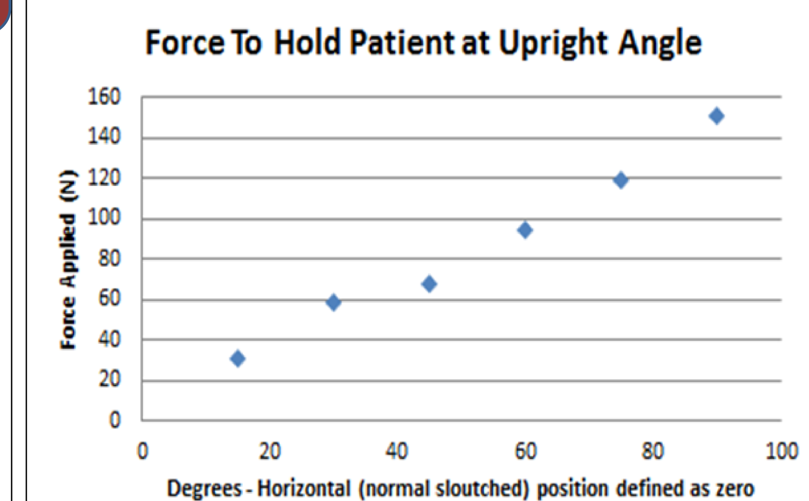


Figure 4: Patient Force Testing

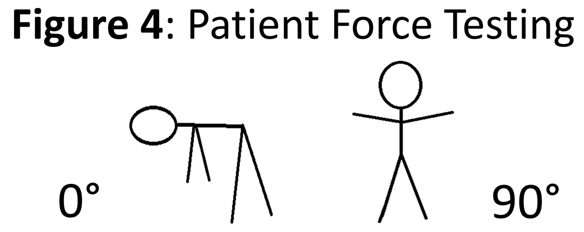
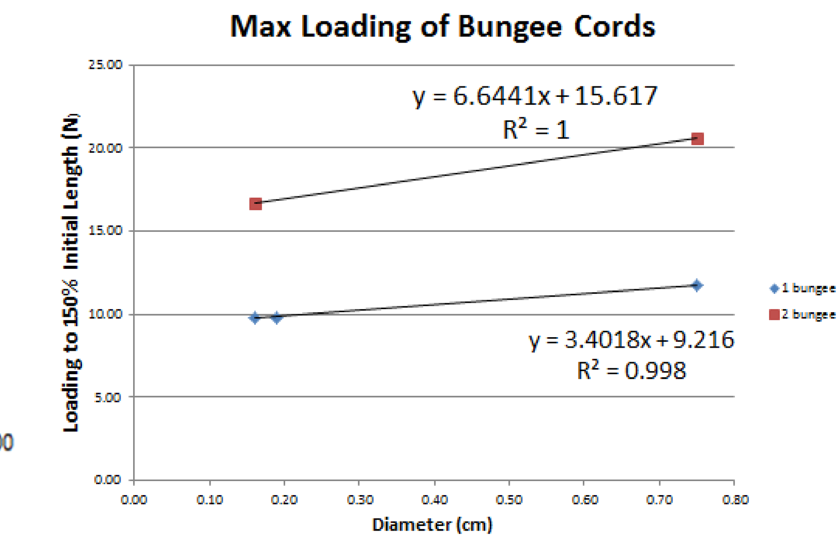


Figure 5 : Patient angle visualization



With the addition of 1 bungee, the diameter requirements decrease by 50%

Figure 6: Maximum loading with single bungee cord and series of bungee cords

Testing: Patient Force Requirements (Figure 4)
- Methods: Handheld dynamometer was used to test the force needed to keep the patient upright
- Results: Max force = 160N or 36lbs. at 90°
  - 0°: torso parallel to the ground (Figure 5)

Testing: Bungee Cords
- Permanent deformation when stretched to greater than 150%
- Methods: axial loading via free weights to test the strength and deformation of bungees
- Results: 1 bungee cord with 1.93 m diameter or 2 bungee cords with 0.98 m diameter are needed (Figure 6)
- Need stronger elastic material – future work

Testing: Cam Mechanism
- Methods: Applied known forces to upper lever arm to determine elongation of bungees and resistance potential using final prototype
- Safely resists 20 N – can increase with elastic band modification

Future Work

- Improve anchoring rings: molded plastics
- Reduce weight of cam mechanism: using CNC
- Stronger elastic material for cam: Nitinol, bungees
- Improve linkage of elastic region to cam: eliminate hook from elastic band
- Improve leg bands: increase surface area to distribute force

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