17-5 Effects of high concentration carbon-dioxide foot bath on lower extremity function and walking ability in spastic paraplegia: A case report

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Objectives: Recently, it has been reported that the effects of artificial high concentration carbon-dioxide (CO\(_2\)) on core temperature, cutaneous blood flow, thermal sensation, however, the effect of artificial high concentration CO\(_2\) water foot baths for spasticity, lower extremity motor function and walking ability was not identified. The purpose of this study was to investigate whether the newly artificial high concentration CO\(_2\) water foot bath inhibits spasticity and improves lower extremity motor function and gait speed in spastic paraplegia patient.

Case Presentation: The patient was a 37 years old man with spastic paraplegia of human immunodeficiency virus encephalopathy, without signs of cognitive impairment. The patient was able to walk without assistance using a T-cane or an ankle-foot orthosis. He had no medical condition that limited footbath usage (such as uncontrolled cardiopulmonary disease, severe joint disability and severe sensory disturbance), severe aphasia that made it impossible to follow verbal instructions, and cognitive dysfunction that interfered with outcome assessments. Informed consent was obtained from him according to the ethical guidelines of the hospital, after he fully understood the purpose and methodology of the study. This work was carried out with permission from the Ethical Committee of Kagoshima University.

Methods: This case study was before and after intervention trial. Six outcome instruments were used at baseline and after the artificial high concentration CO\(_2\) water foot bath: the modified Ashworth scale (MAS) score for the gastrocnemius muscles as a measure of spasticity, ankle clonus, muscle stiffness at triceps muscle of calf, deep body and surface skin temperature as a monitor for physical condition, the active range of motion as an assessment tool for motor function, and the 10-m walk test as a measure of walking ability. Lower-extremity movement acceleration was also measured using an accelerometer. The subject rested in a chair for 10 min and the above-noted physiological reactions during the last 5 min of the resting period were recorded as baseline values. Next, the subject received a 20-min foot bath in water at 38°C, with a 10-min recovery period. The artificial high concentration CO\(_2\) water foot bath improved the acceleration of the spastic lower extremities and this improvement in acceleration lasted for 10 min after the footbath usage.

Results: The subject experienced no discomfort before, during or after the intervention, and all assessments were completed safely. The deep body temperature and skin temperature
increased immediately after and 10 minutes after the artificial high concentration CO₂ water foot baths. The MAS score, ankle clonus and the muscle stiffness for the triceps muscle of calf were decreased. The active range of motion for ankle dorsiflexion and gait speed improved after the 20-min intervention.

**Conclusion:** These findings suggest that artificial high concentration CO₂ water foot bath is an effective method for controlling spasticity, and improves motor function and walking ability in spastic paraplegia patients.

**Keywords:** High concentration carbon-dioxide, Foot bath, Spasticity, Motor function