Acronym: CCISS

Title: Cardiovascular and Cerebrovascular Control on Return from ISS

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Sponsoring Agency: National Aeronautics and Space Administration (NASA)

Increment(s) Assigned: 15, 16, 18, 19, 20

Brief Research Summary (PAO): Cardiovascular and Cerebrovascular Control on Return from ISS (CCISS) will study the effects of long-duration spaceflight on crew members' heart functions and their blood vessels that supply the brain. Learning more about the cardiovascular and cerebrovascular systems could lead to specific countermeasures that might better protect future space travelers. This experiment is collaborative with the Canadian Space Agency.

Research Summary:

- For crewmembers' health, the need to be able to maintain blood pressure immediately after returning to Earth is essential.

- To obtain information on the baroreflex stability (blood pressure regulation) of ISS crewmembers an electrocardiogram and blood pressure data will be gathered prior to flight, inflight and postflight.

- In addition to the electrocardiogram and blood pressure data, an LBNP session will be conducted pre- and post-flight. The level of lower body suction will be gentle and short duration. The resulting stress on the body will be less than simply standing up in 1G.

- Other data collected during the LBNP session will be brain, brachial artery, and aortic blood flows. These flows are all done non-invasively with ultrasound. Arm vein pressure, blood pressure, electrocardiogram, breathing rate and the amount of carbon dioxide expired will also be measured.

- The data gathered during this investigation will lead to countermeasures to help crewmembers maintain sufficient blood pressure after long duration missions.

- This study will provide a basis for studies of individuals who are susceptible to fainting in the upright posture.

Detailed Research Description: The ability to maintain arterial blood pressure and brain blood flow immediately on return to Earth after prolonged space flight is one of the most critical factors for crew health and safety. Although the heart rate component of the arterial baroreflex is impaired on return from space, this is not in itself a critical issue as crewmembers who are about to faint normally have markedly elevated heart rate. Rather, their inability to maintain blood pressure appears to be related to inadequate increases in peripheral vascular resistance. This study will incorporate a new methodology that determines the simultaneous gains of the arterial and cardiopulmonary baroreflexes in the control of peripheral vascular resistance.

A series of six objectives have been identified that will allow a more complete understanding of any alteration in cardiovascular or cerebrovascular responses following long duration space flight. The first two will be addressed with very brief inflight experiments that monitor the heart rate component of the arterial baroreflex and the relationship between heart rate variability and physical activity as indicators of autonomic nervous system control. The remaining objectives will be evaluated during a 32-minute test protocol conducted pre- and immediately postflight. During this test period, the central vein compliance will be monitored. In addition, the arterial and cardiopulmonary baroreflexes will be monitored during experiments that use an optimized schedule of lower body negative pressure (LBNP) to manipulate arterial and central venous blood pressures. Within these same experimental sessions assessments of cerebrovascular responsiveness to changes in arterial blood pressure and arterial partial pressure of carbon dioxide (CO_2). It is anticipated that the ability to regulate blood pressure through baroreflex control of blood vessel constriction will be impaired after space flight. Similarly, it is expected that brain blood flow will be more sensitive to changes in arterial blood CO_2 and thus will not be as tightly regulated after space flight.

Project Type: Payload

Images and Captions:

Continuous Blood Pressure Device (CBPD) is a non-invasive device that uses plethysmography to measure blood pressure at the finger. Image courtesy of NASA.

Del Mar DigiCorder Model 483 Holter Monitor, continuously records ECG of ambulatory subject. Image courtesy of NASA.

MiniMitter Actiwatch is a small wrist or ankle-worn device that simultaneously detects body movement. Image courtesy of NASA.

The LBNP Chamber is a simple box design that facilitates entry by the astronaut - a neoprene skirt is secured around the waist and to the front opening of the Chamber. A standard vacuum cleaner controlled by variable voltage output rheostat regulates suction. Image courtesy of NASA.

NASA Image: ISS015E14753 - Expedition 15 Flight Engineer Clay Anderson is seen here working with an Actiwatch reader and computer during hardware setup for the Cardiovascular and Cerebrovascular Control on Return from the International Space Station (CCISS) experiment in the U.S. Laboratory, *Destiny*. The Continuous Blood Pressure Device (CBPD) is also visible in the background.

Operations Location: ISS Inflight

Brief Research Operations:

- Crewmembers will wear a Holter monitor and Continuous Blood Pressure Device for the Baro Study.
- Crewmembers will also wear the Holter monitor and two Actiwatches to complete the 24-hr Heart Rate Studies.

Operational Requirements: A total of 6 long-duration crewmembers are needed as subjects for the experiment. Baseline data for each subject will be collected at L-30 (Launch minus 30 days) for the Baro Study, 24-hr Heart Rate Study, and LBNP protocol. Baseline data will also be collected at R+1 (Return plus 1 day) for the Baro and 24-hr Heart Rate Studies and R+0 (U.S.) or R+1 (Russia) for the LBNP protocol.

Operational Protocols: Crewmembers will perform CCISS operations on FD+14 (+7) (Flight Day 14) and R-14 (-7). During Day 1 operations the crewmember will don and activate the Actiwatches, CBPD, and Holter Monitor and conduct a 10-minute Baro Study. During the Baro Study, the crewmember will breathe normally for 5 minutes and then breathe at a set pace for 5 minutes. The crewmember will doff the CBPD after the conclusion of the Baro Study. The Actiwatch and Holter Monitor are worn to collect data during the 24-hr Heart Rate Study. Day 2 operations consist of the crewmember downloading data from the 24-hr Heart Rate Study and doffing the hardware.

Review Cycle Status: PI Reviewed

Category: Human Research and Countermeasure Development for Exploration

Sub-Category: Cardiovascular and Respiratory Systems

Space Applications: The information derived from this study will help to better understand the effects of spaceflight on cardiovascular and cerebrovascular functions. By gaining increased knowledge of the specific components of the cardiovascular and cerebrovascular systems that deviate from the normal Earth-baseline responses, it will be possible to recommend specific countermeasures that might better protect future space travelers from complications that could put them at risk on return to the effects of gravity as will occur on re-entry to Earth or landing on the moon or Mars.

Earth Applications: The risk of fainting and falling is increased in older adults. Falls are very serious because they often cause fracture of the hip which is a major cause of prolonged disability, loss of independence and unfortunately for a high percentage of individuals the complications from the fracture will lead to death. Gaining improved knowledge of the mechanisms of loss of blood pressure and the warning signs that might predict risk will reduce the incidence of fainting and falls in the elderly.

Manifest Status: Continuing

Supporting Organization: Canadian Space Agency (CSA)

Previous Missions: Increment 15 was the first mission for CCISS.

Related Publications:

Sigaudo-Roussel, D., Maillet, A., Custaud, M.A., Frutoso, J., Güell, A., Kaspranski, R., Hughson, R.L., Gharib, C., and Fortrat, J.O. Heart rate variability after prolonged spaceflights. European Journal of Applied Physiology. 2002 ; 86: 258-265.

Edwards, M.R., Z.L. Topor and R.L. Hughson. A new two-breath technique for extracting the cerebrovascular response to arterial carbon dioxide. American Journal of Physiology-Regulatory, Integrative and Comparative Physiology. 2003 ; 284: R853-R859.

O'Leary, D.D., J.K. Shoemaker, M.R. Edwards, and R.L. Hughson. Spontaneous beat-by-beat fluctuations of total peripheral and cerebrovascular resistance in response to tilt. American Journal of Physiology-Regulatory, Integrative and Comparative Physiology. 2004 ; 287: R670-R679.

Hughson, R.L., D.D. O'Leary, J.K., Shoemaker, D.C., Lin, Z.L., Topor, M.R., Edwards, and MP Tulppo. Searching for the vascular component of the arterial baroreflex. Cardiovasc. Engin. 2004 ; 4: 155-162.

Shoemaker, J.K., Hughson, R.L. and Sinoway, L.I. Gender affects sympathetic neurovascular control during postural stress. The Journal of Gravitational Physiology. 2002 ; 9: P83-P84.

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Hughson, R.L., Shoemaker, J.K., Arbeille, Ph., D.D. O'Leary, Pizzolitto, K.S., and Hughes, M.D. Splanchnic and peripheral vascular resistance during lower body negative pressure (LBNP) and tilt. The Journal of Gravitational Physiology. 2004 ; 11: P95-P96.

Hughson, R.L., Shoemaker, J.K. Vascular health in space. The Journal of Gravitational Physiology. 2004; 11: P71-P74.

Hughson, R.L., Kerbeci, P., Arbeille, Ph., Mattar, L., and Shoemaker, JK. WISE-2005: Integrative cardiovascular responses with LBNP during 60-day bed rest in women. The Journal of Gravitational Physiology. 2005 ; 12: P61-P62.

Web Sites:
University of Waterloo
CCISS-Canadian Space Agency
International Space Station Medical Project (ISSMP)

Related Payload(s): Integrated Cardiovascular

Last Update: 10/20/2008