1999 Honorable Mention Research Paper

Space Flight: The Dangers of Weightlessness

In the awe-inspiring event of man experiencing interstellar travel many detrimental problems arise. Before 1970, the majority of biomedical studies on space flight were conducted immediately before and after flight. They examined the changes and readaptation processes for astronauts from a weightless to a gravitational environment. After the successful Skylab space station projects from 1973-1974 and the Soviet Salyut missions from 1977-1982, biomedical research and experiments commenced in space. These experiments in space have shown that the physiological aspects can be deadly if not prepared for correctly and adequate medical support is not available. Although problems due to weightlessness and lack of exercise have been thoroughly researched and new machines and procedures have been developed to overcome these difficulties, there is still the opportunity to further understand weightlessness.

The majority of difficulties that arise can be traced back to the zero gravity environment in which humans experience physiological changes which can be detrimental to their health. When humans enter weightless space they become dis-oriented due to the neurovestibular interactions, those that are processed in the brain cavity (DeHart 840). These cause side effects, such as space motion sickness or Space Adaptation Syndrome (SAS) (Shipman, Humans 99). As astronauts enter zero gravity they experience a nauseous sensation which returns with fast actions or movement from a small to a large space in the space vehicle. Those who are more susceptible to this illusory sensation develop space motion sickness and have personalities that are introverted, neurotic, or fearful (DeHart 840-841). This type of motion sickness, similar to seasickness, carsickness, and airsickness (Shipman, Humans 99), affects approximately forty percent of space travelers during the first three days of the missions and lasts from two to four days. The symptoms can be easily detected: nausea, vomiting, headaches due to head and body movement, lethargy (Seedhouse 357), and rarely, paleness or sweating (DeHart 840). The National Aeronautics and Space Administration (NASA) developed a scale based on the United States Senator Jake Garn's experience of SAS. Senator Garn, a former astronaut, underwent the most extreme level of space sickness, called Garn thirteen, which is off the Garn scale of one to ten (Shipman, Humans100). This temporary impairment affects crew performance as seen in the Apollo IX mission where the crew's activities were delayed by twenty-four hours. The Skylab 3 flight also had similar problems when work time was lost for the first three days. Soviet Cosmonaut Titov experienced the first recorded instance of space motion sickness where he felt like he was flying upside down, dizzy, nauseated, and ill (DeHart 840).

In trying to determine the cause of this unavoidable situation, medical researchers Dietlein and Johnson developed the "sensory conflict hypothesis." Their hypothesis explained that the usual sensory inputs in the central nervous system were not at equilibrium in the weightless environment (840) and without visual points of reference in space (Gagarin 133), resulted in abnormal reflexes and sensations. After a period of several days "new sensory thresholds are established that allow the afferent sensory inputs to once again be correctly interpreted"(DeHart 840).

Scientists have developed various treatments to alleviate space motion sickness. One method involves vestibular conditioning where astronauts go through various exercises before space flight to reduce the adjustment period to zero gravity. Drug medications, such as Dexedrine, are also used to combat this illness and are continually being researched (DeHart 841). A newly developed drug, Eleutherococcus, has had many benefits in the health of astronauts, which include the following: it is not addictive, not a stimulant, it has no problems associated
with long-term use and no adverse reactions to the body, it strengthens the immune system, accelerates adaptation to zero gravity, increases energy levels, increases recovery processes from space sickness, and combats the negative effects of radiation. Eleutherococcus increases the activity and the number of white blood cells that regulate and increase the strength of the immune system. In the stressful environment of micro-gravity the body is able to adapt through its own resources by using Eleutherococcus (Seedhouse 358). An astronaut would be prevented from handling an emergency effectively because the symptoms of SAS can be so extreme that at times he or she would be unable to perform their duties (358). Eleutherococcus is necessary to combat these symptoms. Science has not yet developed a perfect drug to overcome this seemingly simple yet dangerous problem of space motion sickness, but progress is continually being made.

In addition to SAS there is a problem of the heart becoming weak due to reduced stress on the blood flow. Cardiovascular deconditioning, which is the deterioration of the heart muscle, always occurs after returning to earth because the cardiovascular system cannot function effectively under the added gravitational stress after living in space for periods of up to six months. Symptoms of cardiovascular deconditioning include elevated heart rate, high blood pressure, and in-flight reduced tolerance due to the "loss of body fluids and electrolytes during the early period of adaptation to weightlessness" (DeHart 841). During the Skylab program and the long Soviet space flights these physiological responses were researched and found to occur early in zero gravity and stabilize soon after the fifth week of flight. Cardiovascular deconditioning becomes a medical problem only after the flight and return to the earth's gravitational environment where it takes about one month to overcome (842).

Two effective methods for dealing with the problem of cardiovascular deconditioning in space and easing the transition back to a 1g environment are antigravity suits and rehydration. When an antigravity suit is inflated a restrictive pressure is forced on the lower half of the body which prevents the pooling of blood into the lower body during the re-entry stress period. This controls and maintains a steady blood pressure in the astronauts. The second approach to minimizing deconditioning is through re-hydration prior to landing on earth. Dietlein and Johnston also tested the rehydration programs and set the standard method where after seven to twenty-eight days of bedrest in space, astronauts drink a saline solution. This coupled with a stress test and a good work-rest cycle will greatly reduce cardiovascular deconditioning and offer protection against re-entry forces (842). In addition to these two methods, exercise programs have been implemented for the crews living in microgravity (Siconolfi-Internet).

Along with SAS and cardiovascular deconditioning the most dramatic physio-logical effects of space flight and weightlessness on humans are the changes in musculature and the disturbances with the motor system. Three to four percent of body mass is lost in the first three to five days of flight due to the loss of fluids through excessive discharge of urine, decreased thirst and fluid intake, metabolic imbalances and muscle atrophy (DeHart 843). The evidence of muscle atrophy during space flight includes the development of an imbalance in nitrogen, "reductions in calf circumferenceincreased urinary excretion of muscle protein-derived amino acids, decrements in strengthin selected muscles, and loss of muscle volume"(Feeback-Internet). Skylab astronauts experienced muscle atrophy with the loss of muscle and fat in their legs, abdomen, and buttocks (DeHart 844). Muscle deteriorates because there is no need to counteract gravity (Gagarin 137). The lack of gravitational pressure on the skeletal and structural functions results in astronauts getting about a half an inch taller (Shipman, Space 328). Muscle atrophy also results in mass loss, which does not depend on the duration of space flight; and actual mass gains have been reported with adequate exercise and caloric intake. Even if mass loss does occur, it is gained back during the post-flight period (DeHart 844).

There are many repercussions due to the lack of gravity, but the most serious effect on the human body is the deterioration of bones. With the removal of pressure on the skeletal structure, the body needs less calcium to support itself. Skylab astronauts excreted calcium at a rate of thirty milligrams a day, which is more than they consumed (Shipman Space 106). Experiments are being conducted to learn more about bone thinning. In a study conducted by NASA, crew members on the Life and Microgravity Spacelab (LMS) mission ingested a tracer that would distinguish calcium consumed and calcium reabsorbed by bone. This determined how an
individual would adapt to the bone-calcium change (Measuring-Internet). Skylab data indicated that a "one-year flight might result in the loss of twenty-five percent of the calcium in the body pool" (Shipman, Space 329).

Even though bone thinning is such a serious problem, extensive research has led to only two solutions, exercise and the usage of antigravity suits. Exercise bicycles or treadmills in space are not popular because they produce sweat which globs and sloshes around on the astronaut's back. Without exercising in space, "It is quite possible that long-duration space flight could result in irreversible skeletal damage" (Shipman, Humans 107-108). There is also no indication that the calcium loss in bone mass ever levels off after time (Shipman, Space 328). The future possibilities for living in space for periods longer than six months are severely limited because of the eventual deterioration of the skeletal structure. Research is ongoing to combat this lethal side effect to weightlessness.

Since there is so much that we can learn from space to apply on Earth there will be a continual need for astronauts and a need to keep them healthy while they are there. In order for astronauts to remain physiologically healthy in space, each aspect of the onboard life support system must be carefully considered and maintained. There are two main operations in this system: pressure control and temperature control. Pressure control is determined by the "required partial pressures of the component gases and by the necessity for change in pressure in the course of a mission" (DeHart 847). Two main goals are considered for the pressure system: air breathability and avoidance of decompression. Decompression sickness occurs after slow rates of decompression when the pressure of the dissolved gases, especially nitrogen, in the tissue is too great. Air breathability depends on the concentrations of the gas components in the air. Most of Earth's atmosphere is oxygen with a partial pressure (Po2) of 158mm Hg, and carbon dioxide and water vapor are also present in smaller amounts. Without the right gas concentrations in the air of the spacecraft, debilitating effects in human performance and hypoxia, a state of oxygen deficiency in the tissue which causes damage at the cellular level (DeHart 91), incurs. For example, when Po2 in the spacecraft is only 85mm Hg. As a result, a concentration of 260mm Hg of oxygen is employed on spacecrafts (847). In weightlessness, air in which the oxygen has been used is richer in carbon dioxide and water vapor and remains near the astronaut's head (Pirie 3). The air purifying and regenerating system involves the usage of nitrogen gas. On the Mir station, currently in orbit, a twenty pound cylinder with two liters of nitrogen gas was transferred onboard to ensure that the station's electrolysis-based backup oxygen regeneration system was properly cleansed (Covault 71). The continued maintenance of the pressure and air regeneration system is vital to the health and survival of the crew in space.

As well as pressure control there is a temperature control system. The temperature control system remains fairly simple. The optimal point of air regulation and thermostatic control is around twenty-two degrees Celcius. In uncomfortable temperatures the astronauts' performance levels decrease (DeHart 852). The Skylab shuttle recycled its water and directed it towards the thermal-control system (Shipman, Space 329-330). It is important that the spacecraft is designed to maximize the comfort of the astronauts and to ensure the working order of the temperature control system in order to optimize their work efficiency in space.

There are many benefits in biology that can be achieved by space exploration, but there are also many potentially deadly problems that can arise if not prepared for correctly. The experiences of living in space have revealed the physical dangers inherent in many closed environments where the forces and pressures placed upon the human body are different than those on earth. The physiological side effects weightlessness can be deadly without the proper equipment and preparation. As Dr. Philip R. Harris stated, "Space is a place not only of high risk, but of unparalleled opportunity"(75). There are many new horizons not yet explored by mankind; but in the future as further experiments and research are conducted to find out the causes and cures for these problems in space, there will always be those who are willing to sacrifice for the chance of exploration.


