

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

Neurobehavioral and Psychosocial Factors Workgroup

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Gender Differences in Mission and Demographic Information for Astronauts Transiting to the International Space Station (ISS)



- **Data obtained from publically-accessible government space agency and military websites for female and male astronauts from 1998-2013 (encompassing all missions to ISS)**
- N=129 US astronauts—26 females (20%) and 103 males (80%)
- Females made fewer repeat transits to ISS than males (1.5 vs. 1.8 transits)
- Greater % of males (72.8%) had military service background compared with females (38.5%)
- Females had more doctoral degrees as males (i.e., 50% vs. 28%); males had more master's degrees than females (85% vs. 58%)
- Females had more bachelor's degrees in biology; males had more bachelor's and master's degrees in engineering (though females had more doctoral degrees in engineering)
- Females were younger than males for all transits to ISS (43.2y vs. 45.9y)
- No differences in the % of male (76%) and female astronauts (69%) who were married
- More males had at least one child (67% vs. 38%) and males had more children than females (on average, one more child)

Terrestrial Medicine-Based Consensus of the Impact of Sex and Gender on Neurobehavioral and Psychosocial Factors *(slide 1 of 2)*



- **Sleep and Circadian Rhythms in the Laboratory Environment**
- No gender differences in neurobehavioral performance in response to sleep loss
- Men gain more weight than women during chronic sleep restriction (CSR)
- CSR induces greater increases in leptin and greater cellular immune activation of interleukin-6 and tumor necrosis factor-alpha in women than men
- CSR decreases adiponectin levels in Caucasian women, but no changes in men
- Gender differences in sleep in healthy young, middle-aged and elderly adults
- Gender differences in chronotype and circadian rhythms

- **Gender and Behavioral Health on Earth: Anxiety and Depression**
- Anxiety disorders and major depressive disorder are about twice as prevalent in women than in men
- Gender differences in symptoms, clinical course, co-morbidity and treatment response

Terrestrial Medicine-Based Consensus of the Impact of Sex and Gender on Neurobehavioral and Psychosocial Factors *(slide 2 of 2)*



- **Gender and Stress**
- Women show heightened stress sensitivity
- Women show an increased prevalence of stress-related affective disorders
- Women display a greater physiological stress response axis than men: higher cortisol levels following stressors
- Women more sensitive to effects of elevated adrenaline during stress activation as part of autonomic nervous system stress response
- Individual life experiences and fluctuations in reproductive hormones in women affect magnitude of gender differences
- Increased cortisol over extended periods produces cardiovascular and immune system effects and effects on learning, memory and mood

Current Understanding of the Impact of Sex and Gender on Neurobehavioral and Psychosocial Factors in Space

(slide 1 of 2)



- **Neurobehavioral and Sleep Measures from Astronauts on ISS**
- No gender differences identified to date in global performance score on Psychomotor Vigilance Test or self-ratings of workload, tiredness and stress, or sleep quality in-flight or post-flight
- **Medication Use to Promote Sleep and Wake in Astronauts**
- How sleep duration and quality on ISS and other analogs relate to medication use is unclear
- While in spaceflight, an unknown number of astronauts use sleep medications and/or wake-promoting medications
- **Relevance of Clinical Disorders to Space and Analog Environments**
- No evidence that female astronauts experience same risk for depression and anxiety disorders as their counterparts in the general population
- **Behavioral Health in Analog Environments**
- Limited data on gender-based differences in behavioral health in isolated and confined extreme environments
- Gender differences in behavioral health in Antarctica are unclear
- No gender differences in personality characteristics in polar work groups or expedition teams
- Women tend to assume a more cooperative and supportive role than men in their interactions with other members of polar work groups
- Women have a somewhat more difficult interpersonal experience than men in polar work groups which may impact performance
- Cultural influences may have an impact on gender-related group processes

Current Understanding of the Impact of Sex and Gender on Neurobehavioral and Psychosocial Factors in Space

(slide 2 of 2)



- **Behavioral Health in Spaceflight**
- Limited data on gender-based differences in behavioral health in space
- Achievement most frequently mentioned value for male and female astronauts in their memoirs
- The Journals Flight Experiment on ISS suggests slight differences between men and women in terms of net-positivity/negativity
- Men exhibited greater positivity than women overall and particularly during the first and fourth quarters of ISS expeditions. Relevant entries of women fluctuated less than men
- Emotional stability among characteristics of successful adaptation and esteemed leadership in isolated and confined personnel, suggesting that any difference reflects successful adaptation by women to ISS

- **Gender and Stress**
- Little research on gender differences in response to specific types of stressors found in space flight and microgravity
- Head-down tilt long-term bed rest study in women found evidence for stress system activation and indications of “impairments in psychological states”. No gender comparisons.
- A 520-day simulated mission to Mars, conducted by Russian Institute of Biomedical Problems used an all-male crew of six. Majority of crewmembers developed sleep disturbances and other behavioral changes undesirable in prolonged space missions.

Recommended Research Priorities *(slide 1 of 2)*



- Determine possible gender differences in pharmacokinetics, pharmacodynamics, side effects, and efficacy for sleep-promoting and wake-promoting medications in spaceflight, and how these differences translate to medication use in space.
- Determine if sleep and circadian rhythm gender differences relate to effective adaptation to changes in the light-dark cycle or changes in light intensity experienced in space and to the ability to obtain restorative sleep.
- Obtain data on the psychological screening and selection process of astronauts with respect to affective disorders and personality measures and determine how these relate to gender.

Recommended Research Priorities *(slide 2 of 2)*



- Determine how psychosocial isolation and separation from family and other important relationships inherent in long-duration spaceflight may elicit gender and cultural differences in performance, satisfaction and coping strategies to these conditions. Data are needed to optimize crew integration and functioning.
- Determine how gender differences in stress reactivity may be affected by microgravity and spaceflight, in particular by psychological stress reported in confined space for extended periods and physiological stress associated with weightlessness.
- Investigate whether individual differences in neurobehavioral and psychosocial factors are larger than reported gender differences.

Research Infrastructure Required to Enable Progress



- System to access information regarding the utilization of sleep-promoting and wake-promoting medications in astronauts relative to frequency and dosage taken
- Techniques to evaluate sleep and circadian rhythms adaptation to spaceflight in male and female astronauts
- System to provide effective behavioral health services for astronauts and their families across tenure in space program
- System to share information about behavioral health issues between service providers for astronauts and scientists, while maintaining astronaut confidentiality
- Changes in infrastructure to enable inclusion of both men and women in analog environments such that mixed-gender crews can be systematically studied

Summary



- Gender differences in mission and demographic variables for astronauts transiting to ISS.
- Gender differences in sleep and circadian rhythms and in some physiological responses to sleep loss on Earth.
- No gender differences in attention, or self-ratings of workload, tiredness and stress, or sleep quality in-flight or post-flight on ISS. Psychoactive medication use in space is unknown.
- Gender differences in prevalence, symptoms, clinical course, co-morbidity and treatment of anxiety and depressive disorders on Earth. No information available for space.
- Limited data on gender-based differences in behavioral health in isolated and confined extreme environments or in space.
- Women show heightened stress sensitivity and increased prevalence of stress-related affective disorders on Earth. Little research conducted in space.