P-23

Feasibility of Knee–actuated Exoskeletal Gait Orthosis for Post-stroke Hemiplegic Gait Disturbance

Tae Hoon Kim, MD[1], Jun Yup Kim, MD, MS[1], Ji Woong Choi, MD[1], Bo Kyoung Kim, MD[2], Yoon Heo, PhD[3], Hyuk–Jae Choi, PhD[3], Jong–Won Lee, PhD[3], Hyeonseok Cho, PhD[3], Mi Jung Kim, MD, PhD[1]

[1]Department of Physical Medicine and Rehabilitation, Hanyang University Medical Center, Seoul, Republic of Korea
[2]Department of Physical Medicine and Rehabilitation, Seongdong Rehabilitation Clinic, Seoul, Republic of Korea
[3]Rehabilitation Engineering Research Institute, Korea Workers' Compensation & Welfare Service, Incheon, Republic of Korea

Introduction

This study was a pilot study to assess the feasibility of the knee-actuated exoskeletal gait orthosis (KAEGO) designed to assist the gait of patients who suffer from gait disturbance due to unilateral lower extremity weakness.

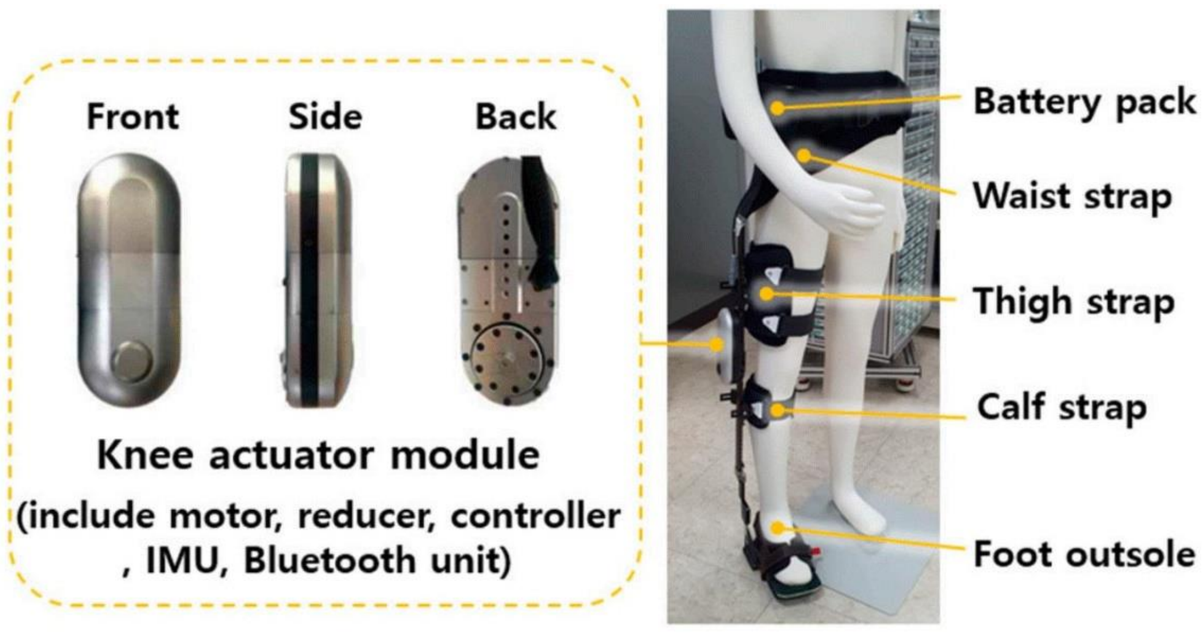

Figure. Component parts and wearing examples of knee-actuated exoskeletal gait orthosis

Methods

All participants had a total of six walking training sessions using KAEGO. KAEGO plays a role in facilitating the flexion and extension of the knee joint during the gait cycle, particularly aiding in the swing phase.

The training sessions were conducted for 40 minutes each, three times a week, over a two-week period, with a walking track length of 20 meters. During the screening visit of the participants, information including demographics, pulmonary function, clinical disease-related parameters, and gait-balance ability test records (Berg Balance Scale (BBS), Timed Up and Go Test (TUGT), Dynamic Gait Index (DGI)) were gathered. At each of the 1st and 6th sessions, 3-minute walk test (3mWT), 6-minute walk test (6mWT), 10-meter walk test (10MWT) were measured wearing KAEGO. Each improvement percentage (IP) was calculated as follows: IP = {(pre-training record) - (post-training record)} * 100 / (pre-training record).

Table 1. Ambulatory function outcomes at pre-training (1st session) and post-training (6th session) with KAEGO

Measure-ments	n	Pre-training	Post-training	*p*	IP
3mWT distance, m	12	78.5 (40.0 – 108.8)	91.6 (64.9 – 109.7)	0.35	0.0 (-4.1 – -20.1)
6mWT distance, m	9	193.2 (140.7 – 260.0)	180.0 (132.8 – 230.8)	0.25	4.1 (-3.9 – -23.7)
10MWT time, sec	16	9.5 (6.5 – 15.0)	7.4 (5.3 – 11.3)	0.02*	-17.8 (-31.4 – -9.4)

Values are median (Interquartile range). Wilcoxon signed rank test were performed.
Abbreviations: IP = improvement percent; KAEGO = knee-actuated exoskeletal gait orthosis; 3mWT = 3-minute walk test; 6mWT = 6-minute walk test; 10MWT = 10-meter walk test.
* $p < 0.05$

Table 2. Spearman correlation coefficients between the baseline physiologic/ambulatory function outcomes and the improvement percentage of 3-minute/6-minute/10-meter walk test with KAEGO

		FVC (% predicted)	FEV1 (% predicted)	BMI
IP of 3mWT	Correlation coefficient	0.75*	0.85*	-0.68*
	p	0.01*	<0.01*	0.01*
	n of pairs	10	10	12
IP of 6mWT	Correlation coefficient	0.5	0.73*	-0.68
	p	0.21	0.04*	0.05
	n of pairs	8	8	9
IP of 10MWT	Correlation coefficient	0.59*	0.33	-0.17
	p	0.02*	0.23	0.52
	n of pairs	14	14	16

Spearman rank correlation analysis were performed.
Abbreviations: BMI = body mass index; KAEGO = knee-actuated exoskeletal gait orthosis; FEV1 = forced expiratory volume in 1 second; FVC = forced vital capacity; IP = improvement percent; 3mWT = 3-minute walk test; 6mWT = 6-minute walk test; 10MWT = 10-meter walk test.
* $p < 0.05$

Results

The median (interquartile range) age of the 21 participants was 61 (53 - 68) and all of them exhibited gait disturbance caused by a prior history of ischemic or hemorrhagic stroke. Of the total participants, 16 (76.2%) were male. Among the participants, 12, nine, and 16 individuals, respectively, performed the 3mWT, 6mWT, and 10MWT at both of the 1st and 6th sessions. The median values for pre-/post-training results for the three types of tests were 78.5/91.6 meters, 193.2/180.0 meters, and 9.51/7.43 seconds, respectively (Table 1). The difference in median between 1st and 6th sessions was found to be statistically significant only at 10MWT by the Wilcoxon signed rank test (Table 2).

The IP for the 3mWT, 6mWT, and 10MWT were calculated using values before and after the six sessions. Spearman correlation analyses showed that baseline Forced Vital Capacity (FVC), Forced Expiratory Volume in one second, (FEV1), and Body Mass Index (BMI) were significantly associated with IP of 3mWT. In addition, FEV1 showed a significant positive correlation with IP of 6mWT. FVC also exhibited a significant positive correlation with IP of 10MWT.

Conclusion

The results of this study implicate that significant improvements in walking speed, as reflected in the 10MWT, after only six sessions of walking training using KAEGO. Also, when analyzing the correlation between IPs of the 3mWT, 6mWT, and 10MWT and baseline physiologic and ambulatory function outcomes, it was found that individuals with higher baseline FVC and FEV1 (% predicted) and lower BMI exhibit greater improvements in walking endurance and speed through the use of KAEGO. Therefore, these results can suggest that KAEGO has the potential to assist in the walking of post-stroke hemiplegic community ambulators.

Acknowledgement

This work was supported by the Korea Medical Device Development Fund grant funded by the Korea government (the Ministry of Science and ICT, the Ministry of Trade, Industry and Energy, the Ministry of Health & Welfare, the Ministry of Food and Drug Safety) (Project Number: 202013B01, RS–2020–KD000160).