

2013 DECADAL STUDY

The Impact of Sex & Gender on Adaptation to Space



A Joint Study by the National Aeronautics and Space Administration and the National Space Biomedical Research Institute

Immune System

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Terrestrial Medicine-Based Consensus of the Impact of Sex and Gender on the Immune System



- There is a considerable body of evidence that there are sex-based differences in immune responses on earth.
- Women appear to make a “more potent” immune response than do men. This includes activation of immunologically important cells and enhanced production of antibody and cell-mediated immune responses
- There are sex-based differences in the microbiome



- Women appear to have lower rates of infection (viral and bacterial) than do men in certain circumstances

- Women appear to have a higher rate of autoimmune diseases, including arthritis and systemic lupus erythematosus, than do men



Aspects of Spaceflight Conditions that Could Affect Immune Responses and Resistance to Infection and Tumors:

- Microgravity
 - Radiation Exposure
 - Stress
 - Nutritional Factors
 - Vibration
 - Temperature Changes
 - Pressure Changes
 - Atmosphere Makeup
 - Sheer Force Changes
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- The variables that could affect immune responses and resistance cannot be isolated.



Observed Effects of Spaceflight Conditions on Immune Responses:

<u>Type of effect</u>	<u>Short-Term or Long-Term Flight</u>
Alterations in leukocyte sub-set distribution	Both
Alterations in cytokine production	Both
Alterations in natural killer cell activity	Both
Alterations in antibody production	Both
Alterations in macrophage function	Both

Current Understanding of the Impact of Sex and Gender on the Immune System in Space



Changes in Resistance to Infection that Could be Related to Spaceflight-Induced Alterations in Immune Responses and/or Microbial Growth, Gene Expression and Virulence:

- Enhanced and more rapid growth of some bacteria
- Enhanced virulence or virulence-related phenotypes in some bacteria, including major obligate (*Salmonella*) and opportunistic (*Pseudomonas*) pathogens
- Enhanced resistance to antibiotics in some bacteria
- Enhanced and altered shedding of herpesviruses
- Bacterial infections in spaceflight, e.g., Apollo 13, Shuttle and ISS missions
- Spaceflight conditions-induced changes in immune responses and bacterial growth and virulence have not been directly linked to enhanced susceptibility to infection or cancer to date, but the possibility exists of such a linkage as very long-term flights that expose crews to new factors (e.g. new forms of radiation) are considered

Current Understanding of the Impact of Sex and Gender on the Immune System in Space



Studies Carried Out to Determine Sex-Based Influences on the Immune Response During Spaceflight Conditions:

<u>Type of Study</u>	<u>Observations</u>
Human spaceflight studies designed to determine sex-based differences	None
Use of human ground based models to determine sex-based differences	Few, none designed for direct comparison
Use of animal models in space to determine sex-based differences	None

Head-Down Tilt Bed Rest – From European Space Agency –Space in Images 2012





- Existing databases from spaceflight should be thoroughly analyzed to look for trends that show sex-based differences in spaceflight effects on immune responses, resistance to infection, and development of cancer
- Experiments should be designed to test the existence of sex-based differences in effects of ground-based models of some spaceflight conditions (e.g. chronic bedrest with a 6° head-down tilt) on immune responses
- Experiments should be designed to specifically test for sex-based differences in effects on the immune system during actual spaceflight.



- There is very little information available on sex-based differences in the effects of space flight conditions on the immune system. In order to provide this information, opportunities for ground-based modeling and spaceflight experiments designed to compare effects of sex differences in spaceflight conditions on the immune system must be provided.

Action Items:

- Develop plan for RFP for experiments using ground based models of space flight conditions to directly compare effects of sex differences on the immune system
- Assure sufficient numbers of women are included in ISS mission crews to allow for direct comparison of sex differences on the the immune system during spaceflight