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ARTIFICIAL GRAVITY BY SHORT ARM CENTRIFUGE OF 1.4 M WITH EXERCISE AS THE COUNTERMEASURES FOR SPACEFLIGHT DECONDITIONING

Abstract

Crew members often suffer from space flight deconditioning including neurovestibular disorientation, cardiovascular deconditioning, myatrophy, and bone mineral loss. Several countermeasures have been introduced, but no single measure has been proved to be effective as the countermeasure. We have constructed the short arm centrifuge with ergometer with the radius of 1.4 m because the available space in international space station was reported to the inside of the cylinder with the diameter of 2.8 m. Subjects were required to lay down with supine position. Their legs were raised up to 70 cm high, and there, cycling pedals, which was fixed at the level of leg rotation, were stepped during centrifuge. G-level of 1.4 G with ergometric exercise of 60 W was loaded in the countermeasure group while control group were requested to lie down without exercise. Prescription of countermeasure was set at the AG load with exercise from the 1.4 G at the heart level and 4 – 5 G at the foot level, with ergometric exercise of 60 W in cumulated 30 min per day. Head-down bedrest of -6 was required to 6 subjects as an analogue of microgravity exposure with 2300 kcal/day, and the same amount of water drinking as the urine volume was recommended in the next day. Before and after the bed-rest, several measurements were applied to assess neurovestibular, cardiovascular, musculoskeletal, and bone metabolism, and bedrest studies were carried out comparing the countermeasure and control groups. Orthostatic tolerance was evaluated by determining the anti-G score, measuring the time to the endpoint of centrifugation from 1.0 to 2.0 G with 0.2 steps, and summing up the products of G level and time in seconds. Tilt test was performed to examine the responses to the orthostasis with recording of muscle sympathetic nerve activity by microneurography. Several hormones including renin, angiotensin II, and aldosterone as well as vasopressin were determined. Muscle dimension was determined by applying the MRI to measure the cross-sectional area of quadriceps femoris and gastrocnemius. Muscle function was tested by measuring maximal forces. Bone metabolism was assessed by measuring the urinary and blood levels of bone metabolism including deoxypyridinoline and other markers. As the results, centrifuge-induced artificial gravity with exercise has been provided significant difference from the control. We concluded artificial gravity is effective in mitigating spaceflight deconditioning in humans.