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Single-Leg Exoskeleton Robot for Gait Training of Hemiplegic Patient – A Pilot Study

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Back ground

The walking of the human body refers to a continuous movement and form using two legs alternately to move the center of gravity of the human body from one place to another. For this, the activity of the muscles and the mobility of the joints must be well coordinated in time and mechanics. However, this coordination can be broken by various causes, which include various diseases and accidents of the central nervous system or musculoskeletal system. Stroke is the most common example of pathologic walking among these central nervous system diseases. Many therapies have been used to restore the gait of the stroke such as traditional physsical therapy and functional electical stimulation. Recently rehabilitation robot was developed to assist walking but their size is too big and can do only on treadmill. For this reason, we used single-leg type exoskeleton robot, which is relatively light and can be worn and walked anywhere without the need for additional equipment such as treadmill.

Method

From March, 2018 to May, 2018, two strokes patients were enrolled in this study. Patients were hemiplegic stroke patients who had been in stroke for more than 6 months. Patients were able to walk independently but their stability and endurance were impaired due to hemiplegia. Gait training was scheduled with twice a week for eight weeks. Each training consisted with 45 minutes walking with single-leg exoskeleton. Neurological status, functional and walking ability were evaluated before the training, after 4 weeks training and the end of the training on 8 weeks. Neurological status was measured with Korean version Fugl-Meyer Assessment lower extremity scale which used to assess functional and neurological recovery in stroke patients.

Result

Total 8-week training did not show significant improvement in neurological assessment such as Korean version Fugl-Meyer Assessment score of lower extremity, coordination, sensation, joint range of motion and pain(Table 1). On the muscle strength test using hand dynamometer there was gradual improvement in both legs muscle strength(Table 2). Gait performance using a timed up to go test, a 4m gait speed test and 6 minutes walking test also showed sequential improvement in two patients(Table 3).

Conclusion

For hemiplegic stroke patients, using single leg exoskeleton robot were useful for improving their strength and gait performance. This robot also had the advantage of being easily worn and less space occupying and portable use without space limitation. Although neurological outcomes of the patients were not changed, further studies are needed to evaluate long-term effects of single leg exoskeleton robot.

Table 1. Korean Version Fugl-Meyer Assessment Lower extremity

Category	Case 1			Case 2		
Lower extremity (.../28)	12	12	12	15	15	15
Coordination /speed (.../6)	5	5	5	5	5	5
Sensation (.../12)	2	2	2	6	6	6
Passive joint motion (.../20)	19	19	19	10	10	10
Joint pain (.../20)	20	20	20	20	20	20

Table 2. Lower leg muscle strength using hand dynamometer

Muscle strength (kg)	Joint	Muscle	Case 1			Case 2		
			Before	4 weeks	8 weeks	Before	4 weeks	8 weeks
Right	Hip	Flexor	20.1	22.5	25.2	7.4	12.2	16.9
		Extensor	19.9	24.2	24.4	14.8	15.2	17.4
	Knee	Flexor	17.3	14.5	20.9	3.5	5.8	6.1
		Extensor	21.1	22.8	25.9	14.5	17.3	17.4
	Ankle	Dorsiflexor	14.8	15.7	18.8	3.1	4.3	4.1
		Plantarflexor	16.9	20.7	21.1	12.8	13.2	14.4
Left	Hip	Flexor	11.9	22.4	17.4	17.3	21.1	17.8
		Extensor	15.3	19.5	24.2	20.7	25.2	26.1
	Knee	Flexor	1.7	1.7	1.8	17.1	20.2	18.1
		Extensor	19.9	24.4	28.3	17.3	24.4	25.7
	Ankle	Dorsiflexor	0	0	0	16.1	15.9	15.7
		Plantarflexor	4.8	10.1	15.1	18.5	18.5	18.5

Table 3. Gait performance

	Case 1			Case 2		
	Before	**4 weeks**	**8 weeks**	**Before**	**4 weeks**	**8 weeks**
Timed up to go test(sec)	29.62	28.27	28.31	25.69	23.52	19.01
4m gait speed test(M/sec)	0.34	0.37	0.37	0.36	0.39	0.39
6 minutes walking test(cm)	121.2	132.8	139.1	125.4	127.9	157.7