Vitamin D: From the Antarctic to the International Space Station to North America

Sara R. Zwart, *Universities Space Research Association*
Scott M. Smith, *Johnson Space Center*
James Locke, *Johnson Space Center*

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

The most recognized role of vitamin D is its involvement in calcium metabolism. Classic target organs include bone, intestine, and kidney. Deficiency of vitamin D will lead to bone diseases, such as rickets in children and osteomalacia in adults. In both cases, the vitamin D deficiency renders the body unable to absorb calcium from the diet—a process that depends on vitamin D. The body depletes bone calcium content to make calcium available to other parts of the body. Vitamin D is critical for space travelers because they lack exposure to ultraviolet light and have an insufficient dietary supply of vitamin D. Astronauts are provided 800 international units per day (IU/d) of vitamin D in supplements to make up for the deficiency; the dose is based on ground analog research.

A good model for studying vitamin D metabolism is Antarctica because of the limited sunlight exposure during the winter period, which lasts about 6 months. The Antarctic science station model has been used successfully as a ground-based analog for space flight in studies of behavior, immune response, and reactivation of latent viruses. The Nutritional Biochemistry Laboratory's (NBL's) experience conducting studies in Antarctica has shown that ground-based models of insufficient sun exposure are a valuable asset for clear determination of the optimal dose of vitamin D required to maintain optimal blood levels of 25-hydroxyvitamin D.

The NBL collaborated with the National Science Foundation to use the Antarctic winter as an analog for two investigations in recent years. In the first study, conducted in 2007, scientists evaluated the effectiveness of three different daily doses of vitamin D in maintaining serum 25-hydroxyvitamin D at 80 nanomoles per liter (nmol/L). Results revealed that 2,000 IU/d increased vitamin D status from baseline levels to about 70 nmol/L, but researchers also discovered that some of the study participants had difficulty complying with the instructions to take the supplement every day.

The NBL conducted the second study during the Antarctic winter in 2009 and found that a weekly dose (10,000 IU, once a week) of vitamin D supplement could be used as effectively as a daily dose. The researchers also found that the effects of stress, viral reactivation, and vitamin D status interact. That is, when biochemical markers of stress levels were high, a higher vitamin D status protected against reactivation of latent virus. Latent virus reactivation is also known to occur during space flight. Both studies revealed that body mass index had a significant effect on a person's response to vitamin D supplementation. A person with a higher body mass index requires more vitamin D to achieve the same blood concentration of vitamin D as someone with a lower body mass index.

In 2011, the Institute of Medicine (IOM) released a report on the reevaluation of vitamin D requirements for North Americans. The 2009 Antarctic publication was featured in the report, specifically in the area of studies that had minimal ultraviolet light—a confounding issue when considering vitamin D requirements. The IOM developed a dose-response curve using data from studies conducted in environments with minimal ultraviolet light, and based the new vitamin D recommendation on the lower confidence interval of that curve. The 2009 Antarctic study contributed three data points to that dose-response curve, and influenced the IOM's calculations and ultimate recommendation. Because the IOM panel had only the initial 2009 publication from which to work, NBL scientists went back to the full data set (and added the data from the second study) to determine whether the same curve could be generated. When all individual subject data were combined, the scientists found that, indeed, the IOM model held up well. However, as mentioned, body mass index affects vitamin D status and the response to intake of vitamin D. These data were published in a letter to the journal editor in 2011 in support of including more information to evaluate the dietary recommendations for Americans.

The data from these ground-based experiments will enable NASA to provide space crews with evidence-based recommendations for vitamin D supplementation. The space agency often points to the broader implications of its research, and this is a perfect example of how work done to better understand space flight literally played a part in establishing dietary recommendations for people across North America.