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Case Study

Long-term body-weight-supported treadmill training for incomplete cervical spinal cord injury: a case report

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Abstract. [Purpose] To investigate the effects of long-term body-weight-supported treadmill training on walking ability and physical function in an elderly individual with incomplete cervical spinal cord injury. [Participant and Methods] The patient was a 68 year-old male with an incomplete spinal cord injury at the C3/C4 level, incurred when he was 56 years old. He initiated home-based body-weight-supported treadmill training using a body-weight-supported treadmill installed at his home. His walking ability was measured as the percentage of body weight load reduction, and his physical function was evaluated using manual muscle testing and measuement of the range of motion of his lower limbs. [Results] The physical function of the lower limbs was improved, maintained, or showed delayed decline until 9.5 years post-injury. [Conclusion] Long-term body-weight-supported treadmill training may improve, maintain, or at least delay the decline of the physical function of participants for several years, without causing any remarkable complications.

Key words: Incomplete spinal cord injury, Body-weight-supported treadmill training, Long-term rehabilitation

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INTRODUCTION

Many complications occur in patients with spinal cord injury (SCI), including not only motor and sensory physical disorders but also the neurogenic bladder and bowel, urinary tract infection, pressure ulcers, orthostatic hypotension, fractures, deep vein thrombosis, spasticity, autonomic dysreflexia, and pulmonary cardiovascular complications[1)]. Especially, elderly people are highly at risk of these complications[2, 3)]. Several studies focusing on rehabilitation during the acute period described these problems[4)]. Although some studies have mentioned the necessity of long-term rehabilitation in the chronic period[1)], only a few studies described specific complications.

The proportion of patients with incomplete tetraplegia is notably greater in the elderly than in younger patients with SCI[5)]. Patients with motor incomplete SCI often show improvement in standing and walking abilities by some degrees, whereas those with motor-complete SCI have very limited possibilities of improving their walking function[6, 7)]. Prolonged standing has been investigated as an activity with possible benefits for patients with SCI, such as improved blood circulation and bladder and bowel functioning[8)].

Body-weight-supported treadmill training (BWSTT) has been increasingly known to recover the walking ability of patients with SCI even during the chronic period[9)]. Moreover, several studies have mentioned that the effects of BWSTT are not only shown in the walking ability but also in physical and cardiovascular functions[10, 11)]. However, BWSTT durations in

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published studies were usually less than several months; thus, whether those effects may continue for a longer period is still unclear, especially for elderly patients.

Therefore, this case report aimed to investigate the effects of long-term physical function in an elderly individual with incomplete cervical SCI with a BWSTT installed for >10 years.

PARTICIPANT AND METHODS

This is the case of a 68 year-old male with a history of incomplete SCI at the C3/C4 level at 56 years old. After the injury, the participant was hospitalized in the acute phase hospital for two months and the convalescence phase rehabilitation hospital for five months and discharged to his home for home care. Oral and written consents were obtained for the publication of this case in accordance with the ethical standards of the Declaration of Helsinki 1964.

The symptoms at the time of hospital discharge were tetraplegia, moderate to absent skin sensation under the C4 level, and muscle hypertonia of the limbs and trunk. The participant has suffered hypotension due to the autonomic disturbance caused by SCI, from 140/90 mmHg pre-injury to 90/60 mmHg post-injury. Assessments at seven months post-injury were as follows: the total activity of daily living (ADL)/Barthel index score of 10; the basic movement scale scores of 1 except for the turn-in bed score of 2; American Spinal Injury Association motor scores of R/15 and L/17, sensory light touch of R/29 and L/27, and sensory pinprick of R/27 and L/26; and modified Frankel score of C1.

After returning home, the participant initially underwent stretching and strengthening treatments three times a week as part of conventional physiotherapy to maintain the residual body functions, prevent secondary complications, and improve his ADL. Additionally, the BWSTT machine, Pnew Assist (Alexandave Industries Co., Ltd., New Taipei, Taiwan), was installed at the participant's home as the training measurements for maintaining a standing posture, permitting his feet to be pressed by proper pressure on the ground, and maintaining endurance. The home-based BWSTT was started 1.6 years post-injury. Figure 1 shows images of the machine and walking with BWSTT. After the BWSTT machine was installed, the BWSTT for 1 hour once a week and conventional training for 1 hour twice a week were provided as an individual rehabilitation program covered by the Japanese National Health Insurance, such as the therapists' visiting rehabilitation.

The initial BWSTT protocol was as follows: the supported weight of 20 kg/50% body weight load reduction, walking speed of 1 km/h and walking time of 8 min, which increased up to 15 min walking time, with an increase in the walking speed and decrease in the supported weight according to previous studies[12–14]. However, the participant could not follow the protocol reported in previous studies. Therefore, BWSTT was scheduled based on the participant's physical condition and ability. The final protocol established 1.5 years after starting BWSTT was to have the walking time at a constant 15 min, the walking speed gradually increased from 1 km/h to 2 km/h with a constant supported weight, and when the walking speed reached 2 km/h, the supported weight slightly decreased and the walking speed started from 1 km/h again. One physiotherapist assisted the participant to maintain an upright posture during BWSTT, and when the physiotherapist judged that the participant could not walk anymore or was too tired, the physiotherapist told the patient to stop walking during BWSTT or changed the condition of BWSTT according to previous studies[12].

The walking ability, as the condition of BWSTT was measured by the percent body weight load reduction calculated using the last measured body weight, which was measured at intervals of 3–17 months. Although the walking distance at BWSTT was recorded, an outcome of walking ability was not applied because the training program targeted a maximum distance of

Fig. 1. Images of machine and walking of body-weight-supported treadmill training.

500 m or 15 min of the target walking time while considering the participant's physical burden and limited training time. The physical function as an outcome of BWSTT was evaluated using the MMT and ROM of the lower limbs every 6–12 months. All tests and measurements were performed by the therapists and nurses.

RESULTS

The walking ability and physical function were evaluated from seven months post-injury and continued for 11 years. The participant had no marked complications during the evaluation period. Figure 2 shows a plot of body weight load reduction after BWSTT. The body weight load reduction could gradually decrease until 4.5 years post-injury but could not decrease thereafter. Moreover, the participant could not walk for the full target time without increasing the supported weight. Between 7.5 and 9.5 years post-injury, the participant maintained the body weight load reduction, although the participant did not sufficiently lift his toes and the toes often touched and rubbed with the belt of the treadmill while walking, especially after an elapse of a certain time after the participant had started walking. The participant could not maintain the body weight load reduction at 10.5 years post-injury and could not achieve 15 min of the target walking time even with an increased body weight load reduction.

Figures 3 and 4 show the plots of the MMT scores of the lower limbs. The MMT scores increased during the first year, as described in a previous report[15)], maintained between 1 and 8.5 years post-injury, and decreased 9.5 years post-injury. Figure 5 shows the ROM plots of the lower limbs. The ROM was maintained for >11.5 years post-injury, except the ROM of dorsiflexion decreased 9.5 years post-injury. Dorsiflexion restrictions were markedly progressed10.5 years post-injury.

DISCUSSION

An elderly participant with incomplete cervical SCI underwent the long-term BWSTT for >10 years. The physical function of the lower limbs was improved or maintained for the first 3 years and had a maintained or delayed decline between 4.5 and 9.5 years post-injury. The previous study showed that an increase in muscle mass in the legs was recorded and plasticity in the lower limb may be induced after the completion of training in repetitive load-bearing stepping[10)], and this study may show the same effects for more than some years. However, the physical function of the lower limbs decreased, probably because of the progressing muscle hypertonia of the limbs. This suggests that the muscle strength of the lower limbs decreased, and the body weight load reduction had to be increased. The muscle strength of the lower limb further decreased because the weight load on the lower limb decreased on BWSTT.

Previous studies have mentioned that BWSTT may improve the walking ability and physical and cardiovascular functions of participants who could stand upright on BWSTT[12, 16)]. However, the BWSTT durations in published papers were usually <5 months, 20 months at the longest, because long-term BWSTT might not be feasible due to specific transportation and health barriers for patients with SCI after hospital discharge[12)]. In the longest BWSTT study, the body weight load reduction decreased during the 12-month training; however, the frequency of BWSTT was decreased and the body weight load reduction increased during the 12-month follow-up training. These findings suggest that BWSTT can improve the walking ability in patients, but the patients cannot maintain the improved walking ability without continuing BWSTT; however, whether the effects of BWSTT may continue for a longer period remains unclear. In this study, long-term BWSTT is thought to improve, maintain, or at least delay the decline of physical function of the participant without marked complications for more than

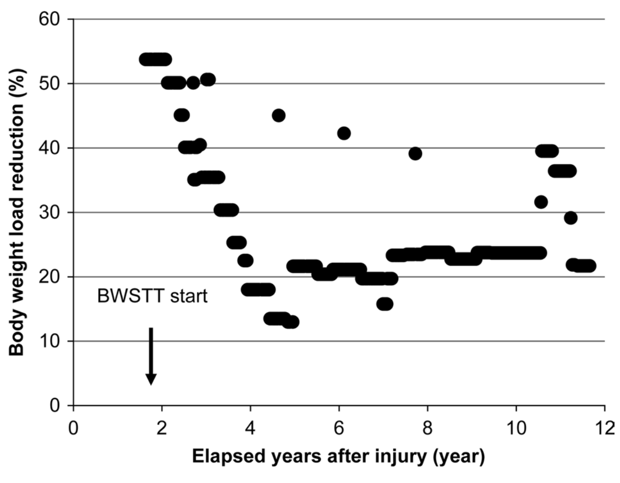

Fig. 2. Plot of the body weight load reduction at the body-weight-supported treadmill training.
BWSTT: body-weight-supported treadmill training.

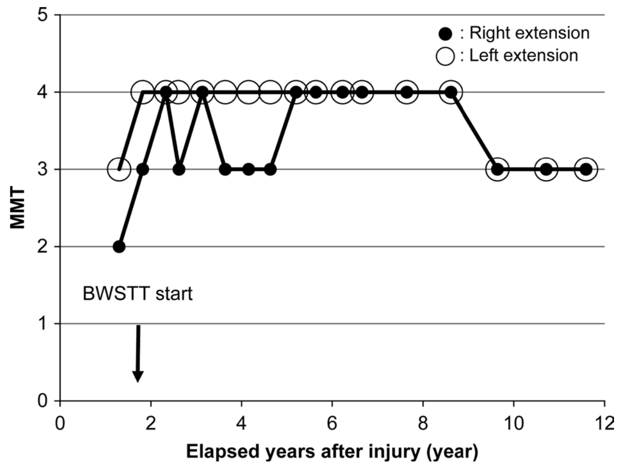

Fig. 3. Plots of MMT scores of the knee at the body-weight-supported treadmill training. BWSTT: body-weight-supported treadmill training; MMT: manual muscle test.

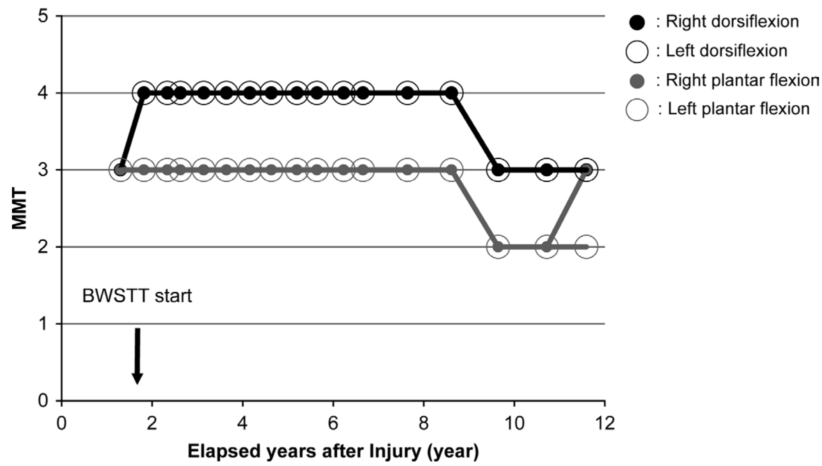

Fig. 4. Plots of MMT scores of the ankle at the body-weight-supported treadmill training. BWSTT: body-weight-supported treadmill training; MMT: manual muscle test.

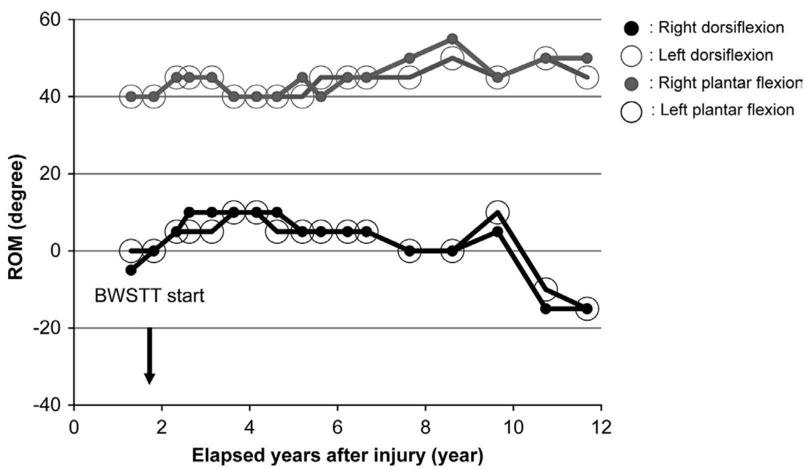

Fig. 5. Plots of ROM of the ankle at the body-weight-supported treadmill training. BWSTT: body-weight-supported treadmill training; ROM: range of motion.

several years even in an elderly participant, whereas the data of previous studies are from younger participants. Moreover, the participant could continue BWSTT for >10 years because BWSTT is suited for long-term rehabilitation.

In BWSTT, the participant who could not maintain a standing posture could eventually walk, and the target days were concrete numeric values and the resulting data could be visualized, which could easily improve and maintain his motivation. However, this is a report based on a single case; thus, these results cannot be generalized. Furthermore, the participant in this case was aged 58–68 during the BWSTT and was not elderly for the entire period. The effects of BWSTT on delaying age-related functional decline among those with incomplete cervical SCI should be clarified.

Funding and Conflict of interest

The authors declare that no funding was obtained for this study and no conflict of interest relevant to this article.

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