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Akash Kusum Maiti
M.Tech. Sam Higginbottom University of Technology and Sciences, Allahabad, Uttar Pradesh, India

Smita Chakraborty
M.Sc., in Food and Nutrition, SNU, West Bengal, India

Triyasa Foujdar
M.Sc., Clinical Dietetics, IGNOU, Delhi, India

Saptarshi Mukherjee
M.Tech. Space Technology, Ajeenkya Dy Patil University, Maharashtra, India

Corresponding Author:
Saptarshi Mukherjee
M.Tech. Space Technology, Ajeenkya Dy Patil University, Maharashtra, India

Possible therapeutic approaches to health hazards of astronauts in microgravity

Akash Kusum Maiti, Smita Chakraborty, Triyasa Foujdar and Saptarshi Mukherjee

Abstract
The exploration of space presents unique challenges to human health due to the microgravity environment. Extended exposure to microgravity can lead to a variety of physiological and psychological health hazards, including musculoskeletal deterioration, cardiovascular deconditioning, neurovestibular disturbances, and impaired immune function. This review article explores the current understanding of these health hazards and examines potential therapeutic approaches to mitigate these risks, ensuring the safety and well-being of astronauts during long-duration space missions.

Keywords: Disturbances, examines, therapeutic

Introduction
Human space exploration has advanced significantly since the first manned missions in the 1960s (Gao, Y., & Chien, 2017) [6]. However, prolonged exposure to microgravity poses several health risks that can compromise mission success and the health of astronauts (Tesei *et al*., 2022) [22]. Understanding the physiological changes that occur in microgravity is crucial for developing effective countermeasures (Aubert *et al*., 2005) [2]. This review aims to provide a comprehensive overview of the health hazards associated with microgravity and discuss possible therapeutic approaches to mitigate these challenges.

Health Hazards in Microgravity
1. **Musculoskeletal Deterioration**

- **Bone Density Loss:** In microgravity, the absence of mechanical loading on bones leads to significant bone resorption, resulting in decreased bone density, particularly in weight-bearing bones such as the spine, pelvis, and legs (Grimm *et al*., 2016) [7].
- **Muscle Atrophy:** The lack of gravitational force in space leads to muscle disuse, causing atrophy, especially in the lower limbs and back muscles. This reduction in muscle mass and strength can impair mobility and physical performance (Narici and De Boer, 2011) [14].

2. **Cardiovascular Deconditioning**

- **Orthostatic Intolerance:** Microgravity leads to a redistribution of body fluids, which can cause cardiovascular deconditioning. Upon returning to Earth's gravity, astronauts often experience orthostatic intolerance, characterized by dizziness, fainting, and difficulty standing upright.
- **Reduced Cardiac Output:** Prolonged exposure to microgravity can result in a decrease in cardiac mass and output, affecting the body's ability to supply oxygen to tissues (Jordan *et al*., 2022) [9].

3. **Neurovestibular Disturbances**

- **Space Motion Sickness:** The altered sensory input in microgravity disrupts the vestibular system, leading to space motion sickness, which can impair cognitive and physical function during the initial days of spaceflight (Aubert *et al*., 2005) [2].

- **Balance and Coordination Issues:** The lack of gravitational cues can lead to long-term impairments in balance and coordination, which may persist even after returning to Earth (Reschke and Clément, 2018) [4].

4. **Immune System Dysregulation**

- **Immune Suppression:** Microgravity has been shown to suppress immune function, making astronauts more susceptible to infections and impairing the body's ability to heal wounds (Bacci and Bani, 2022) [3].
- **Reactivation of Latent Viruses:** Studies have shown that the stress and altered immune response in space can lead to the reactivation of latent viruses, such as the herpesvirus family (Crucian *et al*., 2020) [5].

5. **Psychological Challenges**

- **Isolation and Confinement:** The psychological stress of long-duration space missions, including isolation, confinement, and separation from family, can lead to anxiety, depression, and other mental health issues (Oluwafemi *et al*., 2021) [5].
- **Cognitive Decline:** Extended exposure to microgravity and the space environment can affect cognitive function, including memory, attention, and decision-making abilities (Stahn and Kühn, 2021) [20].

Therapeutic Approaches

1. **Pharmacological Interventions**

- **Bisphosphonates and Calcium Supplements:** To combat bone density loss, astronauts are often prescribed bisphosphonates and calcium supplements. These drugs help reduce bone resorption and maintain bone mass (Leblanc *et al*., 2013) [12].
- **Antihypertensive Drugs:** To manage cardiovascular deconditioning and orthostatic intolerance, antihypertensive drugs may be administered. These medications help regulate blood pressure and improve fluid distribution in the body (Rivasi *et al*., 2020) [19].
- **Immuno stimulants:** To counteract immune suppression, immune stimulants and antiviral medications can be used to enhance immune function and prevent viral reactivation (Alhazmi *et al*., 2021) [1].

2. **Physical Countermeasures**

- **Resistance and Aerobic Exercise:** Exercise is one of the most effective countermeasures against musculoskeletal deterioration. Resistance and aerobic exercises are designed to mimic the effects of gravity on the body, helping to maintain muscle mass and bone density (Swain *et al*., 2021) [21].
- **Treadmill and Cycle Ergometer:** Specialized exercise equipment, such as treadmills with harnesses and cycle ergometers, are used in space to simulate weight-bearing exercises, helping to preserve cardiovascular and musculoskeletal health (Laws, 2021) [11].

3. **Nutritional Interventions**

- **Dietary Supplements:** Adequate nutrition is essential for maintaining health in microgravity. Dietary supplements, including vitamin D, omega-3 fatty acids, and antioxidants, are recommended to support bone health, reduce inflammation, and boost immune function (Kumar *et al*., 2022) [10].
- **Hydration Management:** Proper hydration is crucial to counteract fluid shifts and maintain cardiovascular stability. Astronauts are encouraged to monitor and adjust fluid intake to prevent dehydration and its associated risks (Pramanik *et al*., 2023) [10].

4. **Psychological Support**

- **Cognitive Behavioral Therapy (CBT):** CBT and other psychological interventions can help astronauts manage the stress and mental health challenges of space missions. Regular communication with mental health professionals and the use of virtual reality environments for relaxation are also beneficial (Hofmann *et al*., 2012) [8].
- **Team Cohesion and Support:** Encouraging strong team dynamics and providing social support can mitigate the psychological effects of isolation and confinement, promoting mental well-being during space missions (Palinkas and Suedfeld, 2021) [16].

5. **Advanced Technologies**

- **Artificial Gravity:** Research is ongoing into the development of artificial gravity systems, such as rotating habitats, to simulate Earth-like gravitational forces and prevent musculoskeletal and cardiovascular deconditioning (Clément, 2017) [4].
- **Wearable Sensors and Monitoring Devices:** Wearable technology that continuously monitors physiological parameters can provide real-time feedback on an astronaut's health, allowing for early detection and intervention of potential issues (Mukhopadhyay, 2014) [13].

Conclusion

The health hazards associated with microgravity pose significant challenges to human space exploration. However, through a combination of pharmacological, physical, nutritional, psychological, and technological interventions, it is possible to mitigate these risks and ensure the health and safety of astronauts during long-duration space missions. Continued research and innovation in these areas will be critical as humanity ventures further into space, including potential missions to Mars and beyond.

Future Directions

Future research should focus on developing more effective countermeasures and therapeutic approaches, particularly in the areas of artificial gravity, advanced exercise regimens, and personalized medicine. Additionally, long-term studies on the effects of spaceflight on human health will be essential to understanding the full spectrum of risks and refining strategies to protect astronauts in the challenging environment of space.

Conflict of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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