**Proceedings of the 2022 Design of Medical Devices Conference**
**DMD2022**
**April 11-14, 2022, Minneapolis, MN, USA**

# DMD2022-1023

## POWER ASSISTED WALKER: RISING ABOVE SEATED MOBILITY

**Edward R Ratner[1],**
Minneapolis VA Health Care System and
University of Minnesota
Minneapolis, MN, USA

**A Soleil Bornstein**
Minneapolis VA Health Care System
Minneapolis, MN, USA

**Gary Goldish**
Minneapolis VA Health Care System and
University of Minnesota
Minneapolis, MN, USA

**Allison M Gustavson,**
Minneapolis VA Health Care System
Minneapolis, MN, USA

**Andrew Hansen**
Minneapolis VA Health Care System and
University of Minnesota
Minneapolis, MN, USA

**Steve Morin**
Minneapolis VA Health Care System
Minneapolis, MN, USA

**Jared Bliss**
Minneapolis VA Health Care System
Minneapolis, MN, USA

**Amber Wacek**
Minneapolis VA Health Care System
Minneapolis, MN, USA

### ABSTRACT

*Nearly half of older people cannot easily walk 400 meters. Powered mobility aids such as seated scooters discourage healthful walking and have limitations due to size and cost. Using human-centered design, we have developed a novel power assisted walker (PAW), which can be used as a manual walker or as a standing electric scooter. A user can push the device manually supported by a four-wheeled walker or step onto a footplate and ride it as a three wheeled standing scooter, with safety enhanced by two anti-tip casters. A working prototype has demonstrated the feasibility of this design. It also meets user-defined requirements for safety, usability, and transportability. Designs for additional prototypes overcome several engineering challenges and will enable a wide variety of users to meet their mobility needs in the community.*

Keywords: Mobility, walker, scooter.

### NOMENCLATURE:

| | |
|---|---|
| Ah | Amp hour |
| KPH | Kilometers Per Hour |
| PAW | Power Assisted Walker |
| MS | Mobility Scooter (seated) |
| Wh | Watt hour |

## 1. INTRODUCTION

### 1.1 Need

The 2003-04 Medicare Beneficiary Survey of almost 6000 individuals over the age of 65 found that 28% reported difficulty and another 17% reported inability to walk 400 meters, with an analysis of this data revealing that mobility disability, a simple self-report measure, was a powerful predictor of future health, function, and healthcare utilization [1]. The rapid growth in the fraction of the population over 65 years of age increases the need for novel personal mobility solutions to help people Age in Place [2].

Existing mobility aids, while used by many, are not ideal. For example, among people with chronic

[1] Contact author: edward.ratner@va.gov

lung disease, manual walkers provide support, decrease dyspnea, and can increase steps/day and speed [3], but do not reliably decrease metabolic demands or lead users to be more active [4,5].

Use of a Mobility Scooter (MS) is widespread. In 2011-12, about 2.3% of Medicare beneficiaries used a MS. [6].

Mobility that depends upon a PMS or a power wheelchair creates four problems. First, these devices promote prolonged sitting, which is associated with adverse health outcomes [7]. Second, they are extremely difficult to transport in a car, due to size and weight. A few can be dissembled (a time-consuming process), but many require a trailer, sling or specialized vehicle to transport. Third, despite these limitations, they are relatively expensive, typically retailing for over $1000. Medicare reimbursement in the U.S. is limited to when users "mobility limitation significantly impairs their ability to participate in 1 or more Mobility-Related Activities of Daily Living (MRADLs) in typical locations within the home, such as the kitchen or bathroom.…" [8]. Thus, functional mobility in the home, but inability to even get to the mailbox does not qualify a person for Medicare coverage of a MS. Finally, storage of a MS may be a problem for those who have steps into their house or live in an apartment and lack secure, heated storage in a location that has an electrical outlet for charging.

These observations were the genesis of a project to create a PAW to enable people with mobility impairments greater independence in the community, using modern 2-wheeled scooter technology.

### 1.2 History of Power Assisted Walkers

A history of prior standing powered mobility devices demonstrates longstanding desire for such devices and the novelty of our PAW solution. In 1979, three motorized standing devices were tested in U.S. Veterans Administration hospitals, using 12V batteries and either three or four wheels. None allowed the user to use it as a walker as well as a riding mobility device [9].

Another type of motorized walker is described as having a base with two motors, separately controlling two of the device's wheels to allows for steering. A standard walker that has controls is attached to the base. The user can remove and use the walker without the motorized based for unpowered ambulation [10].

Two groups have sought to enhance ambulation through powered adaptation of a standard four wheel-walker by adding motors to the wheels to provide assisted walking [11,12]. Neither of their devices offered a riding option.

A group of high school students produced a prototype PAW that adapted a standard walker by adding motors to front wheels and a foot plate. Their device allowed users to stand and ride or walk pushing the device. The riding steering mechanism was not apparent, however [13].

These attempts and many others over the past 40 years have yet to provide us with a commercially available device that can enhance mobility by being used as both a walker and an electric scooter.

## 2. MATERIAL AND METHODS

### 2.1 User requirements

Using a human-centered approach, [14] a team of clinicians, engineers and designers identified three key user requirements: safety, usability, and transportability.

Our design process was based upon an archetypal user. This is an older adult who requires supplemental oxygen for lung disease and is limited in ambulation to short distances before fatigue and shortness of breath. She rarely leaves her apartment in a senior building, because of fear she will be unable to tolerate the walk home. Therefore, she does not attend meals in the dining room and cannot take walks with her grandchildren around the nearby pond. At medical appointments, she reluctantly requests a wheelchair.

The goal of our PAW is to enable such an individual to achieve her social, recreational and health goals in her building and in the community, walking whenever possible but with the option to ride independently for longer distances as needed. In addition to people with respiratory illness, those with heart failure, poor arterial circulation (i.e. claudication), and arthritis could greatly benefit from a PAW to extend range of independent mobility. People without significant functional disability but who have limited physical endurance might value a safe standing electric scooter such as our PAW to explore parks, shop in a mall and get to/from a bus stop. The key target for our PAW is people who can walk short distances (although they may require support for balance); for this population a PMS is excessively expensive, heavy, difficult to use in an unmodified home, and potentially problematic to store when not in use.

Safety: Potential users and physical therapists who provided feedback to the concept of a PAW focused on the fears of tipping and injury during motorized operation. A maximum speed comparable to walking is preferred. Brakes are needed to prevent faster speeds going downhill. Locking brakes are needed for safe movement onto and off the device.

Usability: Issues raised include ease of operation and ability to navigate hallways and standard width doorways, a width less than about 68 cm. It must be easy enough to maneuver, at least manually, in tight indoor spaces like public bathrooms or elevators. It must be easy enough to push manually to serve as a walker, when desired or in case of a depleted battery. We do not intend for the device to serve as a walker for people who cannot fully weight bear on both legs, however. Outdoors, it needs to be able to overcome common obstacles such as cracks in sidewalk or a curb cut and be easily maneuvered (manually) over a curb.

Transportability**:** Expectations for transportability were a size and weight for placement in car trunk. This was estimated at about 12 kg.

### 2.2 Design of Initial Prototype

Our PAW builds upon the technology readily available for recreational two-wheeled e-scooters. This includes a wheel hub motor, controller, rechargeable lithium-ion battery and wheels. An initial working prototype was adapted from a Go Trax GXL V2 Electric Scooter (Fig. 1). To overcome the instability and high risk of falls associated with two-wheeled scooters, our PAW started with a three-wheeled configuration, a center front powered wheel and two fixed back wheels. Aluminum sheet was used for the footplate and 25 mm aluminum tubing for the frame. Iterative improvements were required to meet the basic requirements for usability and stability. An initial design for a three-wheeled standing scooter was not reliably stable on turns, even at low (~5 KPH) speed. Therefore, we added two casters to the front of the base. We selected shock-absorbing frog-leg casters for their ability to independently elevate in response to irregularities in the surface on which the device is being travelled.

In its original form as a two-wheel scooter, it has a maximum speed of over 25 KPH. For safety during the testing phase, we added resistors between the battery and hub motor to limit speeds on level surfaces to about 5 KPH. Like most two-wheeled scooters, the GoTrax controller requires a push start, with a speed of about 3 KPH needed to engage the motor after the thumb throttle control is pressed. This limitation was considered unsatisfactory for intended users. The GoTrax hand brake disengages the motor. We did not attach a friction or disk brake to this prototype. Unlike the typical two-wheel scooter, the prototype's standing base allows for a natural, shoulder width position. The back wheels were mounted rearward of the standing position and outside of the base frame.

Authors' testing of this prototype design noted two problems with the front wheel when used in manual mode. The hub motor created noticeable rolling resistance. In addition, the roll of the front wheel impaired user directional control of the caster wheels when manually pushing the PAW using canes attached to the rear of the frame. Therefore, we re-designed the stem-footplate bracket to lift the front wheel off the ground when the stem is tilted back for manual use (Fig. 2). In this manual configuration, the PAW functions like a four-wheeled walker, with two front casters. In the riding mode, the stem is upright, the front wheel has traction, and the casters are slightly off the ground making the device a three wheeled scooter, while having excellent anti-tip protection from the casters. We deferred construction of a mechanism to lock the stem in tilted or horizontal position (for storage) until a subsequent prototype.


**FIGURE 1**. RIDING MODE. (A) STEM WITH BATTERY (B) DRIVE WHEEL (C) CASTER/ANTI-TIP WHEEL (D) HANDLES FOR MANUAL MODE


**FIGURE 2.** MANUAL MODE (A) FRONT WHEEL RAISED (B) CASTERS ON GROUND

### 2.3 Subsequent Design

A second prototype is under construction to address the limitations noted above. To improve frame strength, we are using a welded aluminum dual arch frame, of larger cross-sectional area, a reinforced standing plate, and placed the back wheels between the inner and outer frame arches (Fig. 3). To extend users' gait length in manual mode, the footplate has a concave rear edge of the footplate. Using the handlebars for manual pushing eliminates need for the canes. The stem that is attached to the front wheel and handlebars has brackets for the battery and controller. This stem has a collar around the rod connecting the handlebars to the front wheel. The handlebars are curved and have attached throttle, handbrakes, and speedometer/battery status display.

A key design challenge has been the attachment of the stem to the footplate. A bracket at the base of the stem allows rotation of the stem to the vertical position for riding, at an acute angle to the footplate for manual pushing, or all the way down to parallel with the footplate for transport and storage. A four-bar linkage provides strength and adjustability. A gas strut is attached at a point above the middle of the stem. It has a remote release located on the handlebars, allowing it to lock at any angle desired. The other end of the gas strut attaches to a vertical rod attached to the footplate. This rod has a horizontal attachment back to the stem above the gas strut. This design allows the user to adjust and lock the stem to the desired angle relative to the foot plate for riding, pushing, or transporting/storing the device. There are locking disc brakes on each of the back wheels.

The front wheel is a 36V, 350W Brushless Wheel Hub Motor with an 8-inch (20.32 cm) diameter. Back wheels are the same size. All are solid (non-pneumatic). The selection of this wheel type used a process that considered weight, reliable traction on the incline typical of a sidewalk curb cut, and cost. The controller for the hub motor does not require a rolling start. We designed our device to use a relatively small swappable battery (40V capability with a 3.0Ah/120Wh, 12.5 mm x 8.3 mm x 7.6 mm). At 5 KPH, we estimate a range of about 16 km. For longer distances, a user could carry an extra battery. This design has the advantage of allowing the user to store the PAW in a location that does not have access to an electrical outlet.


**FIGURE 3:** RIDING MODE OF PAW. (A) SCREEN FOR SPEEDOMETER AND BATTERY STATUS (B) THUMB THROTTLE (C) BRACKET FOR CONTROLLER AND BATTERY (D) GAS STRUT (E) HUB MOTOR WHEEL (F) CASTER WHEEL FOR WALKER / ANTI-TIP WHEEL FOR SCOOTER

## 3. RESULTS AND DISCUSSION

### 3.1 Operational function

The initial working prototype was tested by one of the authors (ERR). It has a turning radius of 1 meter, allowing a U-turn in 2-meter-wide hallway, about 1/2 meter less than the minimum mandated international health facility corridor clearance. For smaller spaces, the user can easily step back off the footplate and manually perform a three-point turn or lift the PAW to turn it around. At a maximum speed on level, non-carpeted indoor surface of 5.0 KPH per hour, with a 70 kg rider, it can (barely) climb a slope of about 8% (e.g., a curb cut). It is stable turning at 5 KPH turning, over doorway thresholds, and from a downhill driveway to the street. On an uneven uphill surface, it is possible for the front wheel to lose contact with the surface, if the caster wheels fully support the front of the PAW. In such a case, the user can step off the device and manually lift the device over the uneven area. Disengaging the motor using the brake handle stops the device from full speed within 0.6 meters. This prototype weighs about 11 kg.

### 3.2 Other Human Centered Design Results

In response to clinician, Veteran, caregiver, and even hospital volunteer input, we defined variations of the design for potential users and situations. The following embodiments were included in a provisional U.S. patent application:

- A 3-foot-high frame around the footplate to support a user. This could include safety straps for a user who is unsteady when standing,
- Extending the footplate to allow carrying of two people or carrying boxes/luggage,
- Using a hinged footplate, which would allow a user to push it from closer to the stem than possible with a concave cutout in the footplate,
- Moving the powered wheel from the front to one of the rear wheels. This configuration would allow powered use while walking behind the foot plate (with the front wheel off the ground), assisting a walking user to climb an incline or carry cargo on the footplate,
- Addition of storage on the stem (e.g., a basket) or a bracket to hold a compressed oxygen tank,

- Seating for populations who need intermittent relief from standing while riding. This might be a saddle-type seat at tilted forward and higher than typical chair height which can be mounted in a bracket on the foot plate. This design differentiates our PAW from the many types of PMS better suited for those who need the comfort and support of cushion chair seating for long distance travel, and
- Folding chair for rest breaks

## 4. CONCLUSION

An interdisciplinary team has developed a novel PAW that serves as both a walker and a highly stable standing electric scooter while providing a combination of safety, usability, and transportability.

## ACKNOWLEDGEMENTS

This material is the result of work supported with resources and the use of facilities at the Minneapolis VA Medical Center and supported by the U.S. Department of Veterans Affairs Technology Transfer Program and the VHA Innovators Network. The views, opinions, and interpretations expressed in this article are those of the authors and do not represent the views of the Department of Veterans Affairs or the United States Government.

## REFERENCES

[1] Hardy, Susan, Kang, Yihuang, Studenski Stephanie, and Degenholtz, Howard. “Ability to walk 1/4 mile predicts subsequent disability, mortality, and health care costs.” *J Gen Intern Med*Vol. 26 No. 2, (2011) pp. 130-135.

[2] Latham-Mintus, Kenzie, Manierre, Matthew, and Miller, Keith. “Staying Connected: Alternative Transportation Use, Neighborhoods, and Social Participation among Older Americans.” *Gerontologist*Vol. 62 No. 1 (2022): pp. 75-88. DOI:10.1093/geront/gnab084.

[3] Hill, Kylie, Ng, L. W. Cindy, Cecins, Nola, Formico, Cavalheri, Vinicius, and Jenkins, Sue. “Effect of Using a Wheeled Walker on Physical Activity and Sedentary Time in People with Chronic Obstructive Pulmonary Disease: A Randomised Cross-Over Trial. *Lung*Vol. 198 No. 1 (2020): pp. 213-219. DOI 10.1007/s00408-019-00297-2.

[4] Hill, Kylie, Dolmage, Thomas, Woon, Lynda, Brooks, Dina, and Goldstein, Roger. S. “Rollator use does not consistently change the metabolic cost of walking in people with chronic obstructive pulmonary disease.” *Arch Phys Med Rehabil*Vol. 93 No. 6 (2012): pp.1077-80. DOI 10.1016/j.apmr.2012.01.009.

[5] Lee, Annemarie, Beauchamp, Marla, Goldstein, Roger, and Brooks, Dina. “Clinical and Physiological Effects of Rollators in Individuals With Chronic Obstructive Pulmonary Disease: A SYSTEMATIC REVIEW.” *J Mol Signal*Vol. 38 No. 6 (2018): pp. 366-373. DOI 10.1097/HCR.0000000000000280.

[6] Gell, Nancy, Wallace, Robert, LaCroix, Andrea, Mroz, Tracy, and Patel, Kushang. “Mobility device use in older adults and incidence of falls and worry about falling: findings from the 2011-2012 national health and aging trends study.” *J Am Geriatr Soc*Vol. 63 No. 5 (2015): pp. 853-859. DOI 10.1111/jgs.13393.

[7] Dunstan, David, Howard, Bethany, Healy, Genevieve, and Owen, Neville. “Too much sitting – A health hazard.” *Diabetes Research and Clinical Practice*Vol. 97 No.3 (2012): pp. 368 – 376. DOI 10.1016/j.diabres.2012.05.020.

[8] Center for Medicare and Medicaid Services, “MLN Boolket: Power Mobility Devices.”, (2021) pp. 1-10. from https://www.cms.gov/Outreach-and-Education/Medicare-Learning-Network-MLN/MLNProducts/downloads/pmd_DocCvg_FactSheet_ICN905063.pdf.

[9] Staros, Anthony and Peizer, Edward., “Veterans Administration Prosthetics Center Report.” *Bulletin of Prosthetics Research*Vol. Spring (1979) pp. 164-207. https://www.rehab.research.va.gov/jour/77/14/2/staros.pdf.

[10] Rodenborn, Eugene. 1992. “Motorized Walker.” US Patent number 5168947.

[11] Perkins, Jack. 1981. “Motorized Walker for the Disabled.” US Patent number 4280578.

[12] Rabin, Eli and Ziquian, Dong. 2018. “Motorized Walker.” US Patent 9968507.

[13] T-Tech Academy. from https://www.youtube.com/watch?v=1FSWf8vG0kI.

[14] Melles, Marijke, Albayrak, Armagan, and Goossens, Richard. “Innovating health care: key characteristics of human-centered design.” *Int J Qual Health Care*Vol. 33 Supplement1 (2021): pp. 37-44. DOI 10.1093/intqhc/mzaa127.