Dermatologic Considerations for Spaceflight and Space Exploration

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As of 2022, approximately 600 people have traveled to space, defined as reaching the earth's orbit, including, recently, laypersons and tourists in addition to professional astronauts (NASA, 2023a). As the space industry continues to expand into long-term space exploration, including planned future missions back to the moon and to mars (NASA, 2023b), it will be important for physicians to consider the known and potential health risks associated with space travel. This commentary covers space and health issues with a focus on dermatology, building on previous literature and conversations with experts and providing guidance to clinicians who may be asked to support these endeavors (Arora, 2017). We have grouped the dermatologic issues as environmental risks, space wear, immunity, and radiation exposure related.

ENVIRONMENTAL RISKS

Leaving the safety of the troposphere leads to a number of new environmental changes. When entering a microgravity environment, physiologic fluid equalization occurs. Notably, there is a shift of fluid out of the lower extremities toward the head. The impacts of fluid cephalization may cause facial edema and decreased fluid in the legs. Less visibly, the equalization of pressure may contribute to more fluid in venous plexuses, which can lead to livedo reticularis–like change. These drastic fluid shifts can lead to swelling, discomfort, and increased skin irritation. Ultimately, there is a diuretic phenomenon that occurs with the redistribution of fluid: upon entering a microgravity environment, the body will diurese approximately 2 l of fluid.

Prior literature has reported on hydration of the skin in a long-term mission in the International Space Station (ISS) (Tronnier et al, 2008). Studies of hydration of the stratum corneum, transepidermal water loss, and surface structure of the skin were measured, showing that there may be delayed epidermal proliferation of cells and significant decrease in skin elasticity (Tronnier et al, 2008). Given that transepidermal water loss was increased during space travel and that transepidermal water loss is used to assess skin function and severity of diseases characterized by barrier dysfunction, such as atopic dermatitis, these observed space-related impacts on skin function are anticipated to contribute to challenges of skin barrier function in space.

Furthermore, the skin microbiome may experience alterations (Morrison et al, 2021; Nguyen and Urquieta, 2023; Tozzo et al, 2022; Voorhies et al, 2019), although studies have shown a lack of a consistent shift toward a spaceflight microbiome while on the ISS (Morrison et al, 2021). Potential changes to the skin microbiome pose hypothetical concerns for barrier dysfunction that translates to increased risk of infection and delays in the healing process (Caswell and Eshelby, 2022).

SPACE WEAR

It has been suggested that there may be issues related to astronaut attire. Notably, spacesuits are designed for the extreme temperatures and vacuum of space. Owing to these environmental requirements, suits have been described as uncomfortable and not ergonomic. Beyond designs with incidentally associated discomfort, suits were historically designed for male astronauts. For women, these suits can be even less comfortable and more irritating. Furthermore, astronauts routinely report injuries from spacesuit wear, including pressure wounds in fingers, joints, and skin folds (Aintablian, 2023; Satcher, 2023). Nail avulsion is not uncommon owing to the combination of bulky suits, limited finger padding, and need for often prolonged manual dexterous maneuvers in space (Aintablian, 2023; Satcher, 2023). Astronauts sometimes utilize adhesives to ensure skin-to-glove adherence during maneuvers, which can lead to skin damage and potential irritant or allergic contact dermatitis. Notably, National Aeronautics and Space Administration is designing and launching a new generation of space suits aimed to be more tailored to the astronaut, including sex-specific builds for female astronauts (Falconer, 2023). As space travel becomes increasingly more accessible to the public, it is important to realize how the diversity of body shapes with the misalignment of suit availability may lead to unintended irritation and injury.

IMMUNE SYSTEM AND MICROBIAL ACTIVITY

There appear to be alterations to the immune system in space, with ongoing studies aimed at better understanding the impacts (Malkani et al, 2020). There has been ongoing research looking at spaceflight-associated microRNA expression and its contribution to immune dysregulation in space. Studies have shown viral reactivation, such as Epstein–Bar virus and

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varicella-zoster virus, including shingles (Voorhies et al, 2019). Space travel can also lead to alterations in the microbiome. This may result in skin sensitivities, with symptoms ranging from peeling, dryness, redness, itching, to bruising (Braun et al, 2019). The interaction of general gravitational forces with immunosuppression is an important topic to be considered (Caswell and Eshelby, 2022). Alterations to bone marrow and thymus have been described in association with gravitational forces and may have impacts on acquired immunity (Akiyama et al, 2020). There is notable thymic atrophy and reduced T-cell output from space travel (Benjamin et al, 2016). Observations have also noted reduced B-cell count a week after landing (Tascher et al, 2019). Additional factors at play, including increased stress hormones during spaceflight, may further impact the immune response (Borchers et al, 2002; Grover, 2011; Stowe et al, 2001).

RADIATION EXPOSURE

Exiting the protection of the ozone layer leads to increased potential radiation exposure. There are studies of airline pilots demonstrating increased risk of skin cancer, including melanoma, attributed to extended time at high altitudes and higher UV exposure (Sanlorenzo et al, 2015). Similarly, a study of 312 astronauts demonstrated a statistically significant 3-fold increase in prevalence of nonmelanoma skin cancers compared with nonastronauts (Chancellor et al, 2018, 2014; Institute of Medicine, 2004). Notably, the radiation types differ between flight pilots and astronauts. The radiation that affects astronauts is ionizing radiation, which includes galactic cosmic rays and solar events, whereas airline pilots remain within earth's atmosphere and have increased exposure solely to UVR. As humans explore further into the solar system, astronauts will expectably spend prolonged periods of spaceflight beyond earth's protective magnetic shield and incur increased exposure to different forms of radiation.

CONCLUSION

As the space frontier continues to expand, it is important to keep up with the dermatologic considerations related to space travel. Because physicians may become increasingly involved in the space industry, there will be increasing opportunities for physicians to advocate for the health of spaceflight participants. Fluid shifts, space wear, temperature and aridity, immune system, radiation exposure, and nutrition impact dermatologic health and may require further management. As the final frontier, the skin is the largest skin—environment interface organ. There is anticipation in identifying new and different cutaneous impacts of space travel on the skin. It is important for dermatologists to be aware of and involved in these studies and to be aware of these findings. The effect of space travel on skin health and disease likely represents a nascent field of medical research and opportunity for dermatologists to be involved in the next steps of exploration.

ETHICS STATEMENT

This article was written in compliance with ethical standards. No ethics approval or informed consent was needed for this article.

KEYWORDS

Dermatology; Environmental risks; Radiation; Spaceflight; Spacewear

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CONFLICT OF INTEREST

The authors state no conflict of interest.

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