Space Life Sciences Research Highlights

Research on Recovery after Space Flight May Help Earth-Bound Patients Recover from Bed Rest

Anyone who has ever watched a space flight crew disembark knows that space flight affects leg muscle strength and coordination. Researcher T. Peter Stein wants to understand the metabolic processes that cause the returning crew member's wobbly walk upon return to Earth's gravity. Stein's goal is to find the right combination of exercise and diet to help flight crew members stay stronger and fitter during prolonged flights. His findings may one day help Earth-bound patients return to ordinary activities more quickly after a long period of bed rest.

All animals, including humans, maintain a balance between the energy they take in through the food they eat and the energy they expend in metabolic processes and the activities of living. When skeletal muscles responsible for maintaining upright posture and movement have less work to do than usual—as happens when someone is confined to bed for an extended period or spends an extended period in the microgravity environment of space flight—energy demands are significantly decreased.

Nonetheless, space flight experiments have shown that astronauts often return to Earth in a state of negative energy balance, that is, they have burned more calories than they have taken in through diet. Even with reduced demands on the muscles used for upright posture and walking, astronauts do not eat enough to match the energy they expend in their inflight exercise program and in carrying out their demanding duties aboard the spacecraft. Many researchers have speculated that the protein loss and muscle wasting occurring during space flight might be linked, in part, to this energy deficit. Losing body protein is dangerous for space flight crews, who must maintain their strength and coordination to cope with their challenging work and to be prepared to respond to emergencies.

Exercise is particularly important during space flight. Mission specialist Richard M. Linnehan exercises vigorously during STS-78, the Life and Microgravity Sciences mission.

T. Peter Stein of the University of Medicine and Dentistry of New Jersey had been studying metabolic responses to physiologic stress among injured people. He saw in the space flight program an opportunity to study healthy people subjected to the physiologic stresses of space flight. In an experiment conducted during the Life and Microgravity Sciences space shuttle mission (STS-78) in June 1996, Stein and his colleagues carefully measured the energy expenditure and energy intake of flight crew members and of healthy volunteers who were placed on complete bed rest for the same duration as the shuttle flight.

Both the space flight and bed rest components included exercise. The volunteers on bed rest were served a 2500-calorie daily diet with limited access to a snack basket, and any leftovers were weighed. The astronauts were free to choose what they wanted from among barcoded food items. By scanning the barcode when selecting the food item, the astronaut provided the researchers with an accurate measurement of intake. "A strict diet had been tried aboard Skylab to increase energy intake, but the crew didn't like that approach," says Stein.

Energy expenditure was measured in three ways: by measuring changes in body composition; by measuring body fat before and after the experiment; and by measuring the difference between energy intake and expenditure (using tagged isotopes in drinking water).

At the end of the experiment, the bed rest volunteers had neither gained nor lost weight. Their food intake had decreased to match their reduced levels of activity. The shuttle crew, however, was found to be in negative energy balance and had lost body fat. "Their food intake was short by about the amount of the energy requirements of the inflight exercise program," says Stein.

In a subsequent, longer experiment on the Russian Mir space station, Stein found that the energy deficit was enough to interfere with the body's ability to manufacture new proteins. "Protein synthesis is a crucial metabolic process, because it allows the body to replace muscle tissue as it breaks down," says Stein. "Over the three-month period, the crew lost weight, and protein synthesis decreased. The decrease in protein synthesis was larger than we expected from prior bed rest experiments, because the flight crew had an energy deficit."

Stein points out that the dietary shortfall and its effect on protein synthesis are worrisome not just because they may affect the flight crew's readiness while in space, but because they make the crew more vulnerable during the recovery period upon return to Earth. "The demands of the recovery period are enormous," says Stein. "Like bone, muscle takes about two weeks for every one week in space to recover lost mass and strength. With protein synthesis, what we see is a huge competition for protein resources beginning at landing. Protein is needed to preserve the remaining muscle and to replace what was lost. At the same time, protein is also needed to maintain host defenses. Unless there's a very big increase in dietary intake there aren't enough resources to go around. In fact, voluntary dietary intake is not increased at all over the preflight intake."

Stein wants the crew of the International Space Station to test some possible diet and exercise interventions to speed up the post-flight recovery process. His experiment—scheduled to be one of the first aboard the space station—also will look at the broader question of whether bone and protein loss continue for the duration of a long space flight, or whether the human body eventually adapts to the microgravity environment.

Under the auspices of the National Institutes of Health, Stein is already investigating whether medications or changes in diet and exercise can help with a similar Earth-based challenge: the period of transition when elderly patients return to activity after a long period of bed rest. "During the period of transition from bed rest to activity, patients experience the same competition for protein resources that affects flight crews, making them especially vulnerable to infections, disease, and injuries," he said. "The question is, how do you rehabilitate these patients successfully, and how do you prevent or minimize the loss of metabolic activity that results from this competition for protein resources during the transition?"

Physiological data from John Glenn's historic flight on a recent shuttle mission may provide useful clues. "Unfortunately, though, he was just one such subject," said Stein. "It would be useful to study more people of advanced age, to determine how the less plastic system of the older person recovers from the metabolic stresses of space flight."

References

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