ISSN 2733-6441 / eISSN 2733-645X http://dx.doi.org/10.26862/jkpts.2023.12.30.4.1

대한물리치료과학회지
Journal of Korean Physical Therapy Science
2023. 12. Vol. 30, No.4, pp.1-8

Usability Test for Motion Tracking Gait Assistive Walker

Daon Hwang, M.Sc., P.T. · Ki Hun Cho, Ph.D., P.T.

Dept. of physical therapy. Korea National University of Transportation

Abstract

Background: This study evaluates the usability of the Motion-Tracking Gait Assistive Walker (MTGAW) designed for elderly individuals and those with disabilities, identifying areas for improvement through interviews with physical and occupational therapists.

Design: A survey study involves the usability test for MTGAW.

Methods: Usability evaluations were conducted with 37 physical therapists and occupational therapists. The process included explanation, product usage, satisfaction surveys, and interviews. A satisfaction survey covering 19 items across safety, maneuverability, usability, and management areas was administered. Individual interviews identified areas for improvement.

Results: Overall, high satisfaction was reported across the four areas, but interviews highlighted the need for improvements, such as addressing discomfort due to slow speed and enhancing safety measures to prevent rear-end falls. Adjusting the walker's height and width to suit the user's physique was also suggested.

Conclusion: MTGAW enhances walking support and hand movement freedom but needs refinement in speed control, fall prevention, and customization based on the user physique. Future efforts should focus on developing an improved MTGAW, considering recommendations from physical therapy experts, and conducting studies to analyze its clinical effectiveness for commercialization.

Key words: Gait assistive Walker, Motion tracking, Usability evaluation.

Corresponding author
Ki Hun Cho
Department of Physical Therapy, Korea National University of Transportation, 61, Daehak-ro, Jeungpyeong-eup, Jeungpyeong-gun, Chungcheongbuk-do, 27909, Republic of Korea
T: 043-820-5206 E: mamiya34@gmail.com

Received 2023-03-10 / Revised 2023-04-25 / Accepted 2023-05-25

Ⅰ. Introduction

Older adults who have experienced falls have decreased location and physical mobility due to the fear of falling and limited walking ability and depend on others for their daily life activities (Lee et al, 2009; Kyeoung MJ,2022). Gait assistive devices are designed to alleviate the impact of mobility limitations, enhance independence, and promote greater freedom and independent living. They are necessary for seniors and individuals with mobility impairments to facilitate a more active and independent lifestyle while reducing the burden of therapy and care (Arefin et al, 2020; Dong CP, 2021). In particular, introducing gait assistive devices early during the initial stage of walking training or when independent walking is difficult can increase the base of support (BOS) while standing, induce symmetrical weight load on the lower extremities, and improve gait stability.

The most commonly used gait assistive devices in everyday life include canes, crutches, and walkers. Among them, walkers have the advantage of providing stability by securing a wide BOS and minimizing skewed gait by allowing the use of the assistive device with both hands. However, using walkers with both hands limits the swinging of the arms when walking, preventing the natural gait pattern (Liu 2009), and excessive weight support of walkers can reduce the effect of limb muscle strengthening and cause secondary musculoskeletal damage to the wrists (Bradley and Hernandez, 2011). Visintin and Barbeau (1994) reported that the reduction in the arm-swinging motion while walking with gait-assistive devices is a factor that interferes with the normal gait pattern, and Bateni and Makio (2005) reported that the free movement of the upper extremities should be considered in training for the normal gait pattern when applying gait-assistive devices because the motion of lifting the walker and pushing it forward can potentially disturb the center of mass.

Mobility and maneuverability are necessary to avoid multiple obstacles while moving in a narrow, complex space. However, while conventional walkers provide high structural safety, they have limitations in terms of mobility and maneuverability. Sufficient space is needed to change the direction when walking with a walker, and the user must lift the body of the walker and slightly change the direction in several steps. Such a directional change is a challenging task for older adults with insufficient muscle strength of the lower limbs and reduced concentration and cognitive function, and falls may occur while changing directions.

Therefore, we developed a motion-tracking gait-assistive walker (MTGAW) that reduces the fall-inducing factors of gait-assistive devices identified in previous research and clinical practice, and clinical specialists, including physiotherapists and occupational therapists, evaluated the usability of the walker. Functional satisfaction and improvement areas were determined through the usability evaluation and interviews, which will be reflected in the promotion for of commercialization of the walker in future product development.

Ⅱ. Methods

1. Participants

Thirty-seven physiotherapists and occupational therapists at C Hospital in C City participated in the usability evaluation. All participants were fully informed and understood the purpose and characteristics of this study and voluntarily agreed to participate in the usability evaluation. The usability evaluation involved individual interviews to assess satisfaction with 19 items across four areas and identify areas for improvement after the participants directly used the prototype. The general characteristics of the participants are shown in (Table 1).

Table I. General characteristics of the participants (n = 37)

Parameters	Frequency or mean±SD
Occupation (physical therapist/occupational therapist/total)	25 / 12 / 37
Sex (male/female/total)	13 / 24 / 37
Education level (bachelor’s degree/master’s degree)	30 / 1
Height (cm)	167.11 ± 8.85
Weight (kg)	63.70 ± 10.56
Age (years)	26.54 ± 2.49
clinical experience (years)	2.78 ± 1.13

2. MTGAW (Motion Tracking Gait Assistive Walker)

An MTGAW was developed to assist older adults with mobility and individuals with a disability who have difficulty walking independently. It consists of a motion intent detection unit and a Mecanum wheel-based driving unit (Fig. 1). The motion intent detection unit is equipped with two independent wire displacement sensors and is connected to the straps worn on the top of both femurs of the user. The wires coil and shorten when the user moves forward and loosen and lengthen when the user moves backward. When the user rotates to the right, the right wire lengthens while the left shortens, and when the user rotates to the left, the left wire lengthens while the right shortens. The motion intent detection unit detects the user's motion intention based on the length displacement of the wire according to the above lower limb motions. The Mecanum wheel-based driving unit is designed to move while tracking the user's motion in forward, backward, and rotational directions by using the Mecanum wheel drive according to the user's motion intention input from the motion intent detection unit. In addition, each Mecanum wheel is equipped with a shock absorber and designed to withstand the pressure of the user's weight of up to 200 kg.

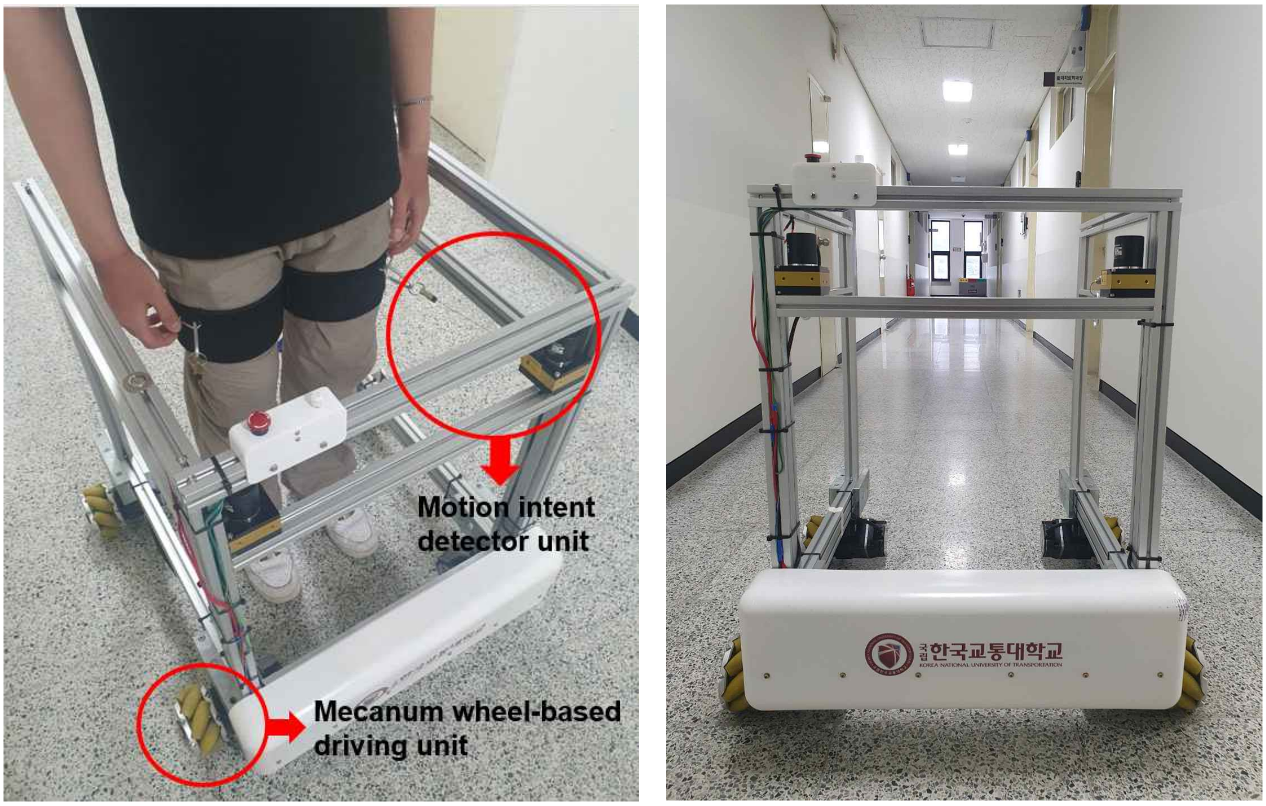

Figure 1. Setting for the motion tracking gait assistive walker

3. Procedures

The usability evaluation was conducted in four stages: usage explanation and demonstration, product use, satisfaction survey, and interview. In the usage explanation and demonstration stage, the purpose, procedure, duration, precautions, and product operation methods were explained, followed by the demonstration. In the product use stage, all participants used the product individually. The participants used the product wearing their usual sneakers in a large space with no obstacles. The participants could use the product for an unlimited time, and two research team members were on standby to prevent safety accidents while the participants used the product. In the satisfaction survey stage, the participants completed a questionnaire of 19 items in four areas. The survey was conducted in a quiet space immediately after product use, with no time limit. Lastly, the researchers conducted one-on-one interviews in the quiet space where the satisfaction survey was conducted. Improvement areas for the product were determined through the interviews. The satisfaction survey data were analyzed using SPSS ver. 21, and the results are expressed as mean and standard deviation values.

Ⅲ. Results

1. Results of Satisfaction Survey

This study investigated the satisfaction on 19 items across four areas: six items on safety, six items on maneuverability, five items on usability, and three items on management. All items were measured on the following 5-point scale: 1 = Very unlikely, 2 = Unlikely, 3 = Neutral, 4 = Likely, and 5 = Very likely. Table II shows the results of the satisfaction survey.

Table II. Results of Satisfaction survey (n = 37)

Area	Item	Questions	Mean ± SD
Safety	Stability at stop	Is there any risk of slipping when pushed in the stationary state?	3.68 ± 0.75
	Directional change	Is the speed of directional adjustment appropriate?	3.24 ± 0.89
	Design (contact hazard)	Are there any elements that could be harmful to the body when used?	2.51 ± 1.02
	Driving risk	Are there factors that can cause risks while driving?	2.78 ± 0.75
	Posture alignment	Is it possible to walk in the correct position?	3.24 ± 0.83
	Reverse risk	Is there a risk of reverse when walking?	3.30 ± 0.94
		Total average	3.13 ± 0.36
Maneuverability	Convenience	Is the basic maneuver convenient?	4.08 ± 0.83
	Wearable components	Are the wearable components adequately configured?	3.76 ± 0.72
	Ease of learning	Is the level of difficulty of operation method training appropriate?	4.11 ± 0.57
	Frame	Can the walker be adjusted to the user's body appropriately?	3.22 ± 0.98
	Directional change	Is it easy to change the direction to the intended way?	3.65 ± 0.82
	Cleaning	Is it easy to clean the walker?	3.00 ± 0.91
		Total average	3.64 ± 0.53
Usability	Utilization in narrow spaces	Is it more efficient than conventional devices in small spaces, such as bathrooms?	2.57 ± 0.83
	Straight 10-M walk	Does it not experience bias or shaking?	3.38 ± 0.92
	Freedom of the arms	Does the walker help in the unrestricted use of the arms when walking?	4.03 ± 0.87
	Motion tracking	Does the walker move while appropriately reflecting the user's motion?	3.78 ± 0.82
		Total average	3.44 ± 0.59
Management	Convenience of movement	Are the weight and size appropriate for walking?	3.14 ± 0.92
		Are the weight and size adequate for transport?	2.68 ± 0.97
	Noise	Are there any noise disturbances when walking?	1.59 ± 0.80
		Total average	2.47 ± 0.60

2. Results of in-depth Interview

Table III shows the main results of the in-depth interview on the four areas.

Table III. Main results of the in-depth interview (*n*= 37)

Area	Positive factors	Negative factors (needs improvement)
Safety	- Stability owing to a heavy weight - Psychological stability owing to the freedom of both hands - Appropriate design	- Needs a function that will cut off power to the system in emergencies - Needs a hip-worn harness
Maneuverability	- Movement is stable and is thought to be effective for early walking training	- Needs measures for posterior fall prevention - Needs a height adjustment function - Slow directional change
Usability	- Freedom of both hands while walking	- Difficulty making precise directional changes in small spaces - The user could trip on the main body of the walker if the stride is large
Management	- Low levels of noise when in operation	- Difficult storage and transport owing to the bulky size and heavy weight

Ⅳ. Discussion

Gait-assistive devices are used to improve independent mobility and prevent falls in older adults and individuals with a disability (Arefin et al, 2020). These devices are selected according to the user's level of balancing ability and whether the assistive device can be grasped using one or both upper limbs (Bruun, 1986; Wu et al, 2010; Hassan et al, 2014; Wilson et al, 2019). Walkers have limited location mobility compared with crutches or canes; however, they provide optimal stability with a wide BOS and help minimize users' anxiety (Oh et al, 2022). However, both upper limbs are required to operate a walker, and incorrect use (e.g., relying on the walker for excessive weight support by using the upper limbs that hold the walker) can interfere with weight transfer to the lower limbs (Melis et al, 1999; Edelstein 2019). Moreover, prolonged, incorrect walker use can result in the user having an inappropriate gait pattern (Bateni and Maki, 2005; Bradley and Hernandez, 2011).

Therefore, we developed an MTGAW that compensates for the shortcomings of conventional walkers. The MTGAW detects gait intention through the wire displacement sensor connected to the user's lower extremities to track and assist the user's walking and allows unrestricted motion of the upper extremities. Additionally, the walker is equipped with Mecanum wheels and has been designed to enable front-back and left-right movements and in-situ rotation motion tracking of the user. While the MTGAW has been developed to address

the known shortcomings of walkers, it is necessary to examine the currently developed prototype's stability, safety, and effectiveness before making it available to older adults and individuals with a disability. Accordingly, this study also involved the evaluation of the developed prototype's usability by clinical experts, including physiotherapists and occupational therapists.

The usability evaluation showed that the MTGAW's detection technology for user motion intention allowed free movement of the hands while walking, thereby providing psychological stability and preventing falls. Another advantage of the walker reported was that the tracking function for the left-right directional change and in-situ rotation motions is essential for everyday life at home, which is not provided in existing gait-assistive devices or walking rehabilitation robots. As such, high satisfaction levels were reported in the four areas. Nevertheless, a few areas for improvement were identified, namely, improvements to reduce the discomfort caused by a slow speed, safety measures to prevent posterior falls, and a function to adjust the height and width of the walker according to the user's body. Speed adjustment should be possible since the current fixed slow speed can further increase fall risk, and improvements are needed to enable the adjustment of the height and width of the product to tailor it to the user's body to prevent tripping on the product when walking. In particular, using the harness used in the study by Visintin and Barbeau (1994) instead of a Velcro-type strap worn on the thighs to connect the body to the wire displacement sensor for motion tracking will be more effective for weight support and enhancing a psychological sense of safety.

Ⅴ. Conclusion

In this study, a usability evaluation, including a satisfaction survey and an interview, was conducted by physiotherapists and occupational therapists to identify the areas of improvement for the MTGAW developed for walking assistance for older adults and individuals with a disability. The survey showed overall high satisfaction levels on 19 items across four areas, and several improvement points were suggested in the interviews. This study constitutes a significant contribution to the field of domestic rehabilitation robotics in Korea. It offers a promising avenue for addressing the shortcomings of existing walking assistive devices. While the MTGAW compensated for the shortcomings of conventional walkers, suggestions were received to ensure safety measures to prevent posterior falls, ameliorate the discomfort caused by the slow speed, and add the height and width adjustment function to customize the walker to the user's body. In the future, an improved MTGAW that reflects the clinician-recommended needs derived from this study should be developed, and for its commercialization, a follow-up study should be performed to analyze the walker’s clinical effectiveness in older adults and individuals with a disability who require walking assistance.

【Acknowledgement】

This research was supported by "Regional Innovation Strategy (RIS)" through the National Research Foundation of Korea (NRF) funded by the Ministry of Education (MOE) (2021RIS-001).

Reference

Arefin P, Habib S, Arefin A et al. A comparison of mobility assistive devices for elderly and patients with lower limb injury: Narrative Review.Int J Aging Heal Mov, 2020, 2.1: 13-7.

Bateni H, Maki B E. Assistive devices for balance and mobility: benefits, demands, and adverse consequences. Arch Phys Med Rehabil, 2005, 86.1: 134-145.

Bradley S M, Hernandez C R. Geriatric assistive devices. Am Fam Physician, 2011, 84.4: 405-411.

Bruun G. Mobility aids, proposal for research and development. In: Development of Electronic Aids for the Visually Impaired: Proceedings of a workshop on the Rehabilitation of the Visually Impaired, held at the Institute for Research on Electromagnetic Waves of the National Research Council, Florence, Italy. Sponsored by the Commission of the European Communities as advised by the Committee on Medical and Public Health Research. Dordrecht: Springer Netherlands, 1986.

Dong CP, Jung HJ, Won DK, et al. Comparison of gait ability according to types of assistive device for ankle joint of chronic hemiplegic stroke survivors. The jouranl of korean academy of physical science. 2021, 28.2: 30-39.

Edelstein J. Canes, crutches, and walkers. In: Atlas of orthoses and assistive devices. Elsevier, 2019. p. 377-382. e3.

Hassan M, Kadone H, Suzuki K et al. Wearable gait measurement system with an instrumented cane for exoskeleton control. Sensors, 2014, 14.1: 1705-1722.

Kyeoung-Man Jung, Yu Jin Jung. Effect of trunk training in wheelchair on fall efficacy, fall risk, activities of daily living in acute stroke patients: Randomized controlled pilot study. The journal of korean academy of physical science,2022, 29.3: 1-11.

Lee JH, Ahn EM, Kim GE et al. The effects of falling and fear of falling on daily activity levels in the elderly residing in Korean rural community. Ann Geriatr Med Res, 2009, 13.2: 79-88.

Liu H. Assessment of rolling walkers used by older adults in senior-living communities. Geriatr Gerontol Int, 2009, 9.2: 124-130.

Melis E H, Torres-Moreno R, Barbeau H et al. Analysis of assisted-gait characteristics in persons with incomplete spinal cord injury. Spinal cord, 1999, 37.6: 430-439.

Oh GB, PARK CS, CHO KH. Immediate effect of weight load on lower limb muscle activity and gait ability in patients with incomplete spinal cord injury during walker gait training. J Spinal Cord Med, 2023, 46.5: 818-824.

Visintin M, Barbeau H. The effects of parallel bars, body weight support and speed on the modulation of the locomotor pattern of spastic paretic gait. A preliminary communication. Spinal Cord, 1994, 32.8: 540-553.

Wilson SJ, Donahue PT, Williams CC et al. Differences in falls and recovery from a slip based on an individual’s lower extremity corrective response. International Journal of Kinesiology and Sports Science, 2019, 7.3: 34-40.

WU W, Au L, Jordan B et al. The smartcane system: an assistive device for geriatrics. In: 3rd International ICST Conference on Body Area Networks. 2010.