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Clinical Trial

Effects of HAL® Robot Suits Gait Rehabilitation for Patients with Neuromuscular Diseases

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Abstract

Introduction: Hybrid assistive limb (HAL) robotic suit were tried for gait rehabilitation in patients with neuromuscular diseases in our hospital.

Subjects and Methods: This study enrolled 13 patients for a first introduction HAL-assisted gait training over 3 weeks.

Results: We noted improvements in average walking, stride length, time up and go, 2-minute walk test, quadriceps femoral muscle strength, and grip strength. Subjects with neurogenic disease exhibited greater improvements in several variables including time up and go, 2-minute walk test, and hand-held dynamometer, compared to those with myogenic disease.

Discussion: Neuromuscular diseases are associated with skeletal muscle impairment and neurodegeneration, resulting in gait dysfunction due to muscle atrophy, muscle weakness, and dystonia. HAL rehabilitation may assist in delaying the deterioration of activities of daily living and quality of life, decrease in activity levels, and development of disuse syndrome.

Conclusion: HAL-assisted gait rehabilitation had few adverse reactions; subjects with neurogenic disease improved more than those with myogenic disease.

Keywords: *Hybrid Assistive Limb; Rehabilitation; Neuromuscular Diseases*

Abbreviations

HAL: Hybrid Assistive Limb; CVC: Cybernic Voluntary Control; TUG: Time Up and Go; 2-MWT: 2-Minute Walk Test; HHD: Hand-Held Dynamometer; IBF: Interactive Bio-Feedback

Introduction

We used the Hybrid Assistive Limb (HAL®; Model ML-05) Robotic Suit [1-3]) for gait rehabilitation in patients with neuromuscular diseases.

Subjects and Methods

This study enrolled 13 (6 male and 7 female) patients with neurological/muscular diseases. Each subject received 10 sessions of HAL®-assisted gait training over 3 weeks; the schedule was determined on the day of admission and the final evaluation was performed on the day of discharge. CVC mode (cybernic voluntary control) was used for the setting of HAL® suit and gait training. We evaluated the subjects using the 10-meter maximum walk test (speed, cadence, and stride length), Timed Up and Go (TUG) test, 2-minute walk test (2MWT), muscle strength (quadriceps muscle and grip strength assessed via hand-held dynamometer [HHD]), gait stability (subjective rating by visual analogue scale), and a questionnaire survey.

Results

Thirteen patients were including myotonic dystrophy (5 patients), limb-girdle muscular dystrophy (4 patients), amyotrophic lateral sclerosis (3 patients), and spinobulbar muscular atrophy (1 patient), with the mean age of 50.8 ± 22 years, body height of 163.3 ± 7.7 cm, and body weight of 57.9 ± 11.3 kg, for a first introduction to HAL®. They were received an average of 11 (10 - 14) sessions of gait training with the HAL® suit. Each session lasted approximately 30 - 40 minutes, with a mean walking distance of 592 ± 235 m per session. We noted improvements in average walking speed (16.1%; 0.92 ± 0.36 m/s to 1.06 ± 0.28 m/s), cadence stride (6.5%; 107.9±30.1 step/m to 115.0±20.5 step/m), stride length (9.1%; 0.51 ± 0.1 m to 0.56 ± 0.1 m), TUG (18.1%; 13.4 ± 4.3 s to 11.0 ± 3.6 s), 2MWT (23.1%; 82.1 ± 31.1 m to 101.1 ± 26.1 m), quadriceps muscle strength (14.2 ± 11 kgf to 17.5 ± 8.7 kgf), and grip strength (7.6 ± 5.6 kg to 8.7 ± 10.0 kg). Subjective gait stability improved from 3.9 ± 2.2 cm to 4.9 ± 2.4 cm ($p < 0.05$). Gait evaluation results are summarized according to disease type in table 1. Subjects with neurogenic disease exhibited greater improvements in several variables including TUG, 2MWT, and HHD, compared to those with myogenic disease (Table 2). Ten subjects had positive perceptions of the HAL® suit including improved gait, posture, endurance, and stability. Walking distance and stride width improved. Subjects noted less frequent stumbling and feelings of accomplishment. Complaints included hospital stay length, HAL® suit weight, and difficulty wearing the HAL® suit.

	Before HAL	After HAL	Improvement rate
Walking speed (m/s)			
All of them	0.92 ± 0.36	1.06 ± 0.28*	16.1%*
Myogenic disease	1.0 ± 0.37	1.11 ± 0.31	10.8%
Neurogenic disease	0.67 ± 0.22	0.94 ± 0.08**	40.1%**
Cadence (step/m)			
All of them	107.9 ± 30.1	115.0 ± 20.5	6.5%
Myogenic disease	114.9 ± 30	116.9 ± 23.2	1.8%
Neurogenic disease	87.1 ± 22.9	109.2 ± 9.3**	25.3%**
Stride length (m)			
All of them	0.51 ± 0.1	0.56 ± 0.1	9.1%*
Myogenic disease	0.54 ± 0.1	0.57 ± 0.1	6.3%
Neurogenic disease	0.45 ± 0.1	0.53 ± 0.1**	19.4%**

Table 1: *Effects of HAL-assisted gait evaluation compere myogenic to neurogenic diseases.*

**:P < 0.05; **:P < 0.01*

	Before HAL	After HAL	Improvement rate
TUG (S)			
All of them	13.4 ± 4.3	11.0 ± 3.6	18.1%*
Myogenic disease	12.0 ± 4.1	10.3 ± 3.9	13.6%*
Neurogenic disease	17.3 ± 2.1	12.8 ± 1.5**	26.4%**
2MWT (m)			
All of them	82.1 ± 31.1	101.1 ± 26.1	23.1%*
Myogenic disease	89.1 ± 31.2	104.4 ± 28.5	17.6%*
Neurogenic disease	61.3 ± 23.7	90.1 ± 16.1**	47.1%**
HHD (kgf)			
All of them	0.51 ± 0.1	0.56 ± 0.1	9.1%*
Myogenic disease	0.54 ± 0.1	0.57 ± 0.1	6.3%
Neurogenic disease	0.45 ± 0.1	0.53 ± 0.1*	19.4%*

Table 2: *Effects of HAL-assisted gait training improved in TUG, 2MWT and HDD.*

**:P < 0.05; **:P < 0.01*

Discussion

Neuromuscular diseases are associated with skeletal muscle impairment and neurodegeneration, resulting in gait dysfunction due to muscle atrophy, muscle weakness, and dystonia [4,5]. HAL® rehabilitation may assist in delaying the deterioration of activities of daily living and quality of life, decrease in activity levels, and development of disuse syndrome. HAL® stimulates neuronal plasticity, protects neurons and muscles, and treats disuse-related atrophy, reinforcing gait cycle re-learning by the Interactive Bio-Feedback (IBF) hypothesis [6], which maximizes use of voluntary movements. HAL®-assisted gait rehabilitation may help prevent progression of muscle atrophy and muscle weakness, potentially lessening the need for future interventions.

Conclusion

1. Patients with neuromuscular diseases were introduced to HAL®-assisted gait rehabilitation.
2. HAL®-assisted gait rehabilitation had few adverse reactions; subjects with neurogenic disease improved more than those with myogenic disease.

Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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