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Medical Care for Humans in Space (3)

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A SPACECRAFT-COMPATIBLE COMBINED ARTIFICIAL GRAVITY AND EXERCISE (CAGE) SYSTEM TO SUSTAIN ASTRONAUT HEALTH IN THE NEXT GENERATION OF LONG-TERM SPACEFLIGHTS

Abstract

Human spaceflights expose astronauts to prolonged durations of microgravity and radiation, leading to life-threatening cardiovascular and neurological damage. One of the most dangerous effects of microgravity is the accumulation of the Cerebrospinal Fluid in the intracranial space. The cephalad-fluid shift and muscular atrophy triggered and worsened by microgravity largely contribute to physiological deconditioning, making medical care for astronauts challenging in many cases. Artificial Gravity (AG) produced by centrifugation may provide an efficient countermeasure against spaceflight physiological deconditioning. The acceleration forces in a centrifuge follow an increasing pattern in the general direction of upper to lower body, resulting in creation of AG. Centrifuge-produced AG results in a downward shift of fluid towards the lower body. This downward motion restores fluid balance in the body, lowering the pressure on the intracranial space and the upper body. Our team at Simon Fraser University's Aerospace Physiology Laboratory has proposed a design for a Combined Artificial Gravity and Exercise (CAGE), that could be compatible for the next generation of the commercial spacecrafts and space stations, as well as Lunar bases. CAGE features a customized squat module, built at the circumference of the centrifuge apparatus. Squatting activates a full-body work out that allows for efficient shift of fluid towards the lower body, while preventing muscle and bone density loss. Squatting motion will also partially power the rotation of the device, providing a sustainable power source for the apparatus during long-term missions. The typical exercise time for astronauts on board of the International Space Station is currently around 2 to 3 hours per day. It is expected that incorporating our proposed CAGE on board of upcoming spacecraft would cut down the current exercise time by approximately half. The significance of this reduction in exercise time, besides reducing medical care complications, is the effective time that can be added to running scientific experiments and operational tasks. Repeating this new exercise regimen using CAGE 2 to 3 times per day for 20 minutes each is likely to maintain a balanced fluid flow in the body and prevent accumulation

of fluid in the intracranial space. Active maintenance of fluid balance in the body will enable astronauts to perform long-term space missions with a significantly lower risk of medical complications associated with microgravity. The use of AG combined with exercise in future space missions will be an essential element for interplanetary travel, medical care, and life establishment on other planetary surfaces.