17-3 The effects of the high concentration carbon-dioxide water foot bath for patients after stroke: A within-subject comparison study

Hirofumi KANOH1), Yuji SAKASHITA1), Chihiro MORIYAMA1), Shuji MATSUMOTO2)

1) Department of Rehabilitation, Tarumizu Municipal Medical Center, Tarumizu Central Hospital
2) Department of Rehabilitation and Physical Medicine, Graduate School of Medical and Dental Sciences, Kagoshima University

Objectives: The warm-water foot bathing is widely used as a clinical method for hemiplegic limb. Recent research have reported that the artificial high concentration carbon-dioxide (CO\textsubscript{2}) water foot bathing have a potent vasodilative action. However, the definite effects of the artificial high concentration CO\textsubscript{2} water foot bath for hemiplegic limbs remain uncertain. We examined that the effects of the artificial high concentration CO\textsubscript{2} water foot bath for patients after stroke.

Patients: Three inpatients after stroke were recruited for this study. The age and duration after onset were 58.3 ± 21.4 years and 63.0 ± 38.9 months, respectively. Of the three patients (two males and one female), two were diagnosed with cerebral hemorrhage, one with cerebral infarction.

Methods: The artificial high concentration CO\textsubscript{2} water foot bath and tap water foot bath were prepared. The concentration of CO\textsubscript{2} water foot bath was approximately 1000-1,200 ppm, and both lower limbs (under the knee joint) were immersed in 38 ℃ water for 20 minutes. Foot bathing in tap water was also carried out under the same conditions in the another day. The following physiological data were measured before foot bathing and after the end of foot bathing. Not only the deep body temperature at axillary, the surface skin temperature at the front of femur, the calf of the leg and the dorsal foot, but also the muscle stiffness at triceps muscle of calf were evaluated.

Results: None of the subjects experienced discomfort before and after both the high concentration CO\textsubscript{2} water and the tap water foot bath. The physiological examination was completed safely in all subjects. The results were as follows: The deep body temperature and the surface skin temperature had increased, and the muscle stiffness had been relieved in the high concentration CO\textsubscript{2} water foot bath compared with the tap water bathing. The deep body temperature of the high concentration CO\textsubscript{2} water foot bath have risen from 36.4 ℃ to 36.9 ℃, the surface-skin temperature of the front of femur (from 26.7 ℃ to 28.1 ℃), the calf of the leg (from 29.5 ℃ to 31.9 ℃) and the dorsal foot (from 29.9 ℃ to 32.3 ℃) have risen, respectively. The muscle stiffness have been relieved from 55.3 to 51.8 before and after. There was no change that the tap water had increased in the deep body temperature and the surface-skin temperature, and the muscle stiffness had been relieved before and after.

Conclusion: These results suggested that the use of the high concentration CO\textsubscript{2} water foot bath was more effective in hyperthermia compared with the tap water. Furthermore, we
considered that carbon dioxide had promoted to increase the skin and the muscle blood flow by vasodilative action to the arteriole, and use of the high concentration CO$_2$ water foot bath contribute to improve the circulatory dynamics for the hemiplegic limb. These findings may suggest that the use of the high concentration CO$_2$ water foot bath is an effective physiotherapy for circulatory dynamics treatment that might facilitate stroke rehabilitation

**Keywords:** High concentration carbon-dioxide, Foot bath, Deep temperature, Surface-skin temperature, Muscle stiffness.