Acronym: Nutrition

Title: Nutritional Status Assessment

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Sponsoring Agency: National Aeronautics and Space Administration (NASA)

Increment(s) Assigned: 14, 15, 16, 17, 18, 19, 20

Brief Research Summary (PAO): Nutritional Status Assessment (Nutrition) is the most comprehensive inflight study done by NASA to date of human physiologic changes during long-duration space flight; this includes measures of bone metabolism, oxidative damage, nutritional assessments, and hormonal changes. This study will impact both the definition of nutritional requirements and development of food systems for future space exploration missions to the Moon and Mars. This experiment will also help to understand the impact of countermeasures (exercise and pharmaceuticals) on nutritional status and nutrient requirements for astronauts.

Research Summary:

- Currently a Clinical Nutritional Assessment is a medical requirement for all U.S. astronauts. This includes collection of blood and urine samples preflight and postflight. Nutrition will expand this protocol by capturing inflight samples and an additional postflight sample. Furthermore, additional biochemical measurements will be included for samples from all sessions, including additional markers of bone metabolism, vitamin status, and hormone and antioxidant/oxidative damage tests.

- The results will be used to better understand the efficacy of countermeasures (e.g. exercise or pharmaceuticals) as well as characterize their impact on nutritional status and nutrient requirements.

Detailed Research Description: The Clinical Nutritional Assessment profile (MR016L) has been implemented with two Mir and all ISS US crewmembers and nominally consists of two pre-flight and one post-flight analysis of nutritional status, as well as an in flight assessment of dietary intake using a Food Frequency Questionnaire. This project seeks to expand the MR016L testing in three ways:

- Include in flight blood and urine collection
- Expand nominal testing to include additional normative markers of nutritional assessment
- Add a return plus 30-day (R+30) session to allow evaluation of post-flight nutrition and implications for rehabilitation

To date, it has not been possible to assess nutritional status during flight because blood and urine could not be collected, stowed frozen, and returned during ISS missions. The altered nutritional status findings for several nutrients postflight are of concern, and require the ability to monitor the status of these nutrients during flight to determine if there is a specific impetus or timeframe for these decrements. In addition to monitoring crew nutritional status during flight, in-flight sample collection would allow for better assessment of countermeasure effectiveness. This protocol is also designed to expand the current MR016L to include additional normative markers for assessing crew health and countermeasure effectiveness, and extend the current protocol to include an additional postflight blood and urine collection (R+30). Several nutritional assessment parameters are altered at landing, but it is not known whether the changes are still apparent after 30 days.

Additional markers of bone metabolism (helical peptide, OPG, RANKL, IGF-1) will be measured to better monitor bone health and countermeasure efficacy. New markers of oxidative damage will be measured (8-iso-prostaglandin F2a, protein carbonyls, oxidized and reduced glutathione) to better assess the type of oxidative insults during space flight. The array of nutritional assessment parameters will be expanded to include serum folate, plasma pyridoxal 5'-phosphate, and homocysteine to better understand changes in folate, vitamin B6 status, and related cardiovascular risk factors during and after flight. Additionally, stress hormones and hormones that affect bone and muscle metabolism will also be measured (DHEA, DHEA-S, cortisol, testosterone, estradiol). This additional assessment would allow for better health monitoring, and more accurate recommendations to be made for crew rehabilitation. These additional parameters were added due to the recommendation of an extramural panel that met to define nutritional standards and requirements in 2005.

The protocol entails:

- Collection of blood and urine samples preflight, postflight and inflight
- Biochemical analysis of these samples at the Johnson Space Center using standard laboratory methods
- Statistical analysis of the analytical results to detect differences in nutritional status

Project Type: Payload

Images and Captions:

The Nutrition blood and urine collection kits for inflight sample collection on board ISS. Image courtesy of NASA, Johnson Space Center.

NASA Image: ISS007E07832 - Expedition 7 Science Officer Ed Lu prepares to add garlic paste to a food packet while preparing a meal in the galley area of the Zvezda Service Module. A can of green peas and eating utensils are visible on the table in front of him. A balanced meal is important to the overall nutrition and health of the crew during long duration exploration.

NASA Image: ISS007E06700 - Food cans and packets floating freely on board ISS during Expedition 7. A balanced meal is important to the overall nutrition and health of the crew during long-duration exploration.

NASA Image ISS013E13224 - Flight engineer Jeffrey Williams unpacks bags containing food and containers in the U.S. Laboratory, Destiny hatch area. A balanced meal is important to the overall nutrition and health of the crew during long duration exploration.

Screenshot of ISS Expedition 14 Commander Michael Lopez-Alegria preparing the centrifuge for the blood samples taken for the Nutrition investigation. The blood sample can be seen in the test tube at the lower left of the image.

Screenshot of ISS Expedition 14 Commander Michael Lopez-Alegria standing in front of the centrifuge after the insertion of the test tubes containing the blood samples drawn for the Nutrition investigation.

NASA Image: ISS014E05124 - Expedition 14 Commander and NASA Astronaut Michael Lopez-Alegria inserts blood and urine samples into the Minus Eighty Degree Laboratory Freezer for ISS (MELFI) until they can be returned to Earth for analysis.

In this screenshot, ISS Expedition 14 Commander Michael Lopez-Alegria labeling a urine collection syringe (lower right of image) that will be used to remove urine from the Urine Collection Device (UCD), floating in the foreground of the image.

NASA Image: ISS014E13963 - Astronaut Suni Williams, Expedition 14 Flight Engineer, prepares a laptop in the Human Research Facility-2 (HRF-2) for data entry during a blood draw as part of the Nutritional Status Assessment (Nutrition) study in the Destiny laboratory module.

NASA Image: ISS014E17530 - Astronaut Michael Lopez-Alegria, Expedition 14 Commander, prepares a urine sample for the Nutrition investigation. The sample is preserved in the Minus Eighty Lab Freezer ISS (MELFI) in the Destiny laboratory module.

NASA Image: ISS015E10554 - Astronaut Sunita L. Williams, Expedition 15 flight engineer, loads test samples in the Human Research Facility 2 (HRF-2) Refrigerated Centrifuge as a part of the Nutritional Status Assessment (Nutrition) experiment. The results of the Nutrition experiment will be used to better understand the time course effects of space flight on human physiology.

NASA Image: ISS015E10555 - Astronaut Suni Williams, Expedition 14 and 15 Flight Engineer, configures her blood samples in the Human Research Facility-2 (HRF-2) Refrigerated Centrifuge, preparing to separate the cellular and liquid components of blood to facilitate sample analysis on the ground.

Operations Location: ISS Inflight

Brief Research Operations:

- Blood and urine samples are collected preflight, inflight and postflight from astronauts.
- Inflight, crewmembers will perform five 24-hour urine collections spread throughout their mission onboard the ISS.
- The blood samples are processed in the Human Research Facility (HRF) refrigerated centrifuge and all samples (blood and urine) are stored in the Minus Eighty-Degree Laboratory Freezer for ISS (MELFI).
- Upon return to Earth the samples are analyzed for vitamins, minerals and other nutritional/physiological markers.

Operational Requirements: Samples will be collected on 12 crewmembers. Sample sessions will occur on Flight Days 15 (+/-5 days), and 30, 60, 120, 180 (+/-14 days). Samples will be returned to Earth for analysis within a year of the sampling date.

Operational Protocols: The crew subject will draw blood and collect urine samples on the five days designated. The blood samples will be processed in the refrigerated centrifuge and then stored in the MELFI. Urine will be collected void-by-void for twenty-four hours and samples stored in the MELFI.

Review Cycle Status: PI Reviewed

Category: Human Research and Countermeasure Development for Exploration

Sub-Category: Integrated Physiology

Space Applications: The inclusion of in flight blood/urine collections and expansion to include additional parameters to better monitor nutritional status is required to better understand the role of nutrition in bone health, changes in body composition, oxidative damage, and defining nutritional requirements for space flight. Maintaining and monitoring nutritional status are important for ensuring crew health during space flight, and will be critical as we embark on longer duration exploration missions in the future.

Earth Applications: Increased understanding of the role of nutrition in physiological adaptation to space flight has broader application on Earth, for one example, relationship of nutrition to bone loss has potential value for patients suffering bone loss on Earth.

Manifest Status: Continuing

Supporting Organization: Exploration Systems Mission Directorate (ESMD)

Previous Missions: A subset of this protocol, Clinical Nutritional Status Assessment Medical Requirement has been performed on two *Mir* missions and ISS Expeditions 1 - 13.

Related Publications:

Smith S, Zwart SR, Block G, Rice BL, Davis-Street JE. The nutritional status of astronauts is altered after long-term space flight aboard the International Space Station. Journal of Nutrition. 2005 ;135(3):437-443.

Smith SM, Davis-Street JE, Rice BL, Nillen JL, Gillman PL Block G. Nutritional status assessment in semi-closed environments: ground-based and space flight studies in humans. Journal of Nutrition. 2001 ;131:2053-2061,

Smith SM, Davis-Street JE, Fesperman JV, Smith MD, Rice BL, Zwart SR. Nutritional assessment during a 14-d saturation dive: the NASA Extreme Environment Mission Operations V project. Journal of Nutrition. 2004 ;134:1765-1771.

Smith SM, Wastney ME, O'Brien KO, Morukov BV, Larina IM, Abrams SA, Davis-Street JE, Oganov V, Shackelford LC. Bone Markers, Calcium Metabolism, and Calcium Kinetics During Extended-Duration Space Fligt in the Mir Space Station. Journal of Bone Mineral Research. 2005 20(2); 208-218.

Paddon-Jones D. Interplay of Stress and Physical Inactivity on Muscle Loss: Nutritional Countermeasures. The Journal of Nutrition. 2006 ;136: 2123-2126.

Web Sites:
Human Adaptation and Countermeasures Division

Related Payload(s): Clinical Nutrition Assessment

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