Walqer LLC

Developing a new Walq-er

PURDUE UNIVERSITY

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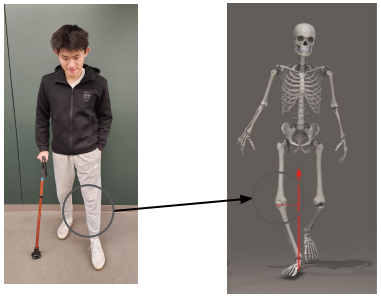
Customer Background

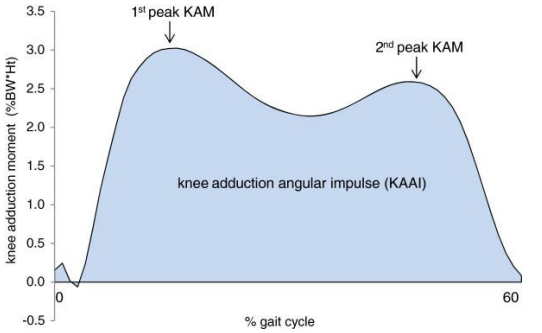
Walqer LLC is a startup company that consists of clinicians that aim to design a product to help patients that suffer from knee osteoarthritis or injury.

Problem Definition

Knee osteoarthritis is a degenerative disease that wears out the cartilage in the knee, causing the patient to experience pain when walking. As of this year, 365 *million* people suffer from *knee osteoarthritis* globally[1].



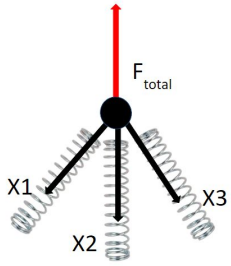
The Gait Cycle consists of three stages: **heel strike**, **midstance**, and **toe off**. The greatest amount of force exerted at *heel strike* and *toe off*.
Our goal is to find a solution to reduce the knee adduction moment, so we can test how much we can alleviate the stresses of walking that could develop into *knee osteoarthritis* later in life.



Levinger, Pazit & Menz, Hylton & Morrow, Adam & Bartlett, John & Feller, Julian & Bergman, Neil. (2013). Relationship between foot function and medial knee joint loading in people with medial compartment knee osteoarthritis. Journal of foot and ankle research. 6. 33. 10.1186/1757-1146-6-33.

[1] 'Osteoarthritis," *World Health Organization*, Jul. 14, 2023 https://www.who.int/news-room/fact-sheets/detail/osteoarthritis#:~:text=With%20a%20prevalence%20of%20365,benefit%20from%20rehabilitation%20(3). (accessed Dec. 04, 2023)

Concepts and Experimentation



A **3-spoke design** may support the user during three stages of the gait cycle. **X1** = heel strike force, **X1,2** = midstance, **X1,2,3** = toe off.
The $\mathbf{F_{total}}$ is the total ground reaction force acted on the knee at each stage of the gait cycle.

Age: 45 and up
Weight: 200~220lbs

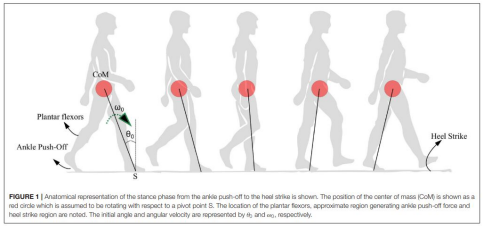


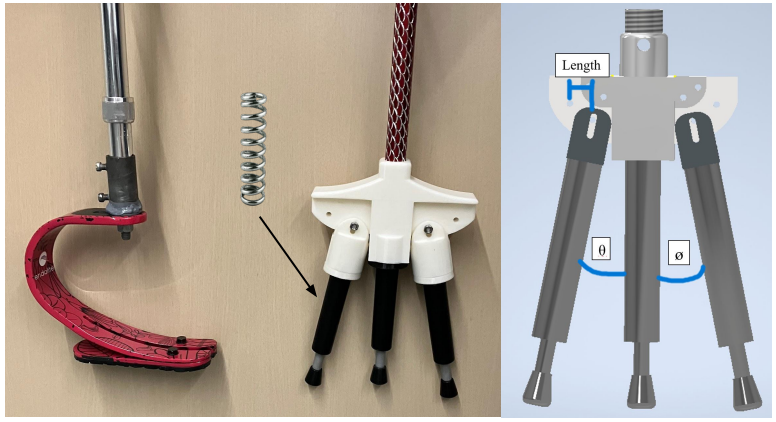
FIGURE 1 | Anatomical representation of the stance phase from the ankle push-off to the heel strike is shown. The position of the center of mass (CoM) is shown as a red circle which is assumed to be rotating with respect to a pivot point S. The location of the plantar flexors, approximate region generating ankle push-off force and heel strike region are noted. The initial angle and angular velocity are represented by θ_0 and ω_0, respectively.

Parakkal Unni M, Menon PP, Wilson MR and Tsaneva-Atanasova K (2020) Ankle Push-Off Based Mathematical Model for Freezing of Gait in Parkinson's Disease. Front. Bioeng. Biotechnol. 8:552635. doi: 10.3389/fbioe.2020.552635

The supportive forces can be calculated using Newton's 2nd law: **F=ma**, and the equation used to calculate the elastic force exerted by spring is: **F = kx**. The *mass* and *acceleration* exerted while walking is counteracted by each spring which has an elastic force determined by the spring's constant (**k**) and amount of deformation (**x**). Each spring is customized for each stage of walking.

Final Design

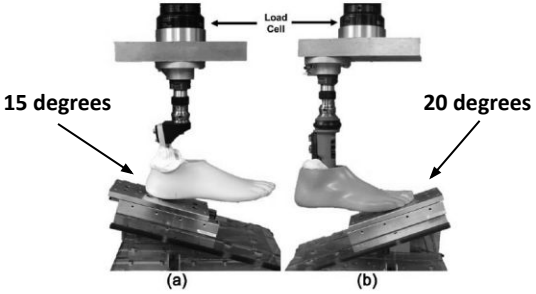
*Prototypes were constructed at Dudley Hall and Bechtel Innovation and Design Center.



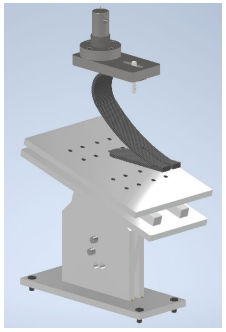
Prosthetic cane | 3 spoke cane | Adjustment Features

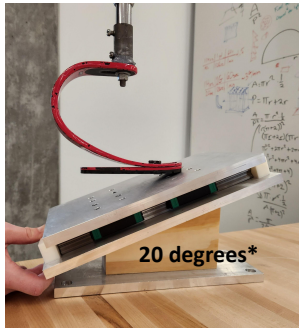
Testing

Prosthetic foot will be being vertically loaded for both the heel and forefoot regions. The inclination angles for the heel and forefoot are **15**° and **20**°, following the **ISO 10328** standard. Vertical compressive force is applied at 100 N/s to a maximum load of 864.38 N.



C. M. Webber and K. Kaufman, "Instantaneous Stiffness and Hysteresis of Dynamic Elastic Response Prosthetic Feet," Prosthetics and Orthotics International, vol. 41, no. 5, pp. 463–468, 2017. DOI: 10.1177/0309364616683980.





Lessons Learned

Using products already available on the market inspired our final design. For example, the 3-spoke design was inspired from the Flex Tip Ground Absorber.

Also using products that target aspects of our design to develop prototypes. A prosthetic foot was used as a base for the walking cane to simulate the natural gait cycle. The international standards will be used to test our solutions.