Urinary Sulfate can Predict Changes in Bone Resorption During Space Flight

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Abstract

Mitigating bone loss is critical for space exploration, and diet can play a major role in this effort. Previous studies showed that dietary composition could influence bone resorption during bed rest. In this study we examined the role of dietary intake patterns in bone mineral loss in astronauts during space flight. Crewmembers were asked to consume, for 4 days at a time, prescribed menus with either a low (0.3-0.6 g/mol) or high (1.0-1.3 g/mol) ratio of animal protein to potassium (APro:K). Menus were developed for each crewmember, and were designed to meet both crew preferences and study constraints. Intakes of energy, total protein, calcium, and sodium were held within ± 5% between the 2 diets. The order of the treatment sessions was randomized, with each session repeated in the same order in each subject. Menus were alternated in a randomized crossover fashion, such that there was one high and one low APro:K session before flight and two of each menu during flight. The high and low APro:K menus provided similar intakes of total energy (based on WHO requirements), total protein, sodium, magnesium, phosphorus, and calcium. A high ratio of dietary animal protein to potassium results in a larger urinary n-telopeptide (NTX) excretion during flight when either a high or low ratio of dietary animal protein to potassium (APro:K) was consumed. Urinary calcium was higher when high APro:K diets were consumed. Urinary calcium was higher when high dietary APro:K diets were consumed. There is a significant amount of variability in the data. While we continue to evaluate the data set (pending complete data sets for all 17 subjects), there are many potential factors. Dietary factors such as total energy, protein (% of kcal), and sodium are being considered, along with other factors, including atmospheric CO₂, exercise, inflammation, and gender. All subjects and samples have landed and post-flight data collections and sample analyses are pending for the last 3 subjects.

Methods

Subjects (n=14, 10 male and 4 female) were astronauts on International Space Station Expeditions 22-40 (missions of 124 – 193 d duration, flown between 2009 and 2014). Subjects were 48 ± 6 y at the time of launch. Their average flight duration was 159 ± 20 d. The protocol was reviewed and approved by the NASA Johnson Space Center Institutional Review Board, and the Japanese Aerospace Exploration Agency and the European Space Agency Medical Boards. Written informed consent was obtained from all subjects before they participated in the study.

The crewmembers were asked to consume prescribed menus for 4-d sessions with either a low (0.3-0.6 g/mol) or high (1.0-1.3 g/mol) ratio of animal protein to potassium (APro:K) before and during flight (two 4-d sessions preflight and four 4-d sessions during flight). The menus were alternated in a randomized crossover fashion, such that there was one high and one low APro:K session before flight and two of each menu during flight. The high and low APro:K menus provided similar intakes of total energy (based on WHO requirements), total protein, sodium, magnesium, phosphorus, and calcium. A high ratio of dietary animal protein to potassium results in a larger urinary n-telopeptide (NTX) excretion during flight when either a high or low ratio of dietary animal protein to potassium (APro:K) was consumed. Urinary calcium was higher when high dietary APro:K diets were consumed. There is a significant amount of variability in the data. While we continue to evaluate the data set (pending complete data sets for all 17 subjects), there are many potential factors. Dietary factors such as total energy, protein (% of kcal), and sodium are being considered, along with other factors, including atmospheric CO₂, exercise, inflammation, and gender. All subjects and samples have landed and post-flight data collections and sample analyses are pending for the last 3 subjects.

Background

While bone mineral loss associated with space flight is likely predominantly triggered by the lack of weight bearing, the nature of this loss is multifactorial. Resistive exercise can mitigate decrements in bone mineral density observed after flight (1, 2), and it is likely that diet can be optimized to further protect bone. It is clear from the scientific literature that a suboptimal diet can exacerbate bone loss in healthy subjects.

Dietary components can influence endogenous acid production due to the presence of acid- and base precursors. Endogenous acids include sulfuric acid produced from sulfur-containing proteins and amino acids. The quantity of sulfuric acid generated is reflected in potassium intake can be used to estimate the content of base precursors in the diet.

Summary


