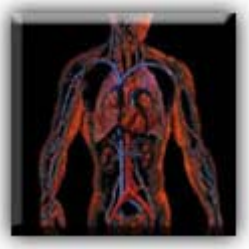
Space Biomedical Engineering & Life Support

Cardiovascular System



Cardiovascular Deconditioning in Weightlessness

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1. Microgravity Cardiovascular Deconditioning

In space, no more gravity is pulling down on the blood in the body; therefore, every point in the body has the same hydrostatic potential. This makes fluid pool towards the thorax instead of near the legs. The heart does not need to exert as much force to pump the blood, resulting in a reduced cardiac mass. Exercise capacity is reduced because the body is not stressed as hard during exercise in zero-gravity compared to earth. Peak oxygen uptake rate (dVO2/dt), a key physiological indicator, decreases when in space. Furthermore, the body sheds blood plasma in space, because it does not need as much fluid in space. This reduces the baroreflex response to a hydrostatic pressure change upon return to a gravitational environment, making the cardiovascular system prone to orthostatic intolerance.

2. Current countermeasures for cardiovascular system

We have some knowledge on how to combat these debilitating effects on the cardiovascular system. Cardiovascular exercises like those on earth were used in space stations like Skylab and Mir [3], as well as on the Space Shuttle. Rowing machines and bicycle ergometers provide the workout needed to reduce the cardiovascular system's degradation. The current estimates from bed rest studies [8] are for an exercise regimen of 4 hours a day to combat muscle loss, although much less exercise is needed for the cardiovascular system. Cardiovascular effects of artificial gravity [1,5], and combined with exercise [2,4], have also been studied. Pharmaceuticals such as midodrine have been shown to combat orthostatic intolerance. Lower-body negative pressure (LBNP) suits

that force blood to pool in the legs are also shown to counteract cardiovascular weakening [5].

3. Designing exercise with the cardiovascular system in mind

We determined that the standard exercise regimen in space should have both a musculoskeletal and cardiovascular component. Since the research into short-term treatment of orthostatic intolerance, such as LBNP suits and drugs, seem promising, the main cardiovascular focus of exercise equipment design should be on maintaining cardiovascular capacity.

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