NASA has focused its future on exploration class missions including the goal of returning to the moon and landing on Mars. With these objectives, humans will experience an extended exposure to the harsh environment of microgravity and the associated negative effects on all the physiological systems of the body. Exposure to microgravity affects human physiology and results in changes to the urinary chemical composition during and after space flight. These changes are associated with an increased risk of renal stone formation. The development of a renal stone would have health consequences for the crewmember and negatively impact the success of the mission. As of January 2007, 15 known symptomatic medical events consistent with urinary calculi have been experienced by 13 U.S. astronauts and Russian cosmonauts.

Previous results from both MIR and Shuttle missions have demonstrated an increased risk for renal stone formation. These data have shown decreased urine volume, urinary pH and citrate levels and increased urinary calcium. Citrate, an important urinary inhibitor of calcium-containing renal stones binds with calcium in the urine, thereby reducing the amount of calcium available to form calcium oxalate stones. Urinary citrate also prevents calcium oxalate crystals from aggregating into larger crystals and into renal stones. In addition, citrate makes the urine less acidic which inhibits the development of uric acid stones. Potassium citrate supplementation has been successfully used to treat patients who have formed renal stones. The evaluation of potassium citrate as a countermeasure has been performed during the ISS Expeditions 3-6, 8, 11-13 and is currently in progress during the ISS Expedition 14 mission.

Together with the assessment of stone risk and the evaluation of a countermeasure, this investigation provides an educational opportunity to all crewmembers. Individual urinary biochemical profiles are generated and the risk of stone formation is estimated. Increasing fluid intake is recommended to all crewmembers. These results can be used to lower the risk for stone formation through lifestyle, diet changes or therapeutic administration to minimize the risk for stone development. With human presence in microgravity a continuing presence and exploration class missions being planned, maintaining the health and welfare of all crewmembers is critical to the exploration of space.
RENAL STONE RISK DURING SPACE FLIGHT:
ASSESSMENT AND COUNTERMEASURE VALIDATION

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Introduction

NASA has focused its efforts on exploration class missions, including the goal of returning to the moon and establishing a base. With these endeavors, humans will experience extended exposure to the unique environment of microgravity. Exposure to microgravity affects human physiology and results in changes to the urinary chemical composition during and after space flight. These changes are associated with an increased risk of renal stone formation. The development of a renal stone would have serious health consequences for the crewmember and negatively impact the success of the mission. As of January 2007, 15 known symptomatic medical events consistent with urinary calculi have been experienced by U.S. astronauts and Russian cosmonauts.

Citrates, an important urinary inhibitor of calcium oxalate stones, binds with calcium in the urine, thereby reducing the amount of calcium available to form calcium oxalate stones. Citrates also prevent calcium oxalate crystals from adhering and forming stones. Potassium citrate (KCIT) supplementation has been successfully used to treat terrestrial patients who have formed renal stones. The evaluation of potassium citrate in microgravity has been performed during the ISS Expeditions 3-6, 8, 11-13 and is currently in progress during the ISS Expedition 14 mission. Human presence in microgravity is a continuing presence and the evaluation of microgravity urinary environment is critical to the success of space missions.

Methods

> 24-hr urines collected pre-, in- and postflight phases of the mission
> Food, fluid, exercise, and medications recorded before and during the urine collection period
> Ingestion of 2 potassium citrate (KCIT) pills daily (with the last meal of the day) from L-3 days to R+14 days
> Biochemical analysis of urine samples for urinary factors associated with stone formation
> Dietary analysis completed to assess environmental influences on the urinary biochemistry

Significant Findings

> Urinary citrate levels were maintained throughout the pre- and postflight periods
> Increased urinary pH levels reduced the risk of uric acid stones
> KCIT subjects showed decreased in-flight and post-flight calcium oxalate supersaturation
> Urinary volume is the strongest predictor of renal stone risk

Educational value of this study to crewmembers was evident by the increased urinary volume and pH. Together with the assessment of stone risk and the evaluation of a countermeasure, this investigation provides an educational opportunity to all crewmembers. Increasing fluid intake is recommended to all crewmembers and can be seen by the increased urinary volume in the ISS crewmember as compared to Mir crewmembers. Prediction of those crewmembers that will develop a renal stone is impossible at this time. Preflight assessment may identify those crewmembers that are at risk and enable measures that may be taken to reduce this risk.