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ORIGINAL ARTICLE

Effects of an Anterior Ankle-Foot Orthosis on Walking Mobility in Stroke Patients: Get Up and Go and Stair Walking

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Abstract

Objective: To examine the effects of an anterior ankle-foot orthosis (AAFO) on walking mobility in stroke patients.

Design: Cross-sectional and repeated-measures study design.

Setting: A university's neurologic rehabilitation department.

Participants: Ambulant stroke patients (N=21).

Interventions: Not applicable.

Main Outcome Measures: Walking mobility was measured by the Timed Up and Go (TUG) test and the Timed Up and Down Stairs (TUDS) test. The paired *t* test was used to determine the difference between the mobility performances measured with and without the AAFO.

Results: There were significant differences between mobility performances with and without an AAFO in the TUG test ($P=.038$) and the TUDS test ($P=.000$).

Conclusions: This study supports the effect of an AAFO on walking mobility in stroke patients. The findings demonstrate that stroke patients wearing an AAFO may ambulate with greater speed and safety on level surfaces and stairs.

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Mobility refers to the ability to independently and safely move from one place to another.[1] Walking mobility is defined as one's capacity for ambulation, which incorporates many types of tasks. Walking mobility tasks include walking initiation, walking on smooth and rough surfaces, and walking up and down stairs. These tasks require both static and dynamic balance.[2] Strokes often cause deficits in balance and mobility, including increases in static postural sway,[3,4] diminished weight-bearing on the paretic limb while standing, asymmetrical weight-shifting ability between the 2 limbs,[5] and overall reductions in the range of weight-shifting.[6] At least 70% of stroke patients are able to regain walking ability, but they generally walk more slowly than healthy individuals.[7] The gait characteristics of stroke patients include a lower cadence, shorter steps and stride length, a shorter stance phase and prolonged swing phase on the affected side, a prolonged double-support phase,[8,9] inadequate propulsion, and an increase in the energy required for walking compared with healthy individuals.[10] These changes in the gait of stroke patients increase their risk of falling. Studies have reported that stroke patients with poor balance experience a high recurrence of falls.[11] Self-confidence in performing tasks without falling was correlated significantly with observer-based balance and gait speed.[12] Subsequent problems caused by falls are numerous, including physical injuries, immobility, psychosocial trauma, and increased costs of care.[13] Therefore, improving balance and mobility to prevent falls is an important goal of poststroke rehabilitation.

Walking up and down stairs is similar to walking that involves reciprocal movements of the legs by alternating the stance and swing phases. When walking up stairs, the knee and ankle joints must produce concentric contractions for forward and upward

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progression. The greatest stability is demanded during the single-leg stance phase, when the swing leg is advancing toward the next step. Walking down stairs requires the generation of eccentric contractions of the hip, knee, and ankle extensors and control of the position of the body in response to the accelerating force of gravity.[1] In addition, factors that affect performance in walking up and down stairs include ankle joint angles (such as the dorsiflexion flexibility of the ankle)[14] and visual detection (such as ambient lighting and stair edge contrast).[15,16] Thus, walking up or down stairs is more challenging than walking on a level surface.

In Taiwan, occupational therapists often provide anterior ankle-foot orthoses (AAFOs) for stroke patients to improve their balance and mobility. The advantages of the AAFO are that it is fabricated quickly, easily, and custom fit; provides excellent foot fixation, toe pickup, and maximal mediolateral stability; and allows normal heel contact on the ground and thus can be worn barefoot indoors as well as with shoes.[17] In addition, the AAFO is formed at an angle of dorsiflexion, approximately 5° to 10°. Clinically, a dorsiflexion of 5° to 10° will facilitate the knee into an appropriate flexion that prevents a tendency toward recurvation during stance[18] and creates satisfactory toe pickup during swing.

Previous studies[19-21] have investigated the effects of an AAFO on the walking ability and gait pattern of stroke patients. Wong et al[21] first revealed that gait pattern did improve by using the AAFO, especially with respect to the foot pressure distribution. Chen et al[19] used a Computer Dyno Graphy system to examine the effects of an AAFO on hemiplegic gait, and the authors concluded that wearing an AAFO led to a faster walking speed and an increased cadence, but no significant difference in gait symmetry was found. Hung et al[20] examined chronic stroke patients who wore an AAFO for at least 5 months and determined that the AAFO improved functional walking ability significantly. The authors also indicated that the use of an AAFO was better suited for younger patients and those with diminished walking ability. Only 1 study[20] reported the effect on functional ambulation using the Timed Up and Go (TUG) test; no one has examined the effects of an AAFO on the stair-walking ability of stroke patients. Therefore, the TUG and Timed Up and Down Stairs (TUDS) tests were used in this study to explore the effects of AAFOs on get up and go and stair-walking mobility in stroke patients.

Methods

Participants

Between June 2012 and September 2012, 254 stroke patients who were undergoing therapy at the university's neurologic rehabilitation department were selected to participate in this study. The criteria for selection were as follows: (1) unilateral hemiplegic stroke patients capable of following simple verbal instructions; (2) ability to walk on a level surface and to walk up and down stairs independently or under supervision with or without assistive devices (handrail or cane) and without wearing an AAFO; and (3) no systemic or local medical problems, other than stroke, that might affect walking mobility.

Four exclusion criteria were established: (1) clinically significant visual impairment; (2) unilateral neglect; (3) aphasia; and (4) the ability to voluntarily dorsiflex the ankle against gravity. The Medical Research Council (MRC) scale for muscle strength grading was used as a screening test to exclude the patients whose affected ankle dorsiflexor was MRC grade 3 or above, since the AAFO is indicated for weakness or paralysis of the ankle dorsiflexor.

Of these 254 stroke patients, 125 were found eligible for study enrollment. One hundred patients were excluded because they had visual impairment, unilateral neglect, or aphasia or because their affected ankle dorsiflexors were MRC grade 3 or above. After an introduction and explanation of the study, potential participants were asked whether they wanted to participate. Two potential participants refused to participate in the study. During the TUDS test, 2 additional patients were excluded for safety concerns. A total of 21 patients participated in the study.

List of abbreviations:

AFO	**ankle-foot orthosis**
AAFO	**anterior ankle-foot orthosis**
BBS	**Berg Balance Scale**
MRC	**Medical Research Council**
PAFO	**posterior ankle-foot orthosis**
TUG	**Timed Up and Go**
TUDS	**Timed Up and Down Stairs**

Outcome measures

The TUG test was used to evaluate basic mobility. Participants were asked to sit in a standard chair (seat height, approximately 46cm; armrest height, approximately 65cm), get up and walk 3m, turn around, walk back to the chair, and sit down again. We recorded the number of seconds each participant required to complete this task. This test possesses a high degree of reliability and validity.[22] The TUDS test included walking up and down a staircase, which had a total of 12 steps, each with a height and depth of 16cm and 26cm, respectively. The participants could use the handrails or a cane and any method (eg, step-over-step or step-by-step patterns) to complete the test. The time required by each participant to walk up and down the 12-step staircase was recorded, and the sum of all the times was determined. To ensure that the patients did not become fatigued, each test was conducted only once.

Procedures

Before the experiment, all participants provided informed consent, and the protocol was approved by the institutional review board. Information about clinical and demographic characteristics was obtained through interviews with the patients and from their medical charts (ie, sex, age, when the stroke occurred, the type of stroke, the duration of AAFO usage). Subsequently, the Brunnstrom motor recovery stage of the lower extremity, invertor or plantar flexor spasticity (using the Modified Ashworth Scale), and the Berg Balance Scale (BBS) scores of each participant were evaluated. The BBS was used to evaluate the participants' balance without wearing an AAFO. This scale includes 14 items on a 5-point scale (0–4 points), with a maximum score of 56 points. Higher scores indicate better balance, and research results have indicated that the BBS has a high degree of reliability and validity.[23,24]

Participants who already had an AAFO made by a therapist were allowed to use the device for testing. If a participant did not have an AAFO, one was fabricated by the participant's occupational therapist.

Participants were requested to complete the TUG and TUDS tests. During the testing process, 2 individuals stood by the participants, 1 on each side, to prevent falls. The sequence of measuring the participants with and without an AAFO was randomized.