

The Human Research Program: Astronaut Health and Elderly Treatment

Because some of the effects of space flight on astronauts have similarities to the effects of human aging, NASA's research can illuminate the mechanisms behind the effects common to both.

Lead Agency:

The Human Research Program, Advanced Capabilities Division, Exploration Systems Mission Directorate, of the National Aeronautics and Space Administration.

Agency Mission:

The Human Research Program (HRP) is instrumental in carrying out the Vision for Space Exploration (VSE), by developing and delivering research findings, health countermeasures, and human systems technologies for spacecraft that will support crews on missions to the moon, Mars, and beyond.

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Partner Agencies:

NASA's HRP funds research with a large number of academic institutions and collaborates with many national and international government agencies and commercial entities.

General Description:

NASA's Human Research Program undertakes biomedical research and develops technologies to assure human health, safety, and performance during space exploration missions to the moon and Mars. Because some of the effects of space flight on astronauts have similarities to the effects of human aging, NASA's research on astronaut health may offer significant utility for treatment of the elderly. The following research areas demonstrate this linkage:

Balance and Gait Control: Falls in astronauts and the elderly can be caused by problems with the sense of balance. Astronaut's nervous systems adapt to weightlessness in ways that disturb balance and gait when they return to Earth or land on another planet. The human nervous system

has evolved components that optimize body movements and posture control under Earth's gravity. Both space flight and aging affect the performance of the components. NASA is investigating ways to help astronauts "learn how to learn" to adapt to new gravitational environments. This involves techniques that systematically test and challenge the balance and gait control systems. (References: BG-1 to BG-12)

Orthostatic Hypotension: The decrease of blood pressure while standing upright may lead to fainting, falls and thus injuries in astronauts and the elderly. Astronauts' orthostatic hypotension has been shown to be related to dehydration and blunted functioning of the cardiovascular control system, and there is evidence of similar mechanisms in elderly hypotensive patients. NASA's work in understanding this problem in astronauts has suggested treatments ranging from mechanical support, to oral rehydration, to a medication named Midodrine that augments the nervous system's control of the circulation. (References: OH-1 to OH-4)

Osteoporosis and Bone Fracture Risk: The injuries from falls in the elderly are often manifested in bone fractures, which are also a significant risk to astronauts if they occur during stressful missions on another planet, at a great distance from definitive medical care on Earth. Osteoporosis is perceived as a disease of the elderly because the inevitable loss of bone mass with aging occurs by a slow, chronic process that does not display symptoms until a low-trauma fracture occurs. But loss of bone strength happens in young, fit astronauts at a much faster rate than in the elderly, in a process that NASA calls premature osteoporosis. This is a long-term health risk to astronauts after a space flight, as well as a risk during the mission. (References: B-1 to B-4)

Impaired Nutrition and Vitamin D Metabolism: Many of NASA's nutritional biochemistry efforts have important applications to the elderly, foremost among them NASA's vitamin D research. This involves astronauts in spaceflight, scientists in the Antarctic, and the self-neglecting elderly. NASA collaborated with the Surgeon General's Office in 2004 and 2005 in conferences titled "Vitamin D and Bone Health Conference: An Update from Earth and Outer Space." (References: N-1 to N-2, VD-1 to VD-3)

Reduced Immunological Response: Innate immunity, the first line response to bacterial infections, is diminished in up to 20% of adults over age 65 who do not develop fevers in response to infections. Immunity has been found to be altered during and following space flight. In particular, the reversible nature of the space flight effects offers hope for slowing or even reversing the effects of aging. Specifically, astronauts have exhibited altered number and function of immune cells and reactivation of latent herpesviruses. (References: I-1 to I-7)

Noninvasive Behavioral Health Techniques: There are neurobehavioral and psychosocial factors that influence both the elderly and astronauts including risk of depression, sleep disorders, and cognitive function changes that can benefit from noninvasive techniques. These noninvasive behavioral health techniques can aid physicians to provide treatments for individuals at risk, to enable them to continue leading productive and healthy lives, whether in space or on Earth.

Excellence: What makes this project exceptional?

Unique perspective and contributions to aging research are resulting from NASA's space biomedical research program.

Significance: How is this research relevant to older persons, populations and/or an aging society?

Balance and Gait Control importance to Aging: Falls in the elderly are a significant (and growing) public health problem because they lead to death, injury, and activity restrictions. Approximately one-third of community-dwelling persons over age 65 falls at least once per year. As a result, 40% of all nursing home admissions are due to fall-related injuries. The risk is greater in women.

Orthostatic Hypotension Importance to Aging: This risk increases rapidly with age and resulted in 164,000 hospitalizations in 1994 alone.

Osteoporosis and Bone Fracture Risk importance to Aging Research: The injuries from falls in the elderly are often manifested in bone fractures, which can lead to hospitalization and subsequent decline.

Nutrition and Vitamin D Research Importance to Aging: Insufficient exposure to the ultraviolet light in sunshine, through immobility or confinement whether on Earth or in a spacecraft, leads to decreased production of Vitamin D. This can increase the risk of diseases such as Alzheimer's and diabetes in the elderly, as well as depression, cancer, impaired physical performance, weakened immune function and decreased bone health which the elderly on Earth may have in common with astronauts on long, hazardous space missions.

Reduced Immunological Response importance to Aging: Immune system dysregulation is observed in both the elderly and astronauts during space flight. Innate immunity, the first line response to bacterial infections, is diminished in up to 20% of adults over age 65 who do not develop fevers in response to infections.

Noninvasive Behavioral Health Techniques importance to Aging: There are neurobehavioral and psychosocial factors that influence both the elderly and astronauts including risk of depression, sleep disorders, and cognitive function changes that can benefit from noninvasive techniques.

Effectiveness: What is the impact and/or application of this research to older persons?

Balance and Gait Control Results/Application of Research: Some of these techniques were applied to community-dwelling participants in a study associated with John Glenn's second space flight in 1998. The techniques applied in spaceflight could also be used in rehabilitation of patients with balance disorders, and for fall prevention training in the elderly.

Orthostatic Hypotension Practical Applications of Research: The most beneficial discovery in this area for astronauts and the elderly in the form of a warning. It came from a study that determined that Midodrine may interact badly with Promethazine (Phenergan ®), a medication used to control severe motion sickness whether due to space flight, radiation treatment, chemotherapy or surgical anesthesia. The effects may include twitching, anxiety and even violent behavior.

Osteoporosis and Bone Fracture Risk Results/Application of Research: NASA has just started funding a collaborative study with the Mayo Clinic to evaluate factors such as ethnicity, gender, genetics, age, nutritional status and fitness level and their importance on bone health in astronauts. This will have obvious implications for the elderly.

Nutrition and Vitamin D Results/Application of Research: NASA-funded research evaluated the ability of diet modification to mitigate bone loss, based on extensive ground research (N1-N2). Vitamin D is a dietary factor related to diseases such as cancers and diabetes, as well as bone health, in people on Earth and in space. The 2005 USDA Dietary Guidelines for Americans specifically called out the need for supplementation of vitamin D in at risk populations, including the elderly, and those with insufficient exposure to the ultraviolet light in sunshine, due to limited mobility and confinement in the elderly (ref. VD-3), or to being in a small spacecraft without many windows that protects astronauts from the unfiltered sun (refs. VD-1 to VD-2). On-going NASA research will determine safe and effective vitamin D dosing regimens in individuals with insufficient ultraviolet light exposure.

Reduced Immunological Response Results/Application of Research: A recent study has demonstrated that the elderly suffer higher levels of latent herpesvirus reactivation, which is usually associated with reduced immune function. NASA studies of astronaut immunity during space flight have revealed similar observations (ref. I-7). The flight of John Glenn (age 77) in 1998 specifically revealed differences in white blood cells and in stress hormone levels between him and his younger crewmates.

Noninvasive Behavioral Health Techniques Results/Application of Research: NASA is funding research at the National Space Biomedical Research Institute designed to address behavioral health risks including: 1) use noninvasive near-infrared neuro-imaging technology to identify biomarkers indicating a tendency to depression, 2) development of speech monitoring technologies that can indicate damage to portions of the central nervous system that can result from radiation exposure or hypoxia (in astronauts) or the early stages of Alzheimer's disease (in the elderly), 3) use of blue light to maintain circadian rhythms and alertness, and 4) developing systems that can provide feedback to astronauts on long, stressful missions to warn them if their cognitive function is changing, so they can seek appropriate treatments and counseling, which could also be made available to the elderly on Earth.

Innovativeness: Why is this research exciting or newsworthy?

In many forms and areas, NASA's research into the causes of maladaptation to weightlessness, and the development of treatments and preventions for them, may offer significant utility and importance for the elderly. The opportunity to provide tangible benefits to the segment of the population who initiated and supported the development of America's exploration of space is a demonstration of the potential of space exploration to improve the lives of all Americans while extending our reach further into the universe.