Lower Body Negative Pressure

Principal Investigator: Dr. John Charles,
NASA Johnson Space Center

Purpose: To test the effectiveness of using Lower Body Negative Pressure and oral fluid loading 24 hours before landing to protect the health and safety of the crew and to shorten the time required to readapt to gravity

Significance: The human body is designed to work on Earth, under the influence of gravity. For example, the circulatory system works to pump blood up from the legs, where gravity would otherwise cause fluids to pool.

When humans go into space, the lack of gravity causes many changes in the body. One change is that fluids, normally kept in the lower body by gravity, shift upward to the head and chest. This is why astronauts' faces appear chubby, or puffy, after a few days on orbit.

The mechanisms that regulate how much fluid is in the human body are accustomed to operating on Earth. When fluids shift to the upper body in microgravity, the body has no way to recognize that only the location, and not the volume, of the fluids has changed. Detectors in the chest indicate that there is too much fluid in the chest, so the body works to restore a normal amount of fluid in the upper body.

The change in fluid volume also affects the heart. The reduced fluid volume means that there is less blood to circulate through the body, so the cardiovascular system makes several adjustments in the way the heart and blood vessels work. As long as a person stays in microgravity, the change in fluid volume and resulting adjustments of the heart are perfectly normal and healthy. However, when the person returns to Earth, gravity once again pulls fluids toward the lower body. Because the volume of blood has decreased, the head and upper body may be temporarily "short" of blood. The heart has to work much harder to pump blood through the body. This can cause lightheadedness, or even fainting, when the astronaut first stands up on Earth. Such symptoms occur only briefly and the body rapidly readapts to being in gravity within hours or days. But to ensure crew safety during landing and readaptation, NASA has been testing the use of Lower Body Negative Pressure to "pre-adapt" crewmembers for landing.

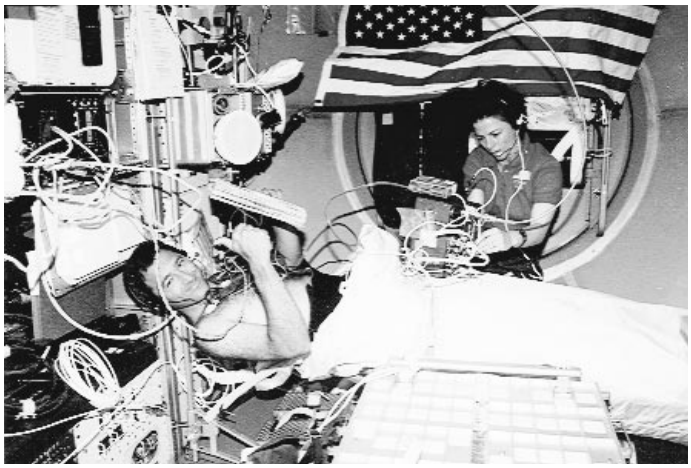
This countermeasure works by exposing the lower body of a crewmember to an air pressure lower than that of the regular spacecraft for an extended period, known as a *soak*. This exposure simulates the effects of gravity and helps "pull" fluids into the lower body. If the crewmember also drinks water and takes salt tablets during the soak, the volume of fluid in the body is restored to near "Earth normal."

The use of low, or negative, air pressure to simulate the pull of gravity has been used and tested in various forms since the early 1970s. The Russians have used a system they refer to as "pneumatic trousers" on their space stations. NASA began experimentation on Skylab and has continued the process with Lower Body Negative Pressure experiment operations on Spacelab. From data obtained on previous missions, including the First United States Microgravity Laboratory, scientists have determined that the combined treatment of fluids, salt tablets, and exposure of the lower body to a lower air pressure can recondition the cardiovascular system for up to 24 hours. Experimentation on the Second United States Microgravity Laboratory will help refine these data and confirm the effectiveness of performing the soak within 24 hours of landing.

This experiment is part of the Extended Duration Orbiter Medical Project, a series of investigations designed to monitor the medical status of crewmembers, to monitor the environment in which they work, and to ensure the health and safety of the crew during 13- to 16-day missions. These experiments take place before, during, and after missions to allow data to be collected over the full range of space operations and readaptation.

In addition to its major goals, this project helps provide a different perspective on human physiology: the response of healthy humans to an extremely unusual environment. Traditionally, medical research and practice examine unhealthy humans in a normal environment. The similarities and differences between data from the two groups help to illuminate the normal and abnormal workings of the human body. While data from neither group by itself can answer many questions about the other group, the combination of the two sets provides much more than a simple summation.

Method: A crewmember will enter a 4-foot air-tight fabric-covered cylinder that seals just below the waist. The air inside the cylinder will be removed to create negative pressure to imitate the "pull" of gravity. Throughout the mission, these brief sessions will be used to simulate standing on Earth. From blood pressure readings, pulse rate, and data on heart size and function collected using ultrasound cardiography, scientists can determine how much cardiac deconditioning has occurred. The final session in flight will be lengthened to pre-adapt the crewmember for return to Earth. Measurements of the cardiovascular responses when the crewmember stands upright after the Shuttle lands will be compared to preflight measurements to determine if the treatment restored normal function. These data will also be compared to similar data from astronauts who did not use the treatment to determine its effectiveness.



Experimentation on USML-1 with Lower Body Negative Pressure has helped scientists in their efforts to ensure crew health and safety upon returning to Earth-normal gravity.