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LONG-TERM STABILITY OF NUTRIENTS INSIDE AND OUTSIDE OF THE BODY ON LONG-DURATION SPACEFLIGHTS: A REVIEW OF SPACE AND GROUND-BASED STUDIES TRACKING NUTRIENTS FROM PREFLIGHT TO POSTFLIGHT

Abstract

Background: With the operating lifetime of the International Space Station extended, humans will be living in low Earth orbit for at least another 10 years[1]. Private and government agencies are also planning missions to land humans on the moon, asteroids and Mars. Such voyages will require astronauts to survive in space for at least 3 years[2] and foods must supply them with a stable source of nutrients. Even with proper nutritional intake, the cells of an astronaut must metabolize the food and uptake its nutrients to maintain health.

Objective: We follow the journey of nutrients in foods from pre-flight to post-flight and examine the stability of nutrients inside and outside of the body to identify how to increase nutrient stability during long-duration space flights while reducing mission costs. We review the literature to:

1. identify how nutrients in astronauts are monitored and measured pre-flight, in space and post-flight and discuss sources of error in these measurements;
2. discuss the preparation, packaging, storage, and consumption of food by astronauts along with the impact each step has on nutrient stability;
3. understand changes to human physiology that occur in space and their impact on metabolism;
4. examine space's impact on human psychology and the way this affects nutritional uptake, and;
5. discuss the costs associated with launching foods and devices to promote nutrient uptake.

While our primary focus is on long-duration spaceflight, results from short-duration spaceflights and ground-based studies are also presented to delineate the effects of microgravity on nutrient stability.

Conclusions: Many studies in the literature do not conduct control experiments and incorrectly attributed the change of nutrient levels in astronauts in space to the microgravity environment[2,3]. The small samples size of astronauts who have flown on long-duration spaceflights (>60 days[3]) is one challenge in nutrition studies since conflicting results are reported by investigators, such as the necessity of coupling nutrition and exercise to prevent the loss of bone mass in space[4]. We also examine technologies that produce food and nutrients in space and compare the quality of these nutrients to their counterparts on the ground. We identify future ground and space-based studies that must be carried out to better

understand nutrient stability on long-duration space missions. This work has meaning not just for space exploration, but also on long-duration arctic and deep-sea missions, and storing foods for emergency relief where nutrient stability is of paramount importance. [1]NASA Release 14-012; [2]JFS.74:H209-H217,2009; [3]J.Nutr.135:437-443,2005; [4]JBRM.27:1896–1906,2012.