The Effects of Space Travel on Health and Recommended Assessments for Space Flight Tourists

Sarah Hoffer PA-S, Christina Gierhart MPAS, PA-C
The University of Findlay

INTRODUCTION

A new type of space race is occurring where multiple companies are developing aircraft to become the first in the United States to send a commercial flight into low Earth orbit. Companies ranging from SpaceX to Virgin Galactic are developing programs that will soon allow people to purchase flights for as little as $250,000 for a few hours of travel but can also be as expensive as $52 million for travel up to 30 days.[1,2] With this new and exciting form of travel, one must also consider the effects that space could potentially cause to the human body[3,4,5]:

- Radiation
- Immune System
- Musculoskeletal
- Neuologic
- Respiratory
- Renal

To ensure the safety of these travelers, it is clear that standards must be established to evaluate travelers pre- and post-flight to ensure there are no long lasting health effects. It is important to identify and establish proper passenger safety and health standards before commercial space travel is initiated by looking at what the potential effects that space can have on the body.

BACKGROUND

Low earth orbit (LEO) is defined as a vehicle that is in orbit around the Earth at a 200 to 400 kilometer altitude.

Space medicine can be defined as "the practice of all aspects of preventative medicine including screening, health care delivery, and maintaining human performance in the extreme environment of space and preserving the long term health of space travelers"[4]

As of right now, medical professionals have little to no experience or guidance when evaluating and certifying a patient for commercial space flight, who may be older than an average astronaut (age 34) and with more chronic medical problems.[8,9] One specific health care professional that could help in the establishment of guidelines for space travel is the flight surgeon. Currently, only minor injuries and diseases are able to be treated on the ISS because of the limited capabilities in flight.

NASA must certify every spacecraft before it carries passengers aboard and meet safety and performance requirements.[12] Private astronaut missions can spend up to 30 days at the ISS starting in 2020 and for each night spent, NASA receives $35,000, which covers costs towards life support, food, air, energy, and data.[1]

METHODOLOGY

Materials were collected from the Trip database, Medline with Full Text, PubMed, Google, the NASA website, and the Aerospace Medical Association. Research terms used included "Astronaut health", "Space medicine", "NASA medical examination requirements", and "Humans in space". Materials were searched for in October, November, and December of 2018 and February, November and December of 2019. Articles were manually selected and researched for trends and similarities between relevant articles. Articles, government policy, and public documents must be directly related to human space travel into low Earth orbit, commercialized space travel, short term duration, and any effects of space on the human body. Peer-reviewed articles must be published within the last 6 years, government documents within the past 10 years, and news articles less than 2 years old. Articles must be based on work that was conducted in the United States, Canada, or the United Kingdom. Airplane flights and cardiac malformation case studies were excluded.

RESULTS

Immune System[4,5]:

- ↑ granulocytes, B cells
- ↓ lymphocytes, natural killer cells
- Candida albicans infections with amphotericin B resistance

Musculoskeletal[4,8,11]:

- 20% muscle mass and strength loss during 5-11 days of flight
  - Mostly lower body
- Bone loss in spine, femoral neck, trochanter, pelvis
- Hypercalciuria, decreased urinary output, changes in urine concentration, increased urinary phosphate and sodium, kidney stone formation
- Space Adaptation Back Pain
  - Females, lumbar region

Effects of space flight on human body:

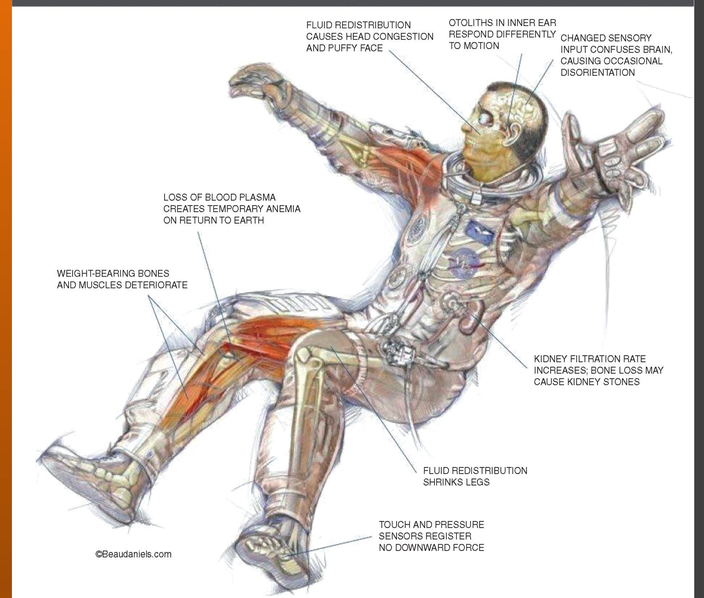

Figure 1. Effects of space flight on the human body. Copyright Daniels and Daniels[4]

Neurologic[4,12]:

- Decompression sickness – numbness, tingling, joint pain, confusion, motor incoordination, LOC, death
- Space adaptation syndrome – N/V, pallor, difficulties with visuomotor tracking tasks and vestibulo-ocular reflexes

Radiation[3,4]:

- Damage to cellular DNA, cytokine response, increased risk of cancers
- Career limit of 1500 mSv for males, 900 mSv for females
  - Average 6 month ISS exposure is 75 mSv
- Premature aging, CV disease, cataract formation, carcinogenesis, CNS degeneration

Required Screenings and Follow Up for Space Travelers

Extremes of ages and those with chronic medical conditions are able to tolerate the launch and reentry accelerations of suborbital space flight.[4] Individuals seeking NASA medical certification to participate in space flights must have[6]:

- EKG
- Pure tone audiometry
- Blood work (Hct, Hgb, lipids, fasting blood sugar, HgA1c
- Field of vision and peripheral vision tests

If cardiovascular disease is confirmed by a cardiologist, the individual is disqualified from participation.[6]

NASA has also developed medical evaluation requirements for former astronauts to monitor any changes that could occur due to their time spent in microgravity and exposure to radiation.[7] Certain tests are part of the lifetime surveillance of astronaut health (LSAH) examination and includes annual[7]:

- Annual CBC, urinalysis, HTN screening
- Liver and renal function tests
- TSH, free T4
- Fasting blood glucose, HgA1c
- Fasting cholesterol, HDL, LDL, cholesterol, triglycerides
- High-sensitivity CRP
- Calcium, magnesium, inorganic phosphate
- PSA (beginning at age 50 for men)
- Iron, TIBC, transferrin, and ferritin
- Visual exam of skin with photographic documentation
- Visual acuity, color vision, EOM assessments
- Hearing questionnaires and pre-tone audiometry
- 12-lead EKG and CV health screening, and carotid intima-media thickness test

Every 3 years:

- DXA scan and bone health serologic markers

DISCUSSION & CONCLUSION

In order to turn a potential space tourist into an astronaut, there needs to be a specific pre- and post-flight standards created that can be used to assess the qualifications and health of a potential traveler in order to avoid any possible adverse incidences. NASA, FAA, AsMA, the ISS medical community, and others have developed medical standards that individuals must meet in order to travel into space.[4,8] These standards are much more rigorous than what would be needed for short duration flight that is 30 days or less. It is hypothesized that those participating will either conduct their health screenings and exams through NASA or the specific company the participant is traveling through who will have trained flight surgeons or similar providers that are knowledgeable in space medicine. It is assumed that the cost of these medical screenings and exams will be covered within the cost of the total trip but, it is unknown how long medical costs would be covered post-flight. A complete physical exam and initial screenings should include CBC with differential, complete metabolic panel, thyroid hormone tests, iron studies, urinalysis, hemoglobin A1-C, cardiovascular risk assessment, 12-lead electrocardiogram, comprehensive skin assessment, complete visual examination, and pure tone audiometry should be done and performed again after returning.[6,7] If there are any chronic conditions that the individual is diagnosed with, they should have pertinent labs or imaging done within 3 months of travel and monitored at closer intervals if they are not at baseline post-flight. Travelers should be advised for the risk of decompression sickness, lumbar back pain, and space adaptation syndrome within the first couple of days as these conditions are experienced most often and can cause significant impairment acutely.[4,12] Post-flight, individuals should initially follow the LSAH examination with certain tests being performed with longer intervals in between but, once travelers are shown to be at baseline, they may be monitored per their primary care provider's recommendations.

REFERENCES

1. Davis J. How much does space travel cost? NBCNews.com. https://www.nbcnews.com/mach/science/how-much-does-space-travel-cost-ncna919011. Published October 15, 2018. Accessed November 7, 2018.
2. Sheetz M. Virgin Galactic space plane takes first test passenger into space. NBCNews.com. https://www.nbcnews.com/mach/science/virgin-galactic-space-plane-takes-first-test-passenger-space-ncna974636. Published February 22, 2019. Accessed February 25, 2019.
3. Chancellor JC, Blue RS, Cengel KA, et al. Limitations in predicting the space radiation health risk for exploration astronauts. *NPJ Microgravity*. 2018;4. doi:10.1038/s41526-018-0043-2. Published April 3, 2018. Accessed October 7, 2018.
4. Hodkinson PD, Anderton RA, Posselt BN, Fong KJ. An overview of space medicine. *Br J Anaesth*. 2017;119:i143-i153. doi:10.1093/bja/aex336. Published November 17, 2018. Accessed November 21, 2018.
5. Cervantes JL, Hong B-Y. Dysbiosis and Immune Dysregulation in Outer Space. *Int Rev Immunol*. 2016;35(1):67-82. doi:10.3109/08830185.2015.1027821. Last updated December 30, 2016. Accessed October 10, 2018.
6. National Aeronautics and Space Administration. NASA Aviation Medical Certification Standards. https://www.nasa.gov/pdf/620882main_Av_med_cert_std_OCHMO_110902_2MED.pdf. Published November 2009. Accessed November 7, 2018.
7. Lewis R. Medical Examination Requirements (MER) for Former Astronauts. NASA. http://www.nasa.gov/hhp/medical-examination-requirements. Published December 8, 2017. Accessed October 16, 2018.
8. National Aeronautics and Space Administration. International Space Station Medical Monitoring. https://www.nasa.gov/mission_pages/station/research/experiments/explorer/Investigation.html?#id=996. Accessed December 3, 2018.
9. National Aeronautics and Space Administration. Frequently asked questions. https://astronauts.nasa.gov/content/faq.htm. Accessed December 31, 2019.
10. National Aeronautics and Space Administration. 10 more things to know about commercial crew transportation. https://blogs.nasa.gov/commercialcrew/2015/01/26/10-more-things-to-know-about-commercial-crew-transportation/. Published January 26, 2015. Accessed December 3, 2018.
11. Canadian Space Agency. What happens to muscles in space? https://asc-csa.gc.ca/eng/sciences/osm/muscles.asp. Modified August 18, 2006. Accessed February 28, 2019.
12. Canadian Space Agency. What is decompression sickness? https://asc-csa.gc.ca/eng/sciences/osm/decomp.asp. Modified August 18, 2006. Accessed February 28, 2019.

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