Vitamin D Studies: From the Antarctic to the International Space Station

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Vitamin D is unique in that exposure to ultraviolet light allows the body to synthesize it from a precursor in the skin. Because the diet of most individuals includes few good natural sources of this vitamin, many people are dependent on sun exposure or supplements for most of their vitamin D requirement.

Vitamin D is critical for space travelers because they lack exposure to ultraviolet light and have an insufficient dietary supply of vitamin D. Despite the provision of vitamin D supplements to International Space Station crew members, the vitamin D status is consistently lower after flight than before and, in several crew members, decreased to levels considered clinically significant.

The most recognized role of vitamin D is its involvement in calcium metabolism. One of its major functions is to maintain normal blood levels of calcium and phosphorus. The typical gold-standard measurement for determining vitamin D status in the body is 25-hydroxyvitamin D, but 1,25-dihydroxyvitamin D is the active form of the vitamin in the body. The liver converts vitamin D to 25-hydroxyvitamin D, which is converted to 1,25-dihydroxyvitamin D in the kidney. From there, 1,25-dihydroxyvitamin D is transported by the circulatory system to target organs. Classic target organs include bone, intestine, and kidney.

Vitamin D has other functions besides those related to skeletal health. Functions that do not involve calcium metabolism include the role of 1,25-dihydroxyvitamin D as an important immune system regulator. In addition, vitamin D may inhibit development of autoimmune diseases including experimental inflammatory bowel disease, rheumatoid arthritis, multiple sclerosis, and type 1 diabetes.

We used Antarctica as a ground-based model for determining the optimal dose and metabolism of vitamin D because of the limited sunlight exposure there during the approximately 6-month winter period. The Antarctic science station model was successful as a ground-based analog for space flights in studies of behavior, immune response, and reactivation of latent viruses. Our studies in Antarctica showed that ground-based models of insufficient sun exposure are a valuable asset to clearly determine the optimal dose of vitamin D required to maintain circulating 25-hydroxyvitamin D at optimal levels.

We investigated the effectiveness of three different daily doses of vitamin D in maintaining serum 25-hydroxyvitamin D at 80 nmol/L with volunteers living in the Antarctic during the winter. While we found that 2,000 IU/d increased vitamin D status from baseline levels to about 70 nmol/L, we also found that compliance in taking the supplements was an issue. In the winter of 2009, we conducted a follow-up study at McMurdo Station in Antarctica to determine whether a weekly dose could be used as effectively as a daily dose. A secondary goal of this study was to investigate the effect of vitamin D status on immune system function. In collaboration with the Johnson Space Center (JSC) Microbiology Laboratory, we investigated latent virus reactivation in relation to the vitamin D status of individuals staying in Antarctica during the winter. Latent virus reactivation is also an established phenomenon in environments such as Antarctica and space flight.

In addition to studies being performed in Antarctica, we are completing an investigation at JSC to determine the kinetics of vitamin D metabolism in subjects taking different doses of a vitamin D supplement: 2,000 IU per day, 10,000 IU per week, or 50,000 IU per month. In collaboration with Dr. John Milner and his Nutritional Science Research Group in the Division of Cancer Prevention at the National Cancer Institute, Bethesda, Md., we are also testing how vitamin D affects gene expression, which may allow us to better understand the role of this vitamin in immune function.

Data from these ground-based experiments will enable us to provide space crews with evidence-based recommendations for vitamin D supplementation. The findings have implications not only for astronauts, but also for other persons with limited exposure to ultraviolet light, including polar workers and the elderly.

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