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Space: The Final Medical Frontier

Are overeager space tourists endangering their health?

Keeping people healthy in space has been a major challenge since the first days of spaceflight. That is partly why NASA has always favored the crème de la healthy crème of human specimens for its missions. Now, however, the burgeoning business of commercial spaceflight is poised to open the galaxy's doors to a much larger—and unhealthier—pool of passengers. If private spaceflight companies keep their promise to allow people of average health to fly, space tourism could become a $1.3-billion industry with more than 25,000 customers by 2021, according to consulting firm Futron Corporation. Virgin Galactic has already booked at least 680 reservations for a two-and-a-half-hour-long trip, with about four minutes spent in what is technically "space"—just more than 100 kilometers above Earth's surface. And a Russian company called Orbital Technologies hopes to build a space hotel equipped for five-day stays at more than 320 kilometers above the highest suite on Earth.

Fewer than a dozen paying customers have made the journey into space so far. We can guess at the kinds of medical problems new waves of space tourists may encounter, however, by examining the experiences of professional astronauts between the 1960s and today. Major health issues for these explorers have included weakened bones and muscles, poor vision, nausea and insomnia. In addition to all these risks, untrained tourists will almost certainly face a wider array of "health problems that you haven't had to deal with in space before," says Jeffrey Jones, a member of the Center for Space Medicine at Baylor College. Even a brief sojourn into space could present serious health concerns for the elderly and those with high blood pressure because of the enormous compression the body endures during takeoff and reentry. Longer voyages will likely aggravate many common medical disorders—including asthma, heart disease and cancer—that would usually disqualify someone from a NASA flight.

Currently there are no federal or state regulations that determine who is eligible for commercial spaceflight, so companies are free to set their own no-fly standards. A Virgin Galactic spokesperson says "most people" will be allowed to fly with them. Some doctors have begun drawing up screening guidelines for those who hope to vacation among the stars; others are considering how to modify a few Earth-bound medical procedures so that, if necessary, they can be applied in space.

NEW PRESSURE

THE ISSUES TO BE TACKLED are formidable. In the past half a century, researchers have learned that space travel changes just about every system in the human body. Launch and reentry place people under strong gravitational forces (*g*-forces), a measure of the stress to which the body is subjected during acceleration. High *g*-forces make the heart work extra hard to circulate blood, especially to the brain (which is one reason high *g*-forces can cause people to lose consciousness). Some commercial spaceflight companies have offered to help customers prepare for the intense strain by whipping them around in a giant centrifuge machine, but the training is not mandatory.

Orbiting Earth in free-fall at, say, 28,000 kilometers per hour and about 400 kilometers above the planet's surface—as is the case for the International Space Station—creates a state of weightlessness. On Earth, gravity keeps the bulk of our fluids in our lower half. When we are weightless, fluids spread out more evenly, draining from the legs and filling up the chest and head. In the process, fluid disperses through the inner ear tubes that help us keep our balance, resulting in nausea, which—even more than pain—is notoriously difficult to ignore and, if followed by vomiting, can lead to severe dehydration. Despite learning techniques to tolerate nausea, professional astronauts often feel queasy during the first days of a flight, so we can expect plenty of sick-to-their-stomach civilians.

Increased fluid in the head is also responsible for one of the most frequent complaints among astronauts after the all too common "space sickness": poor eyesight. All of that excess cranial

Illustration by O.O.P.S.

pressure can flatten the back of the eyeball and thus blur vision.

In addition to shifting fluids, prolonged weightlessness weakens the skeleton. Because astronauts are no longer walking or performing other weight-bearing activities, bone loses between 1 and 2 percent of its mineral density each month in space, says Jeffery Sutton, director of the National Space Biomedical Research Institute. As an added danger, calcium that leaches from bone can contribute to kidney stones—nuggets of minerals that can painfully obstruct the urinary tract.

Muscles also deteriorate in microgravity because they no longer have to work to support the body throughout the day. Although exercise in space can help slow such decay, fluid redistribution becomes a problem once again. Unusually high levels of lactic acid—which is responsible for cramps and aches during a workout—pool in the muscles of space exercisers, cutting their routines short.

Particularly concerning is how space alters the body's hardest-working muscle: the heart. Marlene Grenon of the University of California, San Francisco, and her colleagues have discovered that after just 24 hours in a simulated microgravity environment, the cells that line blood vessels change shape, adhere in different ways and use a different mix of genes than usual.

Space travel takes its toll on the mind as well as the body. Getting a good night's rest in microgravity can be difficult because of persistent lights and sounds on a spacecraft and the eerie feeling of weightlessness. In several grounded simulations of long-term space travel, astronauts living in close quarters occasionally became depressed and foggy. Considering how aggravated airline passengers can get after a flight across the Atlantic, sending a group of space tourists on a seven-month trip to Mars, as the Mars One organization wants to do, might be asking for mutiny.

GALAXY OF WOES

SPACE TOURISTS of average and poor health are bound to face a whole host of medical concerns on top of what even a NASA Adonis must worry about. Most commercial spaceflight customers are likely to be at least middle-aged, which means many will have high blood pressure and heart disease, common disorders for their age range.

Fluid redistribution is particularly dangerous for people with heart disease. As fluids move to the chest and head, rising pressure in the skull bumps up the risk of bursting blood vessels and damaging brain tissue. Similarly, increasing pressure inside the lungs from extra fluid can trigger an asthma attack—a sudden and acute constriction of the airways.

Even motion sickness could be extra dangerous to people with existing cardiovascular disorders. The dehydration, panting and racing blood pressure that come with excessive use of the barf bag, Jones points out, tire the cardiovascular system, which, if already weakened, could culminate in a heart attack. Some scientists have begun studying the heart in rats that are half-suspended (often by their tail), which somewhat mimics the fluid redistribution that happens in microgravity. So far they have learned that after a month—even in this experimental environment—the animals' heart muscle itself changes, becoming larger and less efficient; similar cardiac deconditioning has been reported in human astronauts.

Like microgravity, another one of the greatest dangers to space tourists is something they cannot see with their own eyes: radiation. Giant magnetic fields surrounding Earth deflect electromagnetic energy emanating from stars and black holes that would otherwise incinerate us. Once you leave Earth's magnetosphere behind, you are exposed to all that energy, which shreds DNA and can cause mutations that make a healthy cell start multiplying uncontrollably, leading to cancer.

Supremely healthy astronauts can spend hundreds of days in space without terribly increasing their rates of cancer. But if Mars One is serious about setting up colonies on the Red Planet, it will have to protect its passengers from radiation on the voyage—as well as at the atmosphereless destination. And skittering particles and electromagnetic waves could unfavorably tip the scales for anyone with a genetic predisposition to cancer.

FINAL FRONTIER MEDICINE

PINPOINTING WHO IS VULNERABLE to illness in space is still not enough to guarantee the well-being of space travelers. We must also learn how to adapt medical procedures we have perfected on Earth.

Dorit Donoviel, deputy chief scientist at the National Space Biomedical Research Institute, and her colleagues are exploring easy, noninvasive techniques as alternatives to standard medical practice in space. Traditionally doctors check for a change in brain pressure by sticking a needle into the spinal column or directly into the skull—a procedure that might not fly in space, especially without an attending physician. Instead Donoviel has been trying to gauge changes in internal pressure by recording how sound waves travel through the eye sockets and ear canals. And infrared light, which is absorbed and refracted differently by healthy and injured tissue, might be able to identify internal bleeding. Portable diagnostic devices based on infrared or ultrasound signals would be far more likely to make it to space than the bulky and heavy machines used for MRIs and CT scans.

In the meantime, a report published in 2012 in *BMJ* recommends that primary care clinicians start getting ready to evaluate patients who want to try commercial spaceflight. Conditions such as heart disease, uncontrolled asthma or high blood pressure should merit a warning and explanation of risks from a physician. Researchers are also devising simple ways to get hopeful tourists as healthy as possible before they ever set foot onboard a spacecraft. Low-tech solutions such as making sure people are well nourished and properly hydrated in the weeks before launch might go a fair way toward ensuring an emergency-free flight.

Virgin Galactic says it will offer customers three days of training that will include "physical tests" and "a medical screening" but is not disclosing the precise criteria used to approve tourists for flight, if any. For now the onus falls mainly on tourists and their doctors to take precautions. As a consolation to anyone who must stay grounded, just remember: there's so much to discover on our planet. I hear Iceland is out of this world. SA

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