Original Article

Feasibility and Effect of Gait Training with Assistance from a Motorized Wheelchair with Built-in Bodyweight Support Frame on the Balance and Walking Ability of Elderly Individuals with a Risk of Falling

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ABSTRACT

Objectives: To study the feasibility and effect of gait training with assistance from a motorized wheelchair with a built-in body-weight support frame (MW-BWSF) on the balance and walking ability of elderly individuals with a risk of falling.
Study design: Experimental study.
Setting: Rehabilitation clinic, Department of Rehabilitation, Songkhla Hospital, Thailand.
Subjects: Elderly individuals aged 60 years or older at rehabilitation clinic, Songkhla hospital between March 2022 and February 2023.
Methods: This experimental trial involved elderly individuals aged 60 years or older with minimal leg muscle weakness or who were at risk of falling. The participants were trained with assistance from the MW-BWSF for eight sessions over four weeks. Gait speed, step length, Time Up and Go Test (TUGT), and Berg Balance Scale (BBS) were assessed three times: before the start of the program, at the end of the fourth training session, and the end of the eighth training session.
Results: A total of 22 elderly individuals participated in the study. The gait training with the MW-BWSF showed a statistically significant improvement in gait speed, step length, TUGT, and BBS score after the eight sessions. The total distance walked during training also increased significantly. The participants reported high satisfaction with the device and with the training method.
Conclusions: The study demonstrated the feasibility and effectiveness of gait training with assistance from the MW-BWSF in improving the balance and walking ability of elderly individuals with a risk of falling. This innovative technology has the potential for use as an assistive device for training at home which would also reduce the burden on public healthcare.

Keywords: elderly, risk of falling, leg weakness, motorized wheelchairs

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Introduction

In 2005, Thailand became an aging society and progressed to a complete-aged society in 2022, with an expected transition to a super-aged society by 2033. Elderly individuals often face gait impairment and balance deficit due to age-related changes and illnesses such as stroke and osteoarthritis.[1,2] These impairments increase the risk of falls and fall-related injuries,[3] and are expected to become an increasingly significant burden on public healthcare in the next decade.

Various techniques have been developed to improve balance and reduce falls, with gait and balance training being one of the proven methods.[4-12] Meta analysis has found that the average effectiveness of fall prevention is approximately 30%. Body weight-supported treadmill training (BWSTT) is one of the more effective methods,[13,14] and has been reported to reduce fall rates between 70-90%, likely due to the continuous stepping practice at different speeds and directions during training.

However, BWSTT requires a supervising person to adjust the treadmill speed and amount of bodyweight support, making it difficult for elderly individuals to train independently at home. In response to this need, a novel motorized wheelchair with a built-in bodyweight support frame (MW-BWSF) was invented by Mr. Somkid Somnugpong from the Welding Department of Kamphaengphet Technical College.

The MW-BWSF has two motorized back wheels and allows users to select the direction and speed of the device by manipulating a joystick located at the distal end of the right armrest. Push buttons are provided for adjusting the height of the built-in body weight supporting frame. The mechanical design allows the device to safely support patients with a body weight of up to 100 kilograms. The seat of the wheelchair automatically retracts as the bodyweight supporting frame rises, allowing patients to practice stepping without hitting their legs on the wheelchair seat. When the supporting frame is lowered, the wheelchair seat returns to its normal position, allowing the user to sit safely.

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Movement of the wheelchair along the ground when the steering joystick is not being manipulated. Similarly, adjustment of the weight support height stops automatically when the height adjustment buttons are not being pressed. This innovation was granted a petty patent in 2020. A pilot test conducted with ten healthy adult volunteers weighing 50-100 kg showed good usability with no unexpected risks.

This research was conducted to study the feasibility and effect of gait training with assistance from a MW-BWSF on the balance and walking ability of elderly persons with a risk of falling.

Method

Study design

This experimental trial was approved by the Human Research Ethics Committee of Songkhla Hospital (approval number SKH IRB 2020-MD-IN3-05008).

Participants

The study included elderly individuals aged 60 years or older with minimal weakness of leg muscles (manual muscle testing grade 4-5) with a risk of falling. The research was conducted at the rehabilitation clinic, Department of Rehabilitation, Songkhla Hospital, Thailand. The sample size was calculated based on data from a previous study that examined the effect of partial body weight support treadmill training on the improvement of walking and balance in elderly individuals living in elderly community-dwellers.[13] The mean score on the Berg balance scale Alpha was 0.05 and Beta was 0.20. All values were entered into the formula, giving in a calculated sample size of 22 people.

Inclusion criteria

1. Persons 60 years or older with no history of recent injury or sickness requiring in-patient admission within a month before the study.

2. Minimal weakness of leg muscles (manual muscle testing grade 4-5), or subjectively reported unsteadiness when standing or walking, having worries about falling, or having a history of falling in the last year.

3. Able to walk at least 10 meters (with or without walking aids).

4. Adequate cognitive function and hand dexterity to operate the MW-BWSF correctly.

Exclusion criteria

1. Severe joint contracture of the lower extremities prohibiting an upright standing body position.

2. Heart failure, myocardial infarction, arrhythmia, or any unstable medical condition that makes active low-intensity exercise not possible.

The intervention

A physiotherapist and a physiatrist at Songkhla Hospital carried out the training. All participants were trained under their supervision for eight sessions over four weeks.

The bodyweight supporting harness was put on the participants and secured to the bodyweight support frame. The supervisor then instructed the subjects to adjust the height of the body weight support frame to determine the appropriate position. Getting the machine ready to use required an average of 5 minutes. Subjects were then asked to practice walking straight 10-meter laps, with a U-turn at the end of each lap. The speed and direction of walking was determined by the subject using the joystick. The aim was for the subject to walk continuously for approximately 10 minutes, followed by a 3-minute rest, and then to repeat the process until 30 minutes of walking time had elapsed. Additional rest breaks were allowed as frequently as needed.

Outcome measurements

Gait speed, step length, Time Up and Go Test (TUGT), and Berg Balance Scale (BBS) were assessed three times: before the start of the training program, at the end of the fourth training session, and at the end of the eighth training session. The total distance walked was measured at each training session. Global satisfaction with the device and training method was evaluated using the Treatment Satisfaction

Figure 1. The device in sitting position.

Figure 2. The device in the standing position

Figure 3. The device during training.

Questionnaire for Medication and a 1 to 5 Likert scale at the end of the final training session. The amount of bodyweight support during training was recorded. Participants were also invited to provide open comments about their training experience and any changes they experienced due to the training.

When the body weight support strap appeared slack and participants did not feel the vertical supporting force, the amount of body weight support was recorded as "no support." When the bodyweight support strap was not slack and participants felt a vertical supporting force, the amount of body weight support was recorded as "partial support."

Data were analyzed using IBM SPSS Statistics 21 and Epi-Info 7.2 software. Demographic information, gait speed, step length, BBS, TUGT, and walking distance during each session were recorded and analyzed. In addition, changes in gait speed, step length, BBS, TUGT, and walking distance before training and at the end of the fourth and eighth sessions was analyzed using the Wilcoxon Signed Ranks Test.

Table 1. Baseline characteristics of the population

	Population (N = 22)
Sex[1]	
Male	4 (18.18)
Female	18 (81.82)
Age (yrs)[1] (Mean 76.22)	
60-69	3 (13.64)
70-79	12 (54.53)
> 80	7 (31.83)
Body weight (ks)[1] (Mean 60.95)	
40-49	4 (18.18)
50-59	4 (18.18)
60-69	10 (45.46)
> 70	4 (18.18)
Height (cms)[1] (Mean 155.22)	
140-149	5 (22.73)
150-159	12 (54.53)
160-169	3 (13.64)
> 170	2 (9.10)

[1]Number (%)

Results

Between March 1, 2022 and February 28, 2023, the training program was conducted with 22 participants, 18 females and 4 males. One participant withdrew from the study after a short test run, stating that wearing the harness was "uncomfortable and restraining," and that the participant expected they might not be able to tolerate continuous use of the device for 30 minutes. The participant denied any pain or injurious sensation.

The mean age of the participants was 76.22±7.17 years, the mean weight was 60.95±10.10 kg, and the mean height was 155.22±8.89 cm. Prior to the training, all participants reported feeling unsteady when standing or walking and had concerns about falling. Five participants had a history of one or more falls in the past year. Three participants had motor power grade 4, and all were ambulatory with the support of a walker frame.

Statistically significant improvements were observed in gait speed, step length, TUGT, and BBS at the end of the fourth and eighth training sessions compared to before the program ($p < 0.001$). The study also showed statistically significant increases in total walking distance after the fourth and eighth sessions compared to the first session ($p < 0.001$). Before the study, three participants ambulated with a walker, and three used a one-point cane. At the end of the study, three people ambulated with a walker, and one used a one-point cane.

Regarding partial weight support during walking training, 14 individuals needed bodyweight support, while the rest walked with "no bodyweight support" after the completion of the first training session. At the eighth session, only 11 subjects needed to be assisted with some partial bodyweight support while walking.

The participants in the study gave the training an average satisfaction score of 4.36±0.58 points on a scale of 1-5. In addition, all participants reported increased walking confidence and felt they could walk faster and longer distances than before the training.

Discussion

The assessment tools used in this study, including TUGT, BBS, and temporal-spatial gait parameter assessment, have been validated and demonstrated to be reliable, supporting the validity and reliability of the findings.[16]

The subjects in this study included individuals of different ages and body weights, comparable to the typical elderly population commonly found in geriatric clinics and community health centers.

Table 2. Gait speed, step length, TUGT, BBS, and walking distance before training and after 4 and 8 training sessions

	Before train-ing	After training 4 sessions mean±SD	*p*-value	After training 8 sessions mean±SD	*p*-value
Gait speed[1] (km/hr)	2.06 (0.95)	2.36 (0.95)	< 0.001[a]	2.56 (0.94)	< 0.001[a]
Step length[1] (centimeters)	40.24 (10.94)	43.31 (11.25)	0.010[a]	46.56 (14.44)	< 0.001[a]
TUGT[1] (seconds)	25.50 (31.90)	19.86 (19.79)	< 0.00[1a]	15.72 (13.38)	< 0.001[a]
BBS[1]	40.09 (12.07)	42.86 (12.08)	< 0.001[a]	45.31 (11.46)	< 0.001[a]
Walking distance in each session[1] (meters)	232.36 (103.79)	343.54 (125.25)	< 0.001[a]	418.90 (91.76)	< 0.001[a]

[1]Mean (SD); Wilcoxon Signed Ranks Test, TGUT, Time Up and Go Test, BBS, Berg Balance Scale, [a]Statistically significant

The findings of this study are consistent with previous research by Dr. Wongphaet, which showed that partial body weight support gait training can improve walking ability and balance. While previous studies reported results after training periods of 4 weeks or longer, this study found significant improvement after only 2 weeks, suggesting more rapid improvement in gait and balance is possible than has been reported in previous studies. None of the subjects who completed the training complained of any discomfort or side effects of training using the device. The two subjects who had used a single cane prior to the training used were able to walk confidently without any gait aid and reported feeling "stronger" and "having more confidence" in walking. The three subjects who had used a walker prior to the training used were not able to walk without a walker.

Even though the inclusion criteria and training protocol in this study differ in some respects from the study by Dr. Wongphaet, they share several important features, such as the use of subjective fear of falling and history of falls as inclusion criteria and high repetition gait training with "as little as possible" bodyweight support and "as fast as possible" walking training speed. The inclusion criteria for lower extremity muscle weakness selected for this study were chosen because of the Thai Ministry of Health (MOPH) announcement that leg weakness should be used as one of the criteria for identifying elderly persons at risk of falling.[17] In spite of that difference, a comparison of the results between these two studies is appropriate.

All subjects reported high satisfaction with using this device. However, the opinions of the health care personnel involved in the study have not yet been assessed, something which is essential before a new invention is accepted for clinical use.

As this was a small experimental study without a control group, further randomized controlled trials are necessary. Future research could assess changes in gait ability and balance rehabilitation with the MW-BWSF in other populations, e.g., stroke or Parkinson's disease patients.[18] Additionally it is essential that further research be conducted to determine the feasibility and effectiveness of using this type of device at home, as use during in-hospital training may differ from home use.

Conclusions

Gait training with the help of a motorized wheelchair with a built-in bodyweight support frame (MW-BWSF) can significantly improve gait abilities and balance in elderly individuals with minimal leg muscle weakness or who are at risk of falling. Statistically significant improvement can be achieved after as few as four training sessions.

Disclosure

The authors declare no conflicts of interest related to the device used in this study.

Acknowledgments

The device used in this research is an innovation of Mr. Somkid Somnugpong of the Welding Department of Kamphaengphet Technical College. It was registered as a petty patent with the Department of Intellectual Property on January 7, 2020.

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