Taking space in stride: New analysis could lead to better lunar, Mars spacesuits (w/ Video)

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(PhysOrg.com) -- Anyone who has watched videos of the Apollo astronauts moving across the surface of the moon has noticed the unusual loping gait they sometimes adopted and their slow, almost graceful, movements. Now a new analysis by MIT researchers shows why astronauts moved around this way in their heavy Apollo-era space suits - and provides a mathematical method for evaluating new spacesuit designs for the moon and Mars and their effects on the efficiency of locomotion.

The loping gait of the lunar explorers was similar to a child's skipping, except that instead of switching back and forth on each stride between having the left or right foot in front, the same foot stayed forward the whole time, explains Christopher Carr, a research scientist in the Department of Earth, Atmospheric and Planetary Sciences. Carr is the lead author of a paper on the research appearing Aug. 12 in the online journal *Public Library of Science One*.

A video of an astronaut from Apollo 16 attempting to retrieve and dropped hammer on the moon. Credit: NASA/Ken Glover, ALSJ.

That way of moving, Carr says, "means they don't have to move as much" within the stiff pressurized suits. "They do whatever seems most efficient."

Trying to get around while inside the pressurized suits was "like being inside a balloon," Carr says. "When you bend it, it wants to spring back." When running or loping, that tendency can actually improve efficiency, acting like a spring that stores energy on each stride and then adds a little push on the next. "It can actually be a benefit," he says.

The spring-like nature of the space suit limbs, derived from the pressure used to supply the astronaut with oxygen, reduces metabolic expenditures by supporting the weight of the space suit. In the lab, lower gravity levels are simulated by reducing the weight supported by a subject, such as by having the subject wear a harness. Space suits have a similar effect: imagine hiking with a heavy backpack that is suspended from helium balloons so that you don't have to carry the weight of the pack. Like wearing a harness in the lab, this would feel like an effective reduction in the pull of gravity. For astronauts, this would result in switching, at lower velocities than normal, from walking to running, which is a more efficient gait in lunar and Mars gravity conditions.

But that springiness can also make it very hard to bend, as illustrated by a video of an Apollo astronaut attempting to pick up a hammer he had dropped. As described in the paper, he "can be seen jumping into the air in an attempt to provide (during the following impact) enough force (through body weight and impact loads) to buckle the knee joint and reach a hammer on the lunar surface." It takes the astronaut several such leaping attempts before he is able to retrieve it.

Analyzing how people move while wearing the spacesuits might seem straightforward, but because the suits are so heavy, running inside the suits under Earth's gravity requires more energy than a human can sustain. The suits can only function effectively under reduced gravity such as the moon's, which is one-sixth as strong as Earth's. In fact, the only way to achieve actual reduced gravity conditions on Earth is during "parabolic" flight, which is expensive and allows only brief (roughly 20 second) periods of lunar or Martian gravity. To evaluate gait transitions under real-world conditions the authors examined transcripts and videos from the Apollo missions to the moon

The analysis done by Carr and his co-author, recent Department of Aeronautics and Astronautics graduate Jeremy McGee '09, provides a mathematical way of determining when astronauts may switch gaits, which affects the amount of energy required to traverse a given distance, and may be helpful in the planning of future lunar or Mars surface missions, Carr says. For example, because running is more efficient than walking on the Moon, it may be possible for astronauts to venture farther than expected from a landing craft and still know that they would be able to return safely.

There is probably not enough time left to develop radically new spacesuit designs for planned NASA lunar missions beginning late next decade, Carr suggests, but there might be time to do so for human Mars missions, which are not yet part of firm plans but likely to take place at least a decade later.

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