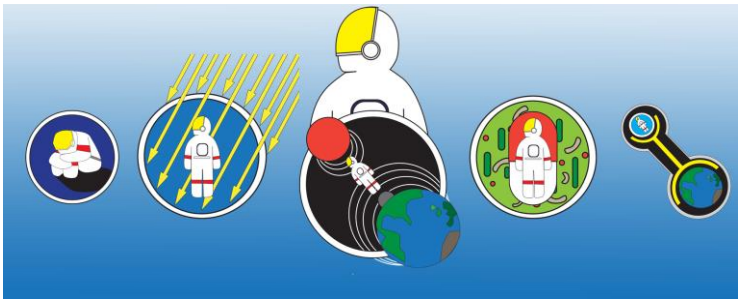


Gravity, Who Needs It? NASA Studies Your Body in Space

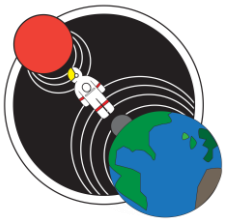
What happens to your body in space? NASA's Human Research Program has been unfolding answers for over a decade. Space is a dangerous, unfriendly place. Isolated from family and friends, exposed to radiation that could increase your lifetime risk for cancer, a diet high in freeze-dried food, required daily exercise to keep your muscles and bones from deteriorating, a carefully scripted high-tempo work schedule, and confinement with three co-workers picked to travel with you by your boss.

Scott Kelly will be the first American to spend nearly one year in space aboard the International Space Station, twice the normal time. Researchers are eagerly awaiting results of the mission to see how much more the body changes after a year in space. One year is a stepping stone to a three-year journey to Mars, and Scott's data will help researchers determine whether the solutions they've been developing will be suitable for such long, onerous journeys.

But what, exactly, happens to your body in space, and what are the risks? Are risks the same for six months on the space station versus three years on a Mars mission? No. There are several risks NASA is researching for a Mars mission. The risks are grouped into five categories related to the stresses they place on the space traveler: Gravity fields, isolation/confinement, hostile/closed environments, space radiation, and distance from Earth.

Beware, what you're about to read can be scary. But the good news is NASA has been working to solve these problems with some of the most brilliant minds in the field. Rest assured, when we take the next giant leap to Mars, we will be ready.

Gravity Fields. There are three gravity fields you would experience on a Mars mission. On the six-month trek between the planets, you would be weightless. On the surface of Mars, you would live and work in approximately one-third of Earth's gravity, and when you return home you will have to readapt to the gravity we take for granted. Transitioning from one gravity field to another is trickier than it sounds. It affects your spatial orientation, head-eye and hand-eye coordination, balance, locomotion, and you're likely to experience motion sickness. If you have to land a spacecraft on Mars, it could be a pretty dangerous situation. NASA has learned that without gravity working on your body, your bones lose minerals, with density dropping at over 1% per month. By comparison, the rate of bone loss for elderly men and women on Earth is from 1% to 1.5% per year. Even after returning to Earth, your bone loss might not be corrected by rehabilitation, so you could be at greater risk of osteoporosis-related fractures later in life. If you don't exercise and eat properly, you will lose muscle strength, endurance, and experience



cardiovascular deconditioning since it does not take effort to float through space. The fluids in your body will shift upwards to your head, which could put pressure on your eyes causing vision problems. You're apt to develop kidney stones due to dehydration and increased excretion of calcium from your bones. Medications react differently in your body in space. Nutrition, including eating enough, becomes important, otherwise you could compromise your health since nutrients are required for the function of every cell and system in your body.

The Key: By analyzing how your body changes in weightlessness and after returning to Earth's gravity, protection against these changes for a Mars mission can be developed. Functional task testing is in place to help detect and minimize the effects of space on your balance and performance. Fine motor skills testing is done to detect any changes in your ability to interact with your computer-based devices. Distribution of the fluids in your body will be closely monitored, to help evaluate any connection to changes in your vision. Compression cuffs worn on your thighs will help keep the blood in your lower extremities to counteract those vision changes. Your back pain would be monitored by obtaining spinal ultrasounds. You will perform periodic fitness self-evaluations that help researchers better understand the decline in cardiovascular function that can occur during spaceflight. Some medicines, like potassium citrate (K-Cit), may help you combat the physiological change that could increase the risk for developing kidney stones. Bisphosphonates drugs have shown to be effective in preventing bone loss. NASA has also designed an efficient way to collect and measure how much urine you produce in space, which is essential to human research since it reveals key information about your health. You will get proper nutrition, including vitamin D supplements since you can't walk outside under the sun. And last, good old regular exercise has been shown to keep your heart healthy, your bones and muscles strong, your mind alert, your outlook more positive, and may even help with your balance and coordination.

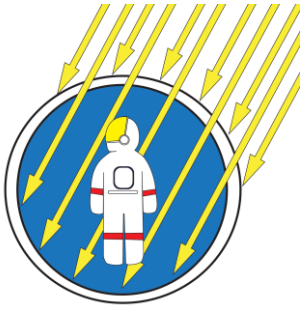
Isolation/Confinement. NASA has learned that behavioral issues among groups of people crammed in a small space over a long time, no matter how well trained they are, are inevitable. Expedition crews selected for a stay aboard the space station are carefully chosen, trained, and supported to make sure they can work effectively as a team for six months. Crews for a Mars mission will undergo even more scrutiny and preparation, since they will travel farther and longer than any previous human, being more isolated and confined than we can imagine. The types of problems you may encounter are a decline in mood, cognition, morale, or interpersonal interaction. You could also develop a sleep disorder because your circadian rhythm might be thrown off due to the 38 extra minutes each day on Mars, or by a small, noisy environment, or the stress of prolonged isolation and confinement. Depression could occur. Fatigue is inevitable given that there will be times with heavy workload and shifting schedules. Still, periods of monotony may lead to boredom rearing its ugly head. Misunderstandings and impaired communications with your team members might impact performance and mission success. A lack of fresh food and mean variety, or deficiency in nutrition, may further contribute to physiological and cognitive decrements. Also, far more autonomy will be required due to the very long communication delays over the vast distances from the space vehicle to Earth. And then there's the possibility of the third-quarter effect, where morale and motivation decline three-quarters of the way into a mission, regardless of how long the mission lasts. The more confined and isolated humans are, the more likely they are to develop behavioral or cognitive conditions, and psychiatric disorders.

The Key: NASA has been studying people in isolated and confined environments for years, and has developed methods and technologies to counteract possible problems. They are using clever devices like actigraphy that help you to assess and improve your sleep and alertness by recording how much you move and how much ambient light is around you. New lighting, spurred by the development of Light-Emitting Diode (LED) technology, will soon be used on the space station to help you align your circadian rhythms which will improve sleep, alertness, and performance. You can assess the effect of fatigue on your performance with a five-minute self-test. Journals give you a safe place to vent your frustrations and give researchers a tool to study behavioral issues and other things that are on the minds of crewmembers who are living and working in isolation and confinement. All of these methods and technologies will help us prepare for longer, farther exploration missions.

Hostile/Closed Environments. NASA has learned that the ecosystem inside the spacecraft plays a big role in everyday astronaut life. Microbes can change characteristics in space, and microorganisms that naturally live on your body are transferred more easily from person to person in closed habitats like the space station. Your stress hormone levels are elevated and your immune system is altered, which could lead to increased susceptibility to allergies or other illnesses, and disease. Every inch and detail of your living and working quarters must be carefully thought-out and designed. Just like you wouldn't want your house to be too hot, too cold, cramped and crowded, very loud, or not well lit, you wouldn't enjoy working and living in such a dwelling in space either.

The Key: NASA is using technology to monitor the air quality of the space station to ensure the atmosphere is safe to breathe and not contaminated with gases like formaldehyde, ammonia, and carbon monoxide. Your urine and blood samples are analyzed to ensure the stress of space flight hasn't caused infectious illnesses like the Epstein-Barr virus to be reactivated. And the risk of microbes that may cause disease to you and your crewmembers will be evaluated using advanced molecular techniques. Various parts of your body and the space station are swabbed for analysis of the microbial population that inhabits the environment. Effective monitoring techniques are in place to identify how your immune system changes in space by analyzing blood, saliva, and urine samples. Your living quarters and work environment are carefully planned and evaluated to ensure that designs balance comfort and efficiency. And the lighting will be similar to what you experience naturally on Earth, thanks to the new LED lighting system.

Space Radiation. The most dangerous aspect of traveling to Mars is space radiation. On the space station, astronauts receive over ten times the radiation than what's naturally occurring on Earth. Our planet's magnetic field and atmosphere protect us from harsh cosmic radiation, but without that, you are more exposed to the treacherous radiation. Above Earth's protective shielding, radiation exposure may increase your cancer risk. It can damage your central nervous system, with both acute effects and later consequences, manifesting itself as altered cognitive function, reduced motor function, and behavioral changes. Space radiation can also cause radiation sickness that results in nausea, vomiting, anorexia, and fatigue. You could develop degenerative tissue diseases such as cataracts, cardiac, and circulatory diseases. The food you eat and the medicine you take must be safe and retain their nutrient and pharmaceutical value, even while being bombarded with space radiation. A vehicle traveling to Mars and a habitat on



Mars will need significant protective shielding, which is nonetheless futile against some types of space radiation.

The Key: The space station sits just within Earth's protective magnetic field, so while our astronauts are exposed to ten times higher the radiation than on Earth, it's still much less than the radiation a mission to Mars will encounter, and of a different type. Shielding, monitoring, and operational procedures control the radiation risks to acceptable levels to keep you safe. To learn what happens above low Earth orbit, NASA has extensively used ground research facilities to study how radiation affects biological systems, and more importantly, how to protect them. They are developing unique ways to monitor and measure how radiation affects you while living in space, and to identify biological countermeasures. Finally, methods to optimize shielding are being studied to help protect us on a journey to Mars.

Distance from Earth. Planning and self-sufficiency are key. How far away is Mars? 140 million miles from Earth on average. In contrast the moon is only 0.239 million miles away. With a communication delay of up to twenty minutes one-way while on Mars and the possibility of equipment failures, you must be able to complete the mission on your own. And what type of food and medicine would you pack if you had to go on a three-year trip without access to a grocery store or pharmacy? Hopefully you plan correctly.

The Key: NASA is using the space station to figure out what types of medical events happen in space over six months and what types of skills, procedures, equipment, and medication are needed, so you will have a good idea of what you'll need to pack for Mars. You can produce Intravenous (IV) solution from purified space station cabin water, and then mix it with salt crystals to produce normal saline for medical administration. Even if you aren't a doctor, you and your crew mates would perform ultrasound scans on yourself using training you received before flight to monitor your bone and organ health. NASA is studying and improving food formulation, processing, packaging, and preservation systems to ensure the nutrients remain stable and the food remains acceptable. Space-resilient medications and packaging that preserve the integrity of pharmaceuticals for long duration missions have also been developed.

NASA is taking action on all of these risks and trying to minimize or mitigate the negative effects on the human body. The results of the one-year mission will provide more insight into these changes over a longer period of time, and present a stepping stone for even longer missions. When we send humans on a journey to Mars, we will make sure that we have conquered the unknowns to ensure a safe trip home back to the gravity we know and love.

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