WOMEN'S HEALTH IN SPACE HEALTH RESEARCH: WHERE ARE THE DATA?

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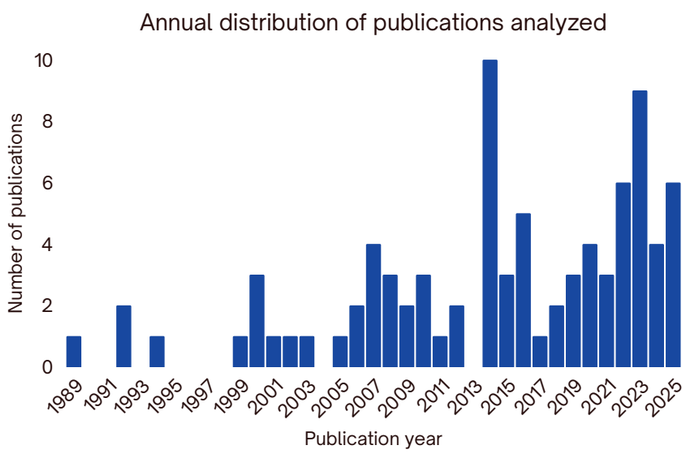
INTRODUCTION

Only 75 women have been to space historically, and this has made female-focused data underexplored.
There is reliance on data from male-dominated spaceflight cohorts, and Earth-based analogs as a result and although important, the extent to which these findings apply to female astronauts is not clear.
The Artemis II program which plans for long-duration missions to the Moon and Mars has made more obvious the importance of understanding sex-based differences as an operational requirement.
This scoping review examines over 3 decades of evidence to point out what we currently know about women's physiological adaptation in space and what the gaps that must be addressed are.

METHODOLOGY

A scoping review was carried out to look into research on women's health in space. The search used PubMed, Semantic Scholar and NASA Technical Reports Server using keywords "female astronauts," "women's health," "spaceflight, "microgravity" in different combinations. 2,373 papers were generated. After removal of duplicates and irrelevant papers, 101 full text papers were accessed.
85 published works between 1989 and 2025 were reviewed after screening abstracts. Studies were selected for their relevance to women's health in space, and findings were grouped into "What We Know" and "What We Don't Know" across key domains, including cardiovascular, reproductive, musculoskeletal, operational medicine, immune system, neurovestibular, and radiation health.



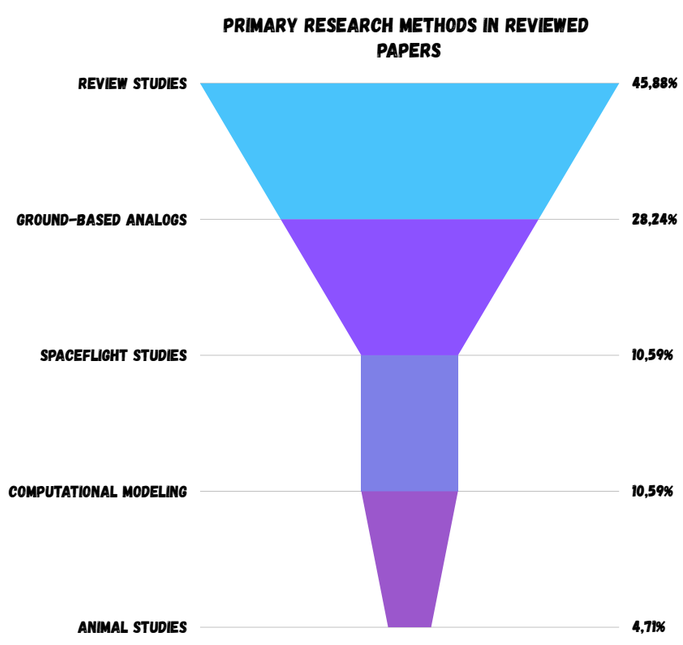
FINDINGS

The 85 papers reviewed showed research concentration in certain domains, and gaps were more obvious in others. Most notable is a critical system like immune function which is comparatively understudied in female-specific contexts.

There has been an increase in female-focused research since 2014, which coincides with NASA's formal recognition of sex and gender differences in space adaptation. Of the papers in this review, only 29 were published before 2014 - over 25 years, while 56 papers were published in the subsequent 11 years.

Results showed reliance on retrospective data (45.9%) and ground-based analogs (28.2%) rather than actual spaceflight studies.

Comparing "What We Know" versus "What We Don't Know" showed consistent patterns across domains. Differences between sexes are noted but the underlying mechanisms are poorly understood and the effectiveness of most countermeasures have not been specifically validated for female astronauts.



Cardiovascular
What We Know
- Women show higher post-flight orthostatic intolerance and different venous responses
- Hormonal contraception affects thrombosis risk
- Plasma volume protection offers no orthostatic benefit

What We Don't Know
- Mechanisms for sex differences and why plasma volume protection makes no difference
- Optimal female-specific countermeasures and long-term deep space cardiovascular risks

Reproductive
What We Know
- Space radiation cause ovarian follicle damage
- Menstrual suppression is commonly practiced
- Ovarian axis function and the corpus luteum may be affected
- Cryopreservation is a fertility preservation option

What We Don't Know
- Effects of long-duration missions on human fertility and optimal contraceptives for long missions
- Combined impact of radiation and microgravity on reproductive tissues and long-term fertility

Musculoskeletal
What We Know
- Higher chance of lower limb muscle atrophy than men with sex specific patterns
- Exercise prevents deconditioning
- Individual variability often exceeds sex differences

What We Don't Know
- If exercise protocols are as effective for women
- Mechanisms behind sex differences in muscle loss

Radiation
What We Know
- Women receive higher organ doses and have higher inherent cancer risk from space radiation
- Current shielding is insufficient in solar particle events
- Female phantoms provide better dose estimates

What We Don't Know
- Actual cancer risk rates and effectiveness of radioprotective agents for female-specific risks
- Optimal shielding designs for female anatomy and how to update risk assessment guidelines

Neurovestibular
What We Know
- Higher incidence of space motion sickness in women
- Simulated microgravity induces oxidative stress

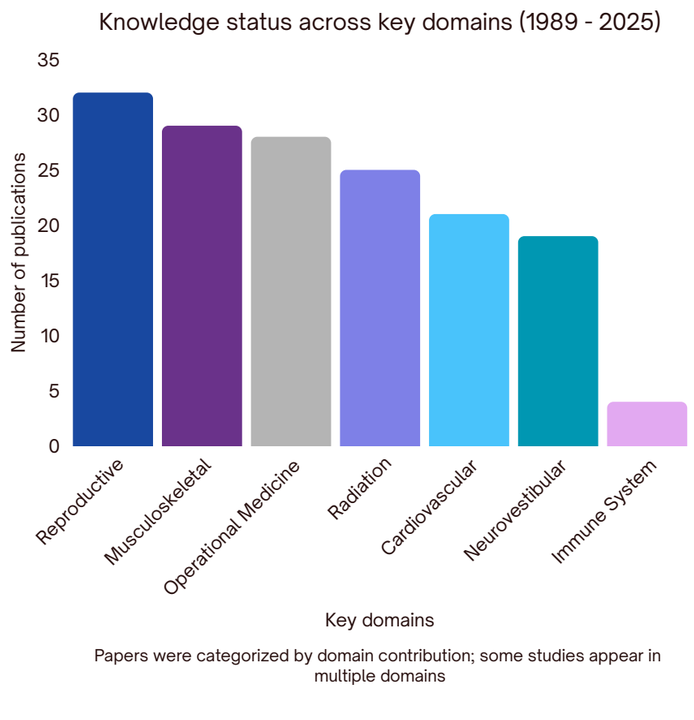
What We Don't Know
- Neurophysiological basis for motion sickness differences and effectiveness of countermeasures
- Long-term consequences of oxidative stress

Immune System
What We Know
- Dry immersion shows sex-specific biomarker changes associated with immune function

What We Don't Know
- Sex-specific immune adaptation patterns during long missions

Operational Medicine
What We Know
- Higher medical evacuation probability for women on long missions, notably from UTIs
- Current equipment may not be optimally designed for female physique
- All-female crews have lower life support resource requirements

What We Don't Know
- How to mitigate UTI risks and implement inclusive spacecraft design
- Practical implementation of resource planning advantages



Papers were categorized by domain contribution; some studies appear in multiple domains

CONCLUSION

This review proves that research on women's health in space has progressed since 2014, but gaps that could impact success and crew safety on future missions remain. There is focus of research in certain domains like reproductive health compared to other systems.

The analysis reveals a consistent pattern across physiological domains: we have documented what differences exist between sexes, but we largely lack understanding of why these differences occur and how to best address them through countermeasures specifically validated for female astronauts. Closing critical gaps demands sex-specific research during spaceflight and not just analog-based inferences and synthesis of existing knowledge.

RECOMMENDATION

To address these gaps, efforts must center studies focused on female physiology across systems and the potency of countermeasures. It will also help to follow up on longitudinal health monitoring extending beyond active service to understand the lifelong impacts of spaceflight on women. Including these into mission planning is an operational net positive to ensure the health, safety and performance of all astronauts on long-duration exploration missions.

KEY REFERENCES

Puukila, S., Alwood, J. S., Christenson, L. K., Ronca, A. E., & Steller, J. (2024b, November 1). Women's health in Spaceflight: Life beyond low Earth orbit. NASA Technical Reports Server (NTRS). https://ntrs.nasa.gov/citations/20240006986
Waters, W. W., Ziegler, M. G., & Meck, J. V. (2002). Postspaceflight orthostatic hypotension occurs mostly in women and is predicted by low vascular resistance. Journal of applied physiology (Bethesda, Md. : 1985), 92(2), 586–594. https://doi.org/10.1152/japplphysiol.00544.2001
Jain, V. (2015). Menstrual cycle control and venous thromboembolism risk in female astronauts [Unpublished manuscript]. NASA.
Ronca, A. E., Baker, E. S., Bavendam, T. G., Beck, K. D., Miller, V. M., Tash, J. S., & Jenkins, M. (2014). Effects of sex and gender on adaptations to space: reproductive health. Journal of women's health (2002), 23(11), 967–974. https://doi.org/10.1089/jwh.2014.4915