

Pulsatile Overall-Vest: A Device to Counteract Microgravity Threat to Astronauts' Health

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Abstract

Astronauts in space experience many changes in their bodies. If astronauts spend extended periods in space in a zero-gravity (more precisely, microgravity) environment, their bone calcium is decreased and their heart muscles and blood vessels become weaker and atrophic. Pulsatile overall-vest (POV) is a new proposed device which is hoped to minimize some of these maladies. This technology can be applied to astronauts' health-care aboard the International Space Station (ISS). The hypothesis I proposed herein is that POV may be regarded as an adjuvant treatment for microgravity threat to performance of astronauts' heart, muscles and circulation of body fluids. POV is expected to induce stronger heartbeats; induce better circulation of intercellular fluid, blood plasma and the interstitial fluid between blood vessels and surrounding tissue; reduce face puff up and minimize cosmonauts' "space sniffles". POV is an overall jacket or vest which covers the whole body except eyes, nose, mouth, neck, fingers, anal area and genitalia. Properties proposed for POV include: elasticity, thinness, double layer made of rubber or silicon rubber; for better endurance, the inner layer is in contact with skin and equipped with inflatable vesicles; for inflation- deflation, a net of air tubes connect the air vesicles to an external air pump. While in action, in each programmed inflation-deflation cycle, air vesicles push against the astronaut's body surface and then relax. Time and duration for using POV would be set by astronauts' physicians. POV implication would have beneficial consequences as: 1) Making the heart muscle to pump stronger; so helps to prevent it from weakening; 2) helping better circulation of body fluids; 3) preventing face puff up and "space sniffles"; 4) through its massage therapeutic effect, it slows down weakening of muscles in prolonged period of weightlessness in microgravity environment. POV is an adjuvant device and is not to replace astronauts' daily exercises on treadmill or similar devices. Cosmonauts will use POV along with their daily-scheduled exercises or as recommended by their physicians.

Keywords: Pulsatile overall-vest, POV, astronauts' health, ISS, health device, microgravity

1. Introduction

Astronauts are doing a great deal of hard work for the whole of world. They consider this as their responsibility to achieve the expectations laid on them. Taking care of the health condition of astronauts is extremely important to ensure their service for the world. Adequate care and attention have to be given to bring about measures to ensure their consistent performance with the support of healthy body [1-3]. Researches on how people react to long spans of weightlessness have revealed a range of health risks, especially ones that affect the body upon return to gravity's pull. Bone density, muscles, heart function, blood flow, red blood cell production and the immune system are usually weakened when astronauts first step back onto the Earth's surface [4-8]. Seeking effective methods to resolve such problems are necessary for space health-management organizations and interested researchers like me.

2. Astronauts' health problems in microgravity environment

Experts say a trip to Mars, a year or two each way, carries the risk of leaving the astronauts because of the health problems [9-14]. Astronauts now tend to do endurance types of exercise, including cycling, rowing and walking on a treadmill that stresses aerobics and stamina. But a wide consensus is developing among space physiologists and NASA officials that this approach is wrong and needs to be supplemented by strenuous workouts that increase mechanical stress on astronauts' muscles.

Almost two-thirds of the average body weight is made up of water, in the form of intercellular fluid, blood plasma and the interstitial fluid between blood vessels and surrounding tissue.

On Earth, all this liquid tends to settle downward in the body. Blood pressure at our feet, for example, is about 100mm of mercury higher than blood pressure in our chests. The need to pump blood against the force of gravity requires the muscles of a powerful heart. Under microgravity conditions in space, there is nothing to pull body fluids down: there is no "down" to pull them to. The first effects are almost immediate [15,16]. Without the restraint of gravity, fluids migrate from the astronauts legs to their heads. Inside a day, legs shrink by up to a liter in volume and faces puff up correspondingly. The extra fluid in the head also leads to blocked sinuses and noses - the "space sniffles" that astronauts generally have to live with throughout their mission.

Other effects are more serious. Blood plasma drops by about 20% and the red blood cell count falls similarly: returning astronauts usually suffer from a temporary anemia. Without gravity to contend with, the heart has to do far less pumping work. Heartbeat slows down. Since the body no longer needs to maintain the powerful heart muscles needed on Earth, heart tissue begins to shrink [15]. Muscle wasting is a serious problem disturbing a major portion of astronauts. Some other effects that microgravity has on astronauts' physiological systems include diminished neural control, dysfunctional immune responses, renal stone formation, and impaired human performance [9,13,17]. Exercise is not enough to reverse the processes, but it helps to minimize them. Astronauts spend several hours a day on a treadmill or similar apparatus; the more exercise they can do in space, the less time it will take to recover on their return [7,17-21].

3. Hypothesis

As a treatment for microgravity health threat of astronauts, Pulsatile overall-vest (POV) has not ever been reported. The hypothesis I propose here is that POV would counteract the microgravity threat on heart, circulation and body fluids of astronauts. This hypothesis is based on the following points: (1) POV can induce stronger heartbeats; (2) POV can induce better circulation of intercellular fluid, blood plasma and the interstitial fluid between blood vessels and surrounding tissue; (3) POV can reduce face puff up; (4) POV can reduce the "space sniffles".

I propose POV as an overall jacket or vest which covers the whole body except eyes, nose, mouth, neck, fingers, anal area and genitalia. Properties proposed for POV include: elasticity, double layer made of rubber or silicon rubber, the inner layer is in contact with skin and equipped with inflatable vesicles, a net of air tubes connect the air vesicles to an external air pump. While in action, in each programmed inflation-deflation cycle, e.g. 20-30 sec inflation and 10-15 sec deflation intervals; inflated air vesicles push against the astronaut's body surface and then relax. In an optimized daily schedule, POV implication would lead to beneficial consequences such as: (1) Compression of skin and the tissue underneath will constrain the peripheral blood vessels; this in turn will make the heart muscle to pump stronger to compensate for the containment; (2) the POV massage effect will dislocate intercellular fluid, blood plasma and the interstitial fluid between blood vessels; hence helping better circulation in surrounding tissue; (3) improved circulation prevents face puff up and reduces "space sniffles"; (4) POV may slow down weakening of muscles through its massage therapeutic effect. POV is an adjuvant device and is not to replace astronauts' daily exercises on treadmill or similar devices. Astronauts will use POV along with their scheduled exercises or as recommended by their doctors.

4. Medical significance

Providing proper health for astronauts throughout their microgravity journeys and after return to Earth is extremely important. POV is proposed to provide a supplementary device to improve the health of astronauts' heart, muscles and circulation. It is applicable for physical workouts with or without use of conventional instrumentations as treadmills. The POV implementation would have advantages as: 1) Making the heart muscle to pump stronger; so helps to slow down its weakening; 2) helping for better circulation of body fluids; 3) preventing face puff up and "space sniffles"; 4) through its massage therapeutic effect, POV slows down weakening of muscles; 5) reduces overall health problems in prolonged period of weightlessness in microgravity environment and on return to Earth.

5. Future testing

Considering the application of POV, further studies are needed to confirm its effects on improvement of astronauts' health. The effectiveness of POV to improve performance of heart, circulation and muscles should be verified firstly by animal experiments both on Earth and in orbit under microgravity conditions both in short and prolonged periods of weightlessness.

The likelihood of its negative influence on other physiological functions should be minimized. When these concerns are clear, I believe that POV could be used as an instrument to assist in minimizing the astronauts' health problems of concern. My ultimate goal about POV instrument is to help suitably preserve the astronauts' health so they can maximize their abilities, perform their duties safely, and execute their responsibilities.

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