Assistive Walking Device for Parkinson's Patients Experiencing Retropulsion

Team 13: Renaldo Facey[1], Mohammed Monkasir Saber[1], Linford Smith[1], Ragon Wong[1], Anh-Thu Vu, MD[1], Jaime Dougherty, PhD[1], Talmadge Gaither[2], Anastasia Kapitonava[2], Jasmine Lu[2], Paige Pammer[2], Margish Ramani[2], Sameep Vakharia[2]

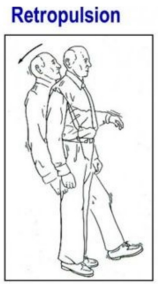
DREXEL UNIVERSITY School of Biomedical Engineering, Science and Health Systems

[1] School of Biomedical Engineering, Science and Health Systems [2]College of Medicine

DREXEL UNIVERSITY College of Medicine

Background

- ~1 Million people with Parkinson's Disease (PD) in the United States[1]
- Parkinson's Disease patients suffer from loss of motor control
- Retropulsion: tendency to fall backwards while walking causing 11% of falls in PD populations (Stage ≥3 PD)[1]
- Falls lead to trauma of back of head, hip dislocation and in some cases, death
- Economic burden due to PD patients who frequently fall is double that of non-fallers[7,8]



Existing Solutions & Limitations

Current solutions:

1. Standard aluminum walker
2. U-Step walker (more expensive)

Limitation = Do not prevent falls from retropulsion

Constraints

Universal:
1. **Time**: 9 months
2. **Budget**: $800
3. **Policy:** No IRB approval for testing on patients, Standards for Assistive Walking Products
4. **Resources:** Innovation Studio

Problem Specific:
5. **Weight:** ≤ 30 lbs
6. **Width:** ≤ 36in
7. **Skin Interaction:** Materials biocompatible and non-irritable
8. **Foldability:** Modifications allow foldability
9. **Client Request:** Must use standard walker

Requirements

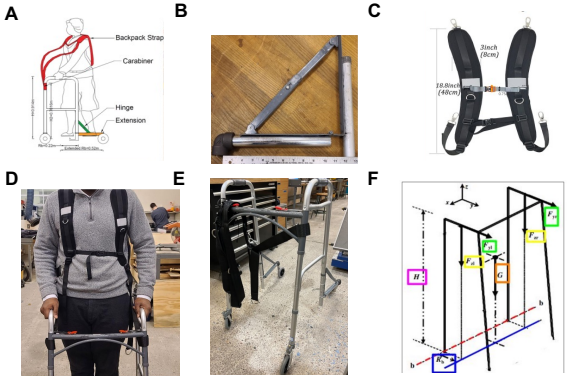
1. **Backward Tipping Index (BTI)**: -1 to 0
2. **Engagement Time:** 1200 ms
3. **Trunk Angle:** 4.5°
4. **Height Adjustability:** 4'10" to 6'2"
5. **Weight Functionality:** 81 kg

Objective

Design a device that protects against falls due to retropulsion for patients with Parkinson's Disease

Prototype

The solution includes an extension at the base of the walker to achieve the required BTI. Additionally, a harness apparatus that attaches the user to the walker helps control the user's posture and trunk angle.



(A) Early Concept Design of Assistive Mobility Device

(B) Detachable Aluminum extension with Hinge

(C) Wearable Straps for Harness System **(D)** Harness Apparatus Front View

(E) First Prototype of Extended Walker **(F)** Prototype Parameters

Acknowledgements

Thank you to the clinical and academic advisors, Anh-Thu Vu, MD and Jaimie Dougherty, PhD, respectively, as well as DrExcel Health and Drexel School of Biomedical Engineering for the project grant.

Verification & Validation

V1:Test for BTI range [-1 to 0].
Method: (1) Final solution measured and BTI calculated using developed mathematical model

$$BTI\ (straps\ and\ ext) = \frac{(f_{yl} + f_{yr}) * h + (f_{ysl} + f_{ysr}) * h_2}{(f_{zl} + f_{zr} - g) * r_b + (f_{zsl} + f_{zsr}) * (r_b + 0.22)}$$

Results:

Rb: 0.55m	H1: 0.91m H2: 0.76m	BTI : -1.05

V2:Test for lateral trunk angle change of -4.5 within 1200ms.
Methods
(2) Video Analysis of the behavior of a weighted mannequin in the device system after a backward perturbation.

Conclusion

Once completed, this device will be a cost-effective way to increase PD patient independence and confidence by reducing retropulsion induced falls. This will improve quality and state of living and reduce the cost burden associated with falls.

Societal Impact

- Positively impacts Stage ≥3 PD patients by reducing retropulsion-induced fall risk
- ~100,000 PD diagnoses per year, 80% treated with medication, 20-50% of treated PD patients reach Stage 3 PD in 5-10 years[5,6]
- Potential use for 16,000-40,000* PD patients reaching Stage 3 PD per year in the U.S.
- Decreased risk of fall and save associated recovery care costs (~$50k per fall)[7,8]

**Estimated number of patients with higher fall risk and retropulsive events*

References

[1] Lindholm,B.et al. Intl Journal of Public Health,2021;18(23).
[2] Ming, D et al. Journal of Neural Engineering, 2009;6(6).
[3]Dias Andre. Sensing Future, 2022.
[4] Ge Wu, et al. Journal of Biomechanics, 2000;33(11):1497-1500.
[5] Connolly BS, et al. JAMA. 2014;311(16):1670–1683.
[6] Scott NW, et al. Eur J Neurol 2016; 23:304-312.
[7] Shi N, et al. Bone. 2009;45:1084 –1090.
[8] Adeyemi A, et al. JB JS Open Access. 2019 Feb 27;4(1):e0045.