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Biological Feasibility of Interstellar Travel

Matthew B. Schneck

Abstract

Exposure to the space environment has resulted in numerous alterations to homeostatic mechanisms within the human body. Immune suppression, musculoskeletal degradation, decreased cardiac output, and fluid redistribution have all been reported throughout short and long term space flight. The goal of this review is to discover if long term interstellar travel is biologically possible for humans. The relative influence of cosmic radiation, microgravity, and high velocity travel on homeostasis has not been previously established for interstellar space travel. Real-time space flight data and ground-based studies were compiled from other researchers. This data was analyzed with the goal of establishing the relationship between the aforementioned environmental pressures and the corresponding homeostatic consequences. Meta-analysis revealed that the predicted homeostatic consequences of interstellar space flight do not significantly inhibit the body's ability to function in the space environment. Although interstellar travel is mechanically restricted, it is biologically plausible provided proper defense mechanisms are applied. Further research must be directed towards eliminating mechanical restrictions including, but not limited to, propulsion mechanisms, circular sustainment systems, environmental protection, and interstellar communication.

Introduction

Throughout history, the desire to explore has driven innovation. Upon entry into the space age, man sought to expand the horizons of the known universe. Exploration of space began with the first manned mission to the moon in 1969. The first steps into the final frontier were taken by Buzz Aldrin and Neil Armstrong. This taste of the unknown left mankind hungry for more. Nearly fifty years later, mankind has its eyes focused on another destination, Alpha Centauri. A journey to such a place would cover about 4.24 light years. Due to the significant increase in flight duration, more consideration must be directed towards examining the risk factors of long term exposure to the interstellar environment. Such environmental pressures include cosmic radiation, high velocity travel, and microgravity. This study will examine the homeostatic consequences of the above conditions and seeks to determine the biological feasibility of such a journey. Consideration will also be directed towards current and theoretical technology that could make this journey mechanically possible.

Homeostasis within the human body is a delicate process. It is governed by a series of positive and negative feedback loops that allow life to exist. The human body is capable of adjusting to its circumstances; however, significant deviation from the norm is often irreversibly fatal. Direct exposure to the space environment would result in nearly immediate death. Luckily, current technology provides protective countermeasures that help to avoid many of the possible homeostatic consequences of long term space flight. Although current technology mechanically restricts interstellar travel, such a journey is biologically plausible due to protective countermeasures and the human body's remarkable ability to adjust to the external environment. It is important to recognize that the goal of this review is to evaluate the feasibility of such a journey from a biological prospective. Even though current mechanical limitations will be discussed, limitations that are purely mechanical in nature, propulsion mechanisms for instance, will not be taken into account when drawing final conclusions.

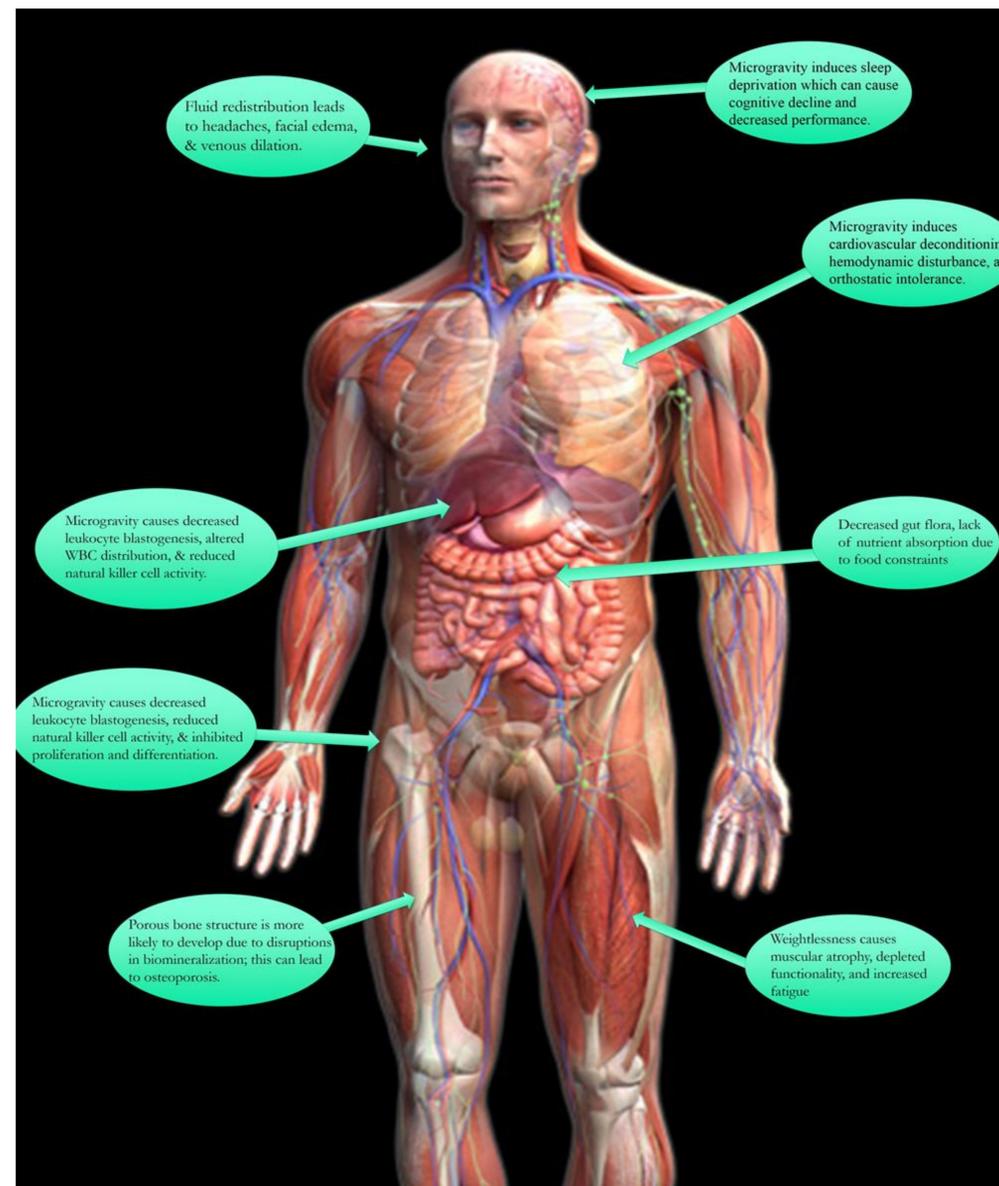
Results

Covering such a significant distance would seemingly take an extreme amount of personal time, but would it? In order to make interstellar space travel reasonable, highly relativistic speeds are desirable. At high velocities, relativistic time dilation would occur. This means that the subjective duration of the journey would be significantly decreased for those onboard the space craft. The time dilation factor is defined by the following equation where γ is the time dilation factor, c is the speed of light, and v is the craft's velocity.

$$\gamma = \frac{1}{\sqrt{1 - \left(\frac{v}{c}\right)^2}}$$

When traveling at highly speeds, radiation becomes an issue. In space, H atoms are present and, at high speeds, turn into ionizing radiation that can kill unprotected creatures quickly. Current research is being directed at electrostatic and magnetic shielding because it can use the inherent nature of subatomic particles against themselves. Using magnetic fields, atoms could be separated into their charged components and then deflected using electrostatic shields.

Homeostatic Consequences



Microgravity is another environmental factor that can cause significant homeostatic deviation. When in microgravity, pathogens express greater virulence and viral reactivation has been shown to occur. Free floating pathogens in condensate remain airborne until they are inhaled or deposit onto a porous surface. On top of pathogenic strengthening, immunosuppression occurs and is characterized by an inhibition of proliferation and differentiation in bone marrow. When in space, precautions must be taken to isolate the ill and protect the healthy. Microgravity can lead to muscular atrophy and biomineralization issues which can result in the formation of porous bone tissue and osteoporosis if conditions persist. Hemodynamic disturbances also occur in these situations. For a more complete list of homeostatic consequences see the figure.

To control infection, astronauts undergo an all encompassing health and vaccination regime. They also receive basic medical training to increase safety. In order to further eliminate the threat of pathogens, circular sustainment systems are in development that regulate everything from particulate filtration to human waste management. In order to counteract the negative effects of microgravity, astronauts should undergo a multi-session exercise program everyday. Theoretical research is currently directed at developing a spinning spacecraft that would use centripetal force to simulate gravity. Hemodynamic disturbances can be managed using occlusion cuffs. Government organizations have also discussed the creation of a "cyborg" in essence, that would live off of mechanical systems instead of biological systems, but due to ethical issues, experimentation of this sort is far off.

Conclusion

Via meta-analysis it has been concluded that interstellar travel is biologically feasible provided proper defense mechanisms are in place. At the current time, interstellar travel is mechanically restricted as mentioned before, but in due time, provided humanity isn't wiped out, technology will reach the levels necessary for interstellar travel to occur. Once the technology is ready, so is mankind. For every environmental pressure, there is systematic way to limit its homeostatic consequences. With protection mechanisms and circular sustainment systems in place, humans will not only survive the unforgiving environment, they will thrive. Interstellar travel is clearly not going to happen for many years. Such a journey would require a huge investment of both time and money, but once the technology exists, humans are perfectly capable of enduring the trip.

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