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The Changes of Cardiopulmonary Function after Robotic Exoskeleton Gait Training in a SCI Patient

Yun Chol Jang[1*], In Sung Choi[1], Jae-Young Han[1], Hyeng-Kyu Park[1], Min-Keun Song[1†]

Chonnam National University Medical School & Hospital, Department of Physical & Rehabilitation Medicine[1]

Objective

Spinal cord injury (SCI) results in various neurological symptoms and may increase the risk of cardiovascular disease, respiratory problems, osteoporosis and psychological problems because of standing or walking issues. Recently, a powered robotic exoskeleton has been developed and used as mobility and gait training devices. There have been few studies on the gait pattern and cardiopulmonary function in chronic SCI patients trained with powered robotic exoskeleton. We report the changes of gait pattern and cardiopulmonary function in a chronic incomplete cervical SCI patient who was trained using the new powered robotic exoskeleton manufactured by domestic firms for incomplete SCI and fragile elderly people.

Case description

A 57-year-old man with chronic incomplete cervical SCI (duration of disease: 3 years) was hospitalized for robotic exoskeleton-assisted gait training. He was able to walk about 10 m using Q-cane. His gait pattern was more like that of hemiplegic patient. Muscle strength of the right upper and lower extremities was good and that of the left upper and lower extremities was poor on manual muscle test. Before participating in our gait training program, he had got conventional rehab (physical therapy and occupational therapy) at a local hospital. We put him through conventional rehab and robotic exoskeleton-assisted gait training program (REP) (Figure 1). REP was done five times per week for 30 minutes per session for 6 weeks. REP consisted of sit to stand, stand to sit and overground walking on the flat aisle, while wearing Angelegs (SG-Robotics, Seoul, Korea) (Figure 1). The gait speed was fit to the patient's pace. A physical therapist evaluated the functional outcome of the patient using Range of Motion (ROM), Manual Muscle Test (MMT), Modified Ashworth Scale (MAS), Korean-Modified Barthel Index (K-MBI), Functional Ambulatory Category (FAC), 3D dynamic posturography system (TecnoBody, PRO-KIN system, TecnoBody Srl, Dalmine BG, Italy), EuroQol-5D (EQ-5D), 10-meter walking test, Timed up and go test, and 3D gait analysis before (T0) and after training (T1). At the time of gait analysis, the patient walked wearing portable gas analyzer (K4B2, COSMED Srl, Rome, Italy) to measure VO2 and MET. He reported mild skin problem (redness) and musculoskeletal pain during the REP, but no other serious adverse events. After 6 weeks of treatment, balance function somewhat improved and gait speed was slightly faster than before (Table 1). Peak MET and peak VO2 decreased during the test. Peak VO2 and peak MET decreased during the test and it means that the patient performed the same activity with less effort and cardiopulmonary function was improved by REP.

Conclusion

Robotic exoskeleton would be a useful gait assistive device in incomplete SCI patients. In our patient, distinctive clinical feature was incomplete tetreplagia like hemiplegia suggesting the widening of application scope of this device.

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Table 1. Changes of gait and cardiopulmonary function

	Before (T0)	After (T1)
Functional assessment		
MMT (right leg/left leg)	(4/4/4) / (2/2/2)	(4/4/4) / (2/2/2)
MAS (right ankle /left ankle)	Gr 1/Gr 0	Gr 1/Gr 0
K-MBI	53	53
FAC	1	1
Balance (average C.o.P. X/C.o.P. Y)		
opened eyes	25/-43	26/-43
closed eyes	45/-55	45/-55
10-meter walking test (sec)		
comfortable	89.00	86.50
fast	76.42	80.12
Timed up and go test (sec)	76.16	77.84
Gait analysis		
cadence (steps/min)	16.4	23.9
speed (cm/s)	6.8	9.7
stride length (cm)	49.5	49.4
right / left stride length (cm)	48.3/50.7	48.8/50.0
right / left step length (cm)	25.7/24.5	26.9/22.6
step width (cm)	15.9	14.0
Cardiopulmonary function		
peak MET	4.6	4.1
peak VO_2	1208.1	1077.9
EQ-5D	12	11

MMT, manual motor test; *MAS*, Modified Ashworth Scale; *K-MBI*, Korean-Modified Barthel index; *FAC*, functional ambulation category; *EQ-5D*, EuroQol-5D

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Figure 1. Robotic exoskeleton-assisted overground walking training

(A) Schematic structure of Angelegs; (B), (C) Gait training wearing Angelegs; (D) 3D gait analysis wearing portable gas analyzer.

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