STANDING WITHOUT GRAVITY: THE USE OF LOWER BODY NEGATIVE PRESSURE FOR RESEARCH AND RECONDITIONING IN SPACEFLIGHT

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Weightlessness during spaceflight causes cephalad redistribution of intravascular and extravascular fluid, provoking cardiovascular and autonomic nervous system adaptations. The resulting functional state is appropriate for weightlessness but can result in orthostatic hypotension and intolerance during and after return to a persistent acceleration or gravitational environment. Lower body negative pressure (LBNP) applies subambient air pressure to the legs and lower abdomen inside a volume sealed at the waist, and decompression by 40-50 mmHg reverses the spaceflight-induced cephalad shift. LBNP has been used both to test the state of cardiovascular system during spaceflight and as a countermeasure by all space-faring nations.

Two configurations have thus far been used in spaceflight since the first LBNP flew on the first Soviet Salyut station in 1971. The Soviet and Russian configuration, used in four Salyut stations, the Mir space station and the Russian segment of the International Space Station, has no saddle to support the body so during decompression the feet press against the bottom of the collapsible chamber which shortens and applies force against the feet proportional to the decompression level. Thus, activation of the skeletal musculature partially counteracts vascular and venous pooling in the enclosed body segments, stimulating the orthostatic compensatory mechanisms as they would be standing on Earth. In the American configuration, used aboard Skylab and the Space Shuttle, a saddle supported the astronaut so the feet did not contact the bottom of the chamber, and vascular engorgement was not countered by muscular contraction. This minimized skeletal muscle involvement, unmasked vascular compensatory mechanisms for research purposes, and allowed measurements of changes in leg volume and muscle sympathetic nerve activity. Both variants have demonstrated research and therapeutic value in appropriately designed protocols.

LBNP continues to be used for research and countermeasures on ISS, and future versions may explore the value of exercise during LBNP as an integrated countermeasure. This paper will review the history and development of LBNP for spaceflight research and therapeutic purposes.

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