National Aeronautics and Space Administration

Exercise Countermeasures Laboratory (ECL) in the News

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PHOTOS COURTESY OF NASA

John Byard runs on the Standalone Zero Gravity Locomotion Simulator at the University of Texas Medical Branch at Galveston, Texas, in January. James Brent, right, operates the device.

HANG TIME

Treadmill developed at NASA Glenn helps astronauts prepare for missions into space

Chrissy Kadlecik
The Chronicle-Telegram

Ever wonder what astronauts do all day suspended in weightlessness?

Don't think they're simply floating through their days in space, because not even living in zero gravity gets them off the hook when it comes to daily exercise.

In fact, NASA is using a new treadmill that allows people to run while suspended horizontally to help astronauts prepare for long missions to the moon and beyond.

A team of engineers at NASA's Glenn Research Center in Cleveland built the Standalone Zero Gravity Locomotion Simulator to imitate conditions astronauts experience while exercising in space, which is critical to counteract the harmful health effects of long-duration space travel, promoting astronauts' well-being and mission success.

On the International Space Station, crew members exercise up to two and a half hours daily to help counter the physiological effects — including aerobic deconditioning, muscle atrophy and bone loss — of space flights, said Gail Perusek, project manager for Exercise Countermeasures at Glenn.

The treadmill simulates zero gravity by suspending human test subjects horizontally to remove the torso, head and limbs from the normal pull of gravity so they are neutrally buoyant, Perusek said.

"The treadmill is oriented vertically, so just like they do on orbit when the crew members run on the treadmill on the Space Station, they wear an exercise harness, which is a lot like a backpack harness with shoulder straps and waist belt, and they are pulled to the treadmill so they can run or walk," Perusek said.

The forces against a test subject's feet are precisely controlled and can mimic conditions of zero gravity in low Earth orbit or conditions on the moon, which has one-sixth of Earth's gravity. In addition to simulating exercise protocols, the device may be used to monitor the physiological effects of spacewalking.

NASA is sending astronauts on six-month missions to the International Space Station and plans to launch humans on missions to the moon by 2020. Crew members will benefit from data NASA gathers from bed-rest studies conducted with the device. NASA's Johnson Space Center in Houston will manage the studies, which will be conducted at the University of Texas Medical Branch in Galveston, Texas. NASA will use the Locomotion Simulator to develop improved exercise routine for astronauts during space flight.

Marsha Nall, manager of the Human Research Program at NASA Glenn, said the bed-rest studies can simulate what a person would experience in microgravity.

"We can then investigate with the proper exercise device and the proper prescription if we are able to maintain the astronaut's health both from a cardiovascular and from a muscle and bone standpoint the way we would like to on orbit," Nall said. "These studies give us the opportunity, in a much less expensive way, to develop devices and exercise prescriptions for crew health which we then ultimately implement on orbit."

The exercise component to space flight is becoming more important as missions lengthen and scientists have found that the exercise modality and the exercise prescriptions being implemented on the Space Station are not as effective as they would like, Nall said.

"We are continually looking for how we can make it better. How can we make exercise more efficient? How can we provide better exercise devices and better exercise protocol?" she said. "Because even though the crew is exercising in their prescribed amount with the devices that are available on orbit, which include cardiovascular and resistive devices, we are still seeing losses of bone and muscle that are not appropriate to maintain the health and performance that we need for astronauts."

The Cleveland Clinic collaborated closely with NASA in the development of the treadmill and is conducting bed rest studies with a similar device to understand how exercise during simulated space flight affects the muscles and bones.

"We are very proud of the collaborative effort this team put forth to develop this system," Perusek said. "It required interdisciplinary expertise in engineering, controls and biomechanics, and we are confident it will facilitate valuable research for years to come.

"We've gotten very positive feedback from the astronauts that we've had that have come to visit us at Glenn and have run on our version of the simulator and they think it is a great tool that can provide a lot of good information and definitely a good test bed for research studies that are going to lead to better exercise devices and protocol."

Contact Chrissy Kadlecik at accent@chronicleit.com or (440) 329-7144.

The Standalone Zero Gravity Locomotion Simulator team at NASA Glenn Research Center in Cleveland. Front row, from left: Michael Rossiter, Steve Guzik, Dan Haas and Mark Savina. Back row, from left: Kelly Gilkey, Gail Perusek, Harold McKenzie, Nelson Morales and Christopher Sheehan.

CES Corporate Spotlight

NASA Glenn Research Center

Walking on Air: NASA's Floating Treadmill

On the space station, astronauts are like superheroes. They twirl and flip as easily as Olympic gymnasts and can hoist more weight than power lifters.

Living in space is not a dream come true; but over time it can cause an astronaut's bones to deteriorate. As NASA prepares to send humans back to the moon and eventually beyond, researchers are looking for new ways to keep astronauts' bones healthy and strong.

To do so, a team of engineers from NASA's Glenn Research Center and The Cleveland Clinic Foundation have developed a new treadmill that simulates the space environment. They'll begin testing with human participants in early spring.

The information they gather will help NASA design better exercise equipment and develop exercise routines for astronauts. It also could help doctors treat and prevent osteoporosis, a disease that threatens 44 million Americans.

Microgravity and bone loss

In the absence of gravity, human bones don't have to perform their primary function of supporting the body's weight. As a result, space station astronauts experience disuse osteoporosis, a type of bone loss common in immobile patients.

The space station is outfitted with special exercise equipment designed to counteract this and other physiological changes that occur in space. Astronauts work out on this equipment up to two hours a day. But they still can lose as much as 1.5 percent of their bone mass per month. That's the same amount of bone a post-menopausal woman can lose in a year.

Running in Space

In space, just like on Earth, walking or running is an important way to keep bones healthy. That's why space station astronauts use their treadmill nearly every day. But researchers on Earth want to know more about how this exercise is working. To further study the effects of running in space, The Cleveland Clinic Foundation and Penn State University built a ground treadmill called the Zero Gravity Locomotion Simulator (ZLS).

This unusual machine is mounted vertically in a free-standing frame and includes padded straps that support a runner under the head, torso, arms and legs. If that doesn't make sense, imagine running in place on a wall.

In this position, there's no gravitational force between the runner and the machine. Like the treadmill used on the space station, the ZLS has a harness with motorized cables to pull the runner toward the treadmill belt, exerting force on the bottom of the runner's feet.

The Hovering Treadmill

Penn State and The Cleveland Clinic have used the ZLS for several years to study astronaut bone loss. But for this experiment, NASA must simulate the environment inside the space station as accurately as possible.

Unlike the ZLS, the treadmill on the space station is detached and actually floating inside the vehicle. This lightens the load to the space station and reduces vibrations that might disturb other experiments. As a result, the treadmill moves a bit with the runner, which may impact the type and amount of exercise an astronaut needs to stay healthy.

To reproduce this floating effect, NASA Glenn engineers added four bearings that look like hockey pucks to the bottom of the ZLS treadmill. These devices, called air bearings, have tiny holes that emit a thin film of air, causing the machine to float inches or much less the pucks on an air-hockey table. This hovering version of the exercise machine, which may closely replicates the on-orbit treadmill, is called the enhanced Zero Gravity Locomotion Simulator (eZLS).

Image right: Illustration of the four air bearings (large red circles) attached to the bottom of the treadmill's frame. Credit: NASA

Early this spring, NASA Glenn will begin testing the eZLS with human participants. Subjects, selected after careful health and fitness screening, will run on the hovering treadmill for 5 to 30 minutes at a time.

A pressure sensor in the sole of the runner's shoe and sensors between the runner's harness and treadmill will measure the force exerted on the runner's body. Meanwhile, accelerometers mounted to the frame will measure the treadmill's movement.

The data collected from these tests will help NASA to build exercise equipment and workout regimens that exert the optimal amount of force on the skeletal system to prevent bone loss. This will mean stronger, healthier crews with a lower risk of injury on the space station, the moon and Mars and shorter recovery periods for astronauts returning from long missions.

It could also enhance medical researchers' understanding of how exercise and inactivity impact osteoporosis, improving the health of millions of Americans at risk for this debilitating disease.

More information

Read more about NASA Glenn's Exploration Systems Directorate

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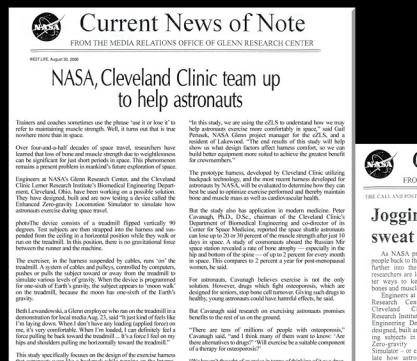

Current News of Note
FROM THE MEDIA RELATIONS OFFICE OF GLENN RESEARCH CENTER

AEST LIFE, August 30, 2006

NASA, Cleveland Clinic team up to help astronauts

Trainers and coaches sometimes use the phrase "use it or lose it" to refer to maintaining muscle strength. Well, it turns out that it is true nowhere more than in space.

Over four-and-a-half decades of space travel, researchers have learned that loss of bone and muscle strength due to weightlessness can be significant for just short periods in space. This phenomenon remains a present problem in mankind's future exploration of space.

Engineers at NASA's Glenn Research Center, and the Cleveland Clinic Lerner Research Institute's Biomedical Engineering Department, Cleveland, Ohio, have been working on a possible solution. They have designed, built and are now testing a device called the Enhanced Zero-gravity Locomotion Simulator to simulate how astronauts exercise during space travel.

photo/The device consists of a treadmill flipped vertically 90 degrees. Test subjects are then strapped into the harness and suspended from the ceiling in a horizontal position while they walk or run on the treadmill. In this position, there is no gravitational force between the runner and the machine.

The exercise, in the harness suspended by cables, runs "of the order of 20 percent of the normal force," said Gail Perusek, project manager for the Exercise Countermeasures Project at Glenn. The cables pull the subject toward or away from the treadmill to simulate various levels of gravity. When the device is programmed for one-sixth of Earth's gravity, the subject appears to "moon walk" on the treadmill, because the moon has one-sixth of the Earth's gravity.

Beth Lewandowski, a Glenn employee who ran on the treadmill in a demonstration for local media Aug. 23, said "It just kind of feels like I'm lying down. When I don't have any loading (applied force) on me, it's very comfortable. When I'm loaded, I can definitely feel a force pulling me down toward the treadmill. I can feel my hips and shoulders pulling me horizontally toward the treadmill."

This study specifically focuses on the design of the exercise harness that astronauts wear like a backpack while running on the International Space Station treadmill. The key to the success of load-bearing exercise, such as treadmill running, is the application of gravity replacement loads to the crew member via a subject load device coupled to the body by a harness.

"In this study, we are using the eZLS to understand how we can make it better. How can we provide better exercise devices and better exercise protocol?" she said. "Because even though the crew is exercising in their prescribed amount with the devices that are available on orbit, which include cardiovascular and resistive devices, we are still seeing losses of bone and muscle that are not appropriate to maintain the health and performance that we need for astronauts."

"We've seen a lot of still being swaddled and glad-handed, but researchers are sure of one difference in either of the bed-rest studies: zero gravity is simulated in the Zero Gravity Simulator, but there are spike camps on the question, but the new bed rest studies and vertical treadmills will help answer it.

"We're working the protocol out right now," said Perusek. "Would you put people in that position 24 hours a day? Or would you also put them flat?"

Once the lunar bed rest studies are underway, NASA will focus on the issue. If it works, as the NASA can quantify the metabolic cost of the activities and figure out if additional exercise will be needed on the missions.

Current News of Note
FROM THE MEDIA RELATIONS OFFICE OF GLENN RESEARCH CENTER

TIME CALL AND POST/THURSDAY, SEPTEMBER 21, 2006

Jogging in space no sweat for NASA Glenn

As NASA prepares to send people back to the moon and eventually into the solar system, researchers are looking for better ways to keep astronauts' bones and muscles strong.

Engineers at NASA's Glenn Research Center and the Cleveland Clinic Lerner Research Institute's Biomedical Engineering Department have designed, built and are now testing subjects in the Enhanced Zero-gravity Locomotion Simulator — or eZLS — to simulate how astronauts exercise during space travel. The eZLS utilizes principles developed for the zero-gravity locomotion simulator currently in use at the Cleveland Clinic.

NASA and Cleveland Clinic designed the eZLS so it would simulate the conditions on the ISS as accurately as possible. When astronauts exercise using the onboard treadmill, it is actually floating inside the vehicle. This lightens the load on the ISS and reduces vibrations that might disturb other experiments. As a result, the treadmill moves a little with the runner, which may limit the effectiveness of the exercise astronauts perform to stay healthy and strong.

To reproduce this floating effect, Glenn engineers added four bearings that look like hockey pucks to the bottom of the eZLS. These bearings have tiny holes that emit a thin film of air, causing the machine to float inches or much less the pucks on an air-hockey table. This hovering version more closely replicates the treadmill used in space.

For the current study, test subjects have been recruited from Glenn, its on-site contractors and the general public. Subjects have gone through extensive pre-screening to ensure they are fit to exercise in the simulator. Test subjects are then strapped into the harness and suspended from the ceiling while they walk or run in a horizontal position on a special vertical treadmill.

In this position, there is no gravitational force between the runner and the machine. As the treadmill used on the ISS, the subject wears the harness and the treadmill moves to which a system of motors and cables is attached at the waist that pull the runner toward the treadmill belt, exerting forces into the harness and on the bottom of the runner's feet that are measured by dozens of sensors.

Cavanagh, who has been studying space medicine since the early 1960s, said he hopes his research will "formalize and clarify the issue of how exercise can contribute to the maintenance of bone mass in people on Earth."

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THE PLAIN DEALER

PHOTOGRAPH BY THOMAS ORISINSKY / THE PLAIN DEALER

Dominic Primo goes for a walk on the vertical treadmill called a Zero Gravity Locomotion Simulator as part of a three-month study on weightlessness at the Cleveland Clinic.

Off the ground

Participant in weightlessness study lies down in hopes of helping astronauts

TOM FEHAN
Plain Dealer Reporter

Dominic Primo will end his mission and return to earth on Monday, March 31. Soon after his 7 a.m. wakeup call, he'll be tilted upward in his bed, a few degrees every half hour. He'll be vertical by 11 a.m. Then, maybe a bit like Frankenstein's monster, he'll take his first careful steps after 12 weeks in bed at the Cleveland Clinic.

He hasn't been sick or idle — far from it.

"My physical attributes and motor skills are fine," he said. "I'm as healthy as I've ever been, probably healthier."

Primo, a 29-year-old Solon resident, normally works backstage as a costumer at Playhouse Square professional. Since Jan. 7, however, he has been lying down on the job for a study at the Clinic's Center for Space Medicine, in partnership with the NASA Glenn Research Center.

"I'm just a lox off the street who's able and willing to do this," Primo said. "They're the ones who can make spectacular breakthroughs," helping, with any luck, both astronauts and people on Earth.

Known as the weightlessness study, or more descriptively the bed-rest study, the project aims to solve the problem of muscle atrophy and loss of leg-bone mass suffered by astronauts during long stays in space.

"At first sight, it doesn't seem suitable," said Dr. Peter Cavanagh, the Clinic's chairman of biomedical engineering and co-director of the Center for Space Medicine.

"But bed rest is an excellent analog for the study of musculoskeletal changes."

Putting it simply, he said, the idea "is to remove the force of gravity from the direction it usually occurs when the body is standing or moving on Earth."

In a weightless environment, blood and fluid tend to pool in the upper part of the body, particularly the head. Lack of fluid in the legs may explain the bone and muscle loss.

More information

Want to apply to participate in the study? Contact Ricki Englehaupt, R.N., at 216-445-1002 or englehr@ccf.org.

Confined to bed for 12 weeks in a Cleveland Clinic/NASA study on weightlessness, Dominic Primo hopes to grow a beard in January — and then to shave it.

April 2008 U.S. MEDICINE 23

NASA Simulates Weightless Workout To Study Exercise In Space

By Katie Leisch
WASHINGTON — Without gravity, our disintegrate bones, weaken muscles and lose strength. Astronauts must perform exercise daily to slow this process down and the National Aeronautics and Space Administration (NASA) has a new way to simulate weightless workouts: the standalone Zero Gravity Locomotion Simulator, or eLS.

Similar to a treadmill, the eLS is designed and built at NASA's Glenn Research Center in Cleveland in collaboration with the Cleveland Clinic, which has a zero-gravity treadmill of its own. These types of treadmills allow a person to run or walk while suspended in a harness that pulls the runner's feet and head removed from the normal pull of Earth's gravity.

About three years ago, engineers at Glenn also built the eLS, to enhance the Zero Gravity Locomotion Simulator, a larger than the new eLS treadmill at Glenn, where it is used to test hardware for zero-gravity workouts. The eLS, on the other hand, will be used in NASA bed rest studies at the University of Texas Medical Branch in Galveston. Both treadmills will be used to develop exercises