Functional space foods improve the QOL in moon village

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The gravity of the moon is only one-sixth the gravity of the earth. Therefore, it is an environment where muscle atrophy and osteoporosis are likely to occur, although not as much as weightlessness. We have been studying the mechanism of muscle atrophy caused by weightlessness and low gravity and its nutritional prevention. As a result, the accumulated oxidative stress and the activated ubiquitin-dependent proteolytic pathway in myocytes are important for the muscle atrophy caused by weightlessness and low gravity[1, 2]. Furthermore, we also found that dietary polyphenols and soy protein are effective for inhibiting oxidative stress and ubiquitin-dependent proteolysis, respectively. Based on these results, soybean is a food material rich in proteins, and isoflavones (soy polyphenols), which are able to prevent the muscle atrophy. There are staple foods suitable for each culture, such as potatoes for Germans and rice for Japanese. In order for human beings to live safely and securely on the moon for a long time, it is necessary to find a staple food suitable for the environment of the moon. Currently, we are working on a project to grow this soybean at a space plant factory and make it the staple food of the moon space food.

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Effect of hypogravity on human physiology on the Moon surface

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The gravitational acceleration on the Moon is approximately 1.625 m/s^2 (9.807 on the Earth), and it is 1.66%, 1/6 of the Earth's gravity. In comparison with the physiological changes under 1G and microgravity, there are several concerns on the Moon surface life.

First concern is cardiovascular change. Under microgravity, significant amount of body fluid in the lower body shifts to the headward. Hypogravity will cause several cardiovascular changes during stay on the Moon. One is cardiovascular deconditioning, which is caused by the reduction of circulatory blood volume. Recent reports on the International Space Station revealed other concerns during hypogravity, that are spaceflight associated neuro-ocular syndrome (SANS) and morphological changes in the cerebrum. Since the lunar gravity is 1/6G, attenuated fluid shift is estimated, but not confirmed.

Second one is somatosensory adaptations. Humans has adapted 1G in their proprioceptive sensation and movement. When living on the Moon, how long time is necessary to adapt this 1/6G condition is unknown.

Third one is musuculoskeletal weakness, in another words, myatrophy. Microgravity has revealed to cause myatrophy. Aerobic exercise seems to be effective to ameliorate this myatrophy, but the effect of 1/6G for considerably long time is unknown.

Fourth is effect on bone metabolism. The lack of the impact on the weight bearing bones causes osteoporosis. Recent Japanese data showed that the bone mineral density during ISS stay improved by the administration of bisphosphonates, however, how long it should be is not clarified.

Fifth is the hematological and immunological concerns. Microgravity stay sometimes cause anemia, called "space anemia," possibly related to bone marrow dysfunction. Immunological problems were reported to be suppression of T-cell function.

The countermeasures for hypogravity on the Moon, we have been proposing "artificial gravity with exercise" is the best and most time saving strategy. At first, short arm centrifuge with exercising device might be possible, but long stay necessitates the long-arm rotation of habitat.

Furthermore, there is a problem of "point of no return" regarding the health of astronauts. This is a question of how long it will take for the physiological changes in the physiological systems to return to their original state if they live under altered gravity. Unless this problem is solved, artificial gravity is inevitable for returning to the 1G environment on the Earth.

Effect of the Hybrid Training Method on the Disuse Atrophy of the Musculoskeletal System of the Astronauts Staying in the International Space Station for a Long Term

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Musculoskeletal atrophy is one of the major problems of extended periods of exposure to weightlessness such as on the International Space Station (ISS). We developed the Hybrid Training System: HTS to maintain an astronaut's musculoskeletal system using an electrically stimulated antagonist to resist the volitional contraction of the agonist instead of gravity[1]. The present study assessed the system's orbital operation capability and utility, as well as it's preventative effect on an astronaut's musculoskeletal atrophy. HTS was attached to the non-dominant arm of an astronaut staying on the ISS, and his dominant arm without HTS was established as the control (CTR). 10 sets of 10 reciprocal elbow curls were one training session, and 12 total sessions of training (3 times per week for 4 weeks) were performed. Pre and post flight ground based evaluations were performed by MRI (muscle volume), and DXA (BMD, lean (muscle) mass, fat mass). The experiment was completed on schedule, and HTS functioned well without a problem. Triceps muscle volume according to MRI changed +11.7 % and that of biceps was +2.1% using HTS, however -0.1% and -0.4% respectively for CTR. BMD changed +4.6% in HTS arm and -1.2% for CTR. Lean (muscle) mass of the arm changed +10.6% only in HTS. Fat mass changed -12.6% in HTS and -6.4% in CTR. These results showed the orbital operation capability and utility, and the preventive effect of HTS for an astronaut's musculoskeletal atrophy. The initial flight data together with the ground data obtained so far will be utilized in the future planning of human space exploration.

[1] N. Shiba et al., Electrically Stimulated Antagonist Muscle Contraction Increased Muscle Mass and Bone Mineral Density of One Astronaut - Initial Verification on the International Space Station − PLoS ONE 10(8): e0134736. 2015

Moon Olympics

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In the coming age of popular space travel and space residence, "Space Sports" will surely appear. Children love sports as well as space, and they will be fascinated by such questions as: "How will my body move in weightlessness?" and "When I am weightless, what sports can I do?" Sports are very important for astronauts, too. Astronauts must do physical training for two hours per day on the ISS to maintain their physical strength. But they don't enjoy boring training - they much prefer to “play sports". If we can develop sports in a weightless environment, where you can exercise your body enjoyably while helping with physical training, there will be great benefit to the minds and bodies of astronauts. As IOC has agreed on sponsorship of the Olympic Games with the advertising company Dentsu Inc, we will propose a system to produce sports events in space, through collaboration between the United Nations Office for Outer Space Affairs and Dentsu. We will create sports whereby everyone, including the disabled and children, will be able to enjoy themselves. For example, live broadcasts from the Moon of "Bird-Human" races, and of Moon Olympic Games will inevitably attract viewers from all over the world - as the Apollo landings did even half-a-century ago. People will thereby gain awareness of the Earth in space as inhabitants in an environment that transcends races and religions without borders. Through the experience of sports in the universe, people may even reach the point of talking of “Spacemanship” - a more sublime and inspiring version of sportsmanship.