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Walking Assistance in a Patient with Chronic Obstructive Pulmonary Disease Using a Powered Exoskeleton: A Case Report

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6. Abbreviations

COPD Chronic obstructive pulmonary disease
PR Pulmonary rehabilitation
FEV1 Forced expiratory volume in 1s
FVC Forced vital capacity
MIP Maximal inspiratory pressure
MEP Maximal expiratory pressure
30STST 30-second sit-to-stand test
6MWD Six-minute walking distance
6MWT Six-minute walking test

7. Keywords
Walking Assistance；Chronic Obstructive Pulmonary Disease（COPD）；Exoskeleton; pulmonary rehabilitation (PR)

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Walking Assistance in a Patient with Chronic Obstructive Pulmonary Disease Using a Powered Exoskeleton: A Case Report

Exercise capacity in patients with chronic obstructive pulmonary disease (COPD) is often limited by dyspnea. Exoskeleton assist, conceptually a wearable robot, is a novel emerging technological solution that aims to enable improved walking performance .[1-2] Although it has been reported for patients with neuromuscular impairments, there have been few studies focusing on exoskeleton assist in patients with COPD. We presented a COPD patient who performed four weeks of pulmonary rehabilitation (PR) program. The patient wore the exoskeleton during all the exercise sessions.

The 54-year-old male with COPD visited the outpatient clinic because of progressive dyspnea. Spirometry revealed severe obstructive ventilatory dysfunction. The patient was taken on therapy with Fluticasone Furoate (100ug/62.5ug/25ug, 1 puff once daily) and albuterol (100 mg, 2 puffs as needed). However, he still had a recurrent dyspnea after exertion. Based on the positive effects of PR in COPD[3] and of exoskeleton assist training in improving walking performance, we hypothesized that using a powered exoskeleton during exercise sessions of PR could improve the weakened exercise capacity and respiratory function more than a classic PR program. The Keeogo powered exoskeleton (B-Temia Inc.) is a mobility assist device (Figure 1) activated by user movement to synchronize assist. A motor at each knee joint augments leg muscle power and recognizes physical activities, including bending at the knee, sitting, and walking. The patient participated in sessions three times per week for 4 weeks. The PR program comprised prescribed, individualized exercise, strength and Inspiratory muscle training. We assessed his pulmonary function, respiratory muscle strength, and physical function before and after the comprehensive PR. The patient completed the unassisted natural 6-minute walk test (6MWT) and 30-second sit-to-stand (30STST) , fitting to the exoskeleton and practicing 6MWT and 30STST.

After 4 weeks of the PR program, The patient's functional exercise capacity improved by 36m (7%) in the unassisted natural 6MWT and 6 repetitions (33%) in the 30STST, fitting to the exoskeleton and improving 35m (8%) in the 6MWT and 11 repetitions (110%) in the 30STST. The respiratory muscle strength results showed an improvement in maximal inspiratory pressure (MIP) and maximal expiratory

pressure(MEP). The pulmonary function results showed an improvement in forced expiratory volume in 1s (FEV1) and forced vital capacity(FVC). The upper limb strength improved by 20Nm (24%) and 15Nm (14%) for abduction and adduction of the upper limb and by 1(3%) and 2.1 (6%) for the handgrip strength.

These results suggest that the Keeogo powered exoskeleton is safe and feasible for the patient, and show that functional exercise with it improved his pulmonary function, respiratory muscle strength, and physical function in the PR program. Exoskeleton assist have been reported to reduce energy expenditure in the healthy elderly during walking.[4-5] The mechanism of the patient's walking is related to ventilatory capacity, which is challenged to support the increased oxygen consumption of walking, and the exoskeleton may reduce the energy expenditure and be beneficial to COPD patients. However, further research is need to investigate the effect of exercise with a powered exoskeleton in a PR program.

Fig.1. The patient with chronic obstructive pulmonary disease(COPD) wore the exoskeleton during practicing 6-minute walk test (6MWT).

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