

Health Promotion for Astronauts and General Citizen

Tips for a Healthy Long-Life Learned from Space Medicine



JAXA, the Japanese Society of Physical Fitness and Sports Medicine, the Japanese Orthopaedic Association, and the Japanese Association of Rehabilitation Medicine, provide you with tips and hints for a healthy long-life, from the viewpoints of their respective expertise.



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Space Medicine-Related Missions of Astronaut Furukawa -- Tasks that capitalize on his medical doctor profile

Astronaut Furukawa, who had been on the International Space Station since June 2011, has a background as a medical doctor and conducted various space medical experiments as well as public relations and educational activities during his 165-day stay in space.

1. Accumulation of Japan's space medical experimental data and enhanced analytical precision

Following Astronauts Wakata and Noguchi, Astronaut Furukawa also participated as an experimental subject. He was expected to augment the sample count for medical studies and thus enhance the reliability of findings. His research activities included:

- The effect of long-duration microgravity exposure on cardiac autonomic function by analysis of the electrocardiogram
- Biomedical analyses of human hair exposed to long-duration spaceflight
- Evaluation of human microflora
- Bisphosphonate as a countermeasure to bone loss induced by spaceflight

2. Organizing a space medicine experiment support system (with a view to in-orbit/remote diagnosis and health monitoring)

Astronaut Furukawa was to organize a system to centrally manage data from medical experiments performed in orbit, and review it from the perspective of a medical doctor. Through its continued development and improvement, the system is expected to become the basis for establishing an in-orbit/remote diagnosis and health monitoring system.

3. Participation in space medicine by the general public

Proposals for experiments were invited, such as monitoring changes in the body in the space environment. Astronaut Furukawa then performed these experiments while in space. In microgravity of space, body fluid shifts from the lower to the upper part of the body, resulting in a flush or reddening of the face. The spine also stretches, making the body a few centimeters taller. Such phenomena were actually measured.

Space medicine and health promotion for general citizen

Tips for a healthy long-life learned from space medicine

1. Present-day society and the need for health promotion

With over 21% of people aged 65 or older in 2007, Japan has entered the era of the “super-aged society”. There are now five million people requiring nursing care; one elderly person in our society is currently supported by three younger people. Many Japanese people hope to live life as independently as possible within such an unprecedented super-aged society. To enable a healthy long-life, certain techniques and daily practices for healthy bodies and minds are necessary.

2. Space medicine is the ultimate preventive medicine

Outer space is a harsh environment characterized by microgravity, confined spaces, and cosmic radiation. The field of space medicine is responsible for maintaining astronauts’ health and optimizing their performance. A study is underway to reduce risks such as bone loss and muscle atrophy. For example, a prolonged stay in space with little gravity results in weakening of the bones and muscles that otherwise support body weight, which is precisely the problem faced by elderly people on Earth. Space medicine provides the means of alleviating such problems. The knowledge obtained from this research can also benefit the lives of people on Earth.

3. Health promotion information from space medicine is available

Bone loss and muscle atrophy are common issues for astronauts and the elderly alike. To have a healthy long-life, it is important to practice effective health improvement techniques and take preventive measures against health problems. JAXA has summarized information on the significance of and tips for health promotion, assisted by the Japanese Society of Physical Fitness and Sports Medicine, the Japanese Orthopaedic Association, and the Japanese Association of Rehabilitation Medicine. It is our hope that this brochure will help with your daily efforts toward maintaining a healthy long-life.

JAXA Astronaut
Chiaki Mukai, M.D., PhD



Applying the Fruits of Space Medicine to Health Promotion

In spaceflight, changes identical to those related to aging occur quickly



One day of muscular atrophy change observed in space is equivalent to two days of being bedridden, or half a year in an elderly adult.



<Comparisons of the muscular atrophy rates>

- Long-duration stay in space
10 to -20% compared with before flight (-30% max)
 - Short-term spaceflight
Triceps surae muscle: -1%/day
(During stays in space, the antigravity muscles (those of the back, triceps surae) are more prone to decline than voluntary muscles (those such as biceps brachii that are controlled at will).)
 - Bed rest study on Earth
Triceps surae muscle: -0.5%/day
 - Age-related muscular atrophy
Aged 30 to 60: -0.7%/year
Aged over 60: -2%/year
- * The bed rest study is an experiment featuring a bedridden state on Earth to simulate a space environment.

Astronauts' bone loss rate by region

Region	Bone loss rate (%/month) (mean) ± (s.d.)
Trochanteric (region of the femur)	1.56±0.99
Lumber spine	1.06±0.63
Upper limb	0.04±0.88

Based on JMNI 7: 33-47, 2007 by LeBlanc A, et al.

< Bone loss in spaceflight>

- Bone density in the femoral neck: -1.5%/month
- 1.5% loss per month, which means a 9% loss during a 6-month stay in space.
- Rate of decline 10 times faster than in those with osteoporosis
- It takes 3 to 4 years to recover the bone mass.
- The Ca balance (intake-excretion) decreases by -250 mg/day during flight.

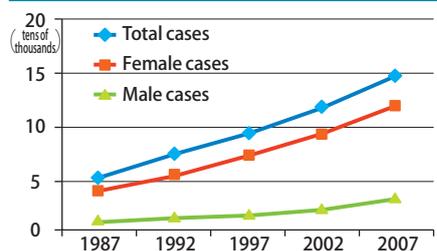
Creatures on Earth have survived by undergoing repeated evolution and selection in harsh environments, developing new techniques. Today, it has also become possible for Japanese astronauts to travel in outer space.

However, what they have experienced in space is a rapid weakening of the body. Bone mass declines ten times faster than in those with osteoporosis, exacerbating the risk of fracture and urinary calculus. Calf muscles thin by 1% a day, which is equivalent to 2 days bedridden, or half a year of muscular atrophy in an elderly person.

These phenomena are caused by the absence of gravity (weightlessness). The human body, which has evolved in the Earth environment, has structure and functions suited to 1G (normal gravity). Safe human spaceflight requires improvements in astronaut health technologies for long duration missions.

Here, we provide you with health promotion tips obtained from the space medicine study performed by Japanese astronauts during their long-duration stays on the International Space Station.

Japan's bone fracture counts in the proximal femur by year



Based on Osteoporosis Japan 18: 146, 2010 by Hajime Orimo, et al.

< Bone loss due to osteoporosis>

- Due to aging and decrease in female hormone, bone density in the femoral neck: -1 to -2%/year
- Bone density under -30% of that of young adult mean corresponds to osteoporosis.
- Currently 11 million people in Japan are suffering from osteoporosis. Half (50%) of women in their 70s have significant osteoporosis.
- Due to the increase in elderly people, the incidence of bone fracture is growing.
- 150 thousand people a year undergo surgery due to fractures of the proximal femur.

1 Tips for preventing osteoporosis

Osteoporosis progresses asymptotically. Get a bone checkup in a medical hospital to evaluate your bone density.

To strengthen your bones, three elements, i.e. meals, exercises, and pharmaceutical drugs, are important.

① Meals	Try to take meals of well-balanced nutrients, including sufficient calcium (800 gm per day in milk, small fish, etc.), vitamin D (fish and mushrooms), and vitamin K (natto or fermented soybeans). Adequate sunbathing is also important.
② Exercise	Incorporate bone loading and muscle balance exercises into your daily routine.
③ Drugs	In case of a higher risk of bone fracture, the use of effective drugs reduces this risk.



Spaceflight represents an accelerated model of the aging change. Bone loss risks can be alleviated by taking effective preventive measures.



Message from JAXA

<http://iss.jaxa.jp/med/research/>

The website gives an overview of the studies in space medicine and biology being performed by JAXA along with information on workshops held by JAXA.

2 Tips to maintain physical fitness efficiently

Aerobic exercise enhances the cardiorespiratory fitness and resistance (muscle) exercise prevents muscular atrophy. Both are necessary for all people.

●● Aerobic exercise ●●

To be performed three times per week, for 30 minutes each time, at a “somewhat hard” intensity. An interval training that alternates between rapid high-intensity work and slow low-intensity work every 2 to 3 minutes is effective for improving aerobic performance.

Type	Jogging, cycling
Intensity	Somewhat hard
Duration	30 min or more, 2 to 3 times per week

* Interval training (alternating between high and low work) enhances your cardiopulmonary function.

●● Muscle exercise ●●

Train your trunk (abdominal and back) muscles, and upper and lower limbs by applying an exercise load that fatigues you when repeated around 10 times. To enhance recuperative power and prevent muscle damage, avoid repeating the same exercise the next day.

Type	Movement of the trunk, and upper and lower limbs.
Intensity	8 to 12 repetitions per set, 1 to 3 sets per session
Frequency	Twice or more per week

* To promote muscle hypertrophy and prevent muscle damage, adequate workout and rest are necessary.

3 The body's circadian rhythm is important to improve daytime work performance

In the International Space Station, which orbits the Earth every 90 minutes, insomnia and reduced work performance may result from a disturbed biological rhythm.

To improve daytime performance, it is important to focus on:

- | 1 | Keeping regular hours
- | 2 | Adjusting light levels
- | 3 | Successful control of stress

and thereby maintaining an adequate circadian rhythm.



Tips for maintaining your circadian rhythm

| 1 | Keeping regular hours

- Take breakfast, lunch, and supper at regular time
- Work out 2 or 3 times per week to maintain your physical fitness
- Adjust your schedule of work and rest

| 2 | Light level adjustment

- Expose yourself to light after getting up
- Dim the lighting before going to bed.



| 3 | Successful control of stress

- Try to alleviate possible causes of stress and learn how to increase stress tolerance.
- Have your own methods of stress relief (relaxation and refreshment)
- Value communication with your family and friends

Space medicine is the ultimate preventive medicine



To live a healthy long life, practicable health promotion techniques and proactive efforts are important.



Space medicine and health maintenance in the longevity society bring new challenges and issues

Space medicine is the ultimate “preventive medicine”, which reduces medical risks for astronauts, helps maintain their health, and enhances their performance.

Bone loss, muscle atrophy, and disturbed circadian rhythms are common issues for both astronauts and the elderly alike and can be prevented if the risks are addressed correctly.

We hope these space medicine technologies for astronauts will provide helpful information to people living in a super-ageing society.

Three Tips for a Healthy Long-Life

Physical activities are useful for stress relief, refreshment, getting acquainted with people, and enriching our lives. Activities are also helpful for maintaining physical fitness, reducing body fat, preventing arterial sclerosis, and achieving a sound and long- life. Let's enjoy and continue your favorite exercises as well.

●● Check your exercise deficiency level! ●●

Let's determine whether you are doing enough exercise on a daily basis.
Check the applicable items, and determine your total score.

Check item	Score			
1) Do you often use an elevator or escalator?	Yes (2 points)	Sometimes (1 point)	No (0 point)	points
2) Do you try to walk when going somewhere nearby?	Yes (0 point)	Sometimes (1 point)	No (2 points)	points
3) Do you spend most of your holidays lying at home?	Yes (2 points)	Sometimes (1 point)	No (0 point)	points
4) Do you consider it tiresome to move your body?	Yes (2 points)	Sometimes (1 point)	No (0 point)	points
5) How many days per week do you have time to exercise (including agricultural work)?	Three or more days (0 point)	One or two days (1 point)	Almost never (3 points)	points
6) Do you weigh yourself every week?	Yes (0 point)	Sometimes (1 point)	No (2 points)	points
7) Do you feel the fatigue of the day in the late afternoon or evening?	Yes, very much (2 points)	Yes, a little (1 point)	No (0 point)	points
8) Do you get tired when you walk upstairs to the third floor?	Yes, very much (2 points)	Yes, a little (1 point)	No (0 point)	points
9) Are you confident you can continue to exercise regularly from now on?	Yes (0 point)	Not sure (1 point)	No (3 points)	points
			total	points



17 points or more	Warning! Review your past life style and immediately change your attitude. Always aim to move your body.
13 to 16 points	Caution! If you continue your current lifestyle, the risk of developing a lifestyle-related disease will increase. Try to spend a physically active life.
9 to 12 points	Try to move your body a little more actively.
5 to 8 points	Favorable. Target a more pleasant life.
0 to 4 points	Great! Continue your current active life.

1 Three Kinds of Exercises for Better Health

| 1 | Aerobic exercise

for stamina improvement and fat burning.
Exercises to take in sufficient oxygen to the body
Walking, jogging, swimming, aerobic dancing, etc.

| 2 | Resistance exercise

for maintaining muscle strength, bone mass, and good posture.
Exercises in which muscle strength is exerted while a load is applied to the body.
The load is applied under your own weight or using dumbbells and elastic bands.

| 3 | Stretching

for improvement of flexibility/suppleness and joint motion ranges.
Gently stretch muscles and tendons (15 to 30 seconds).



Ensure a good balance of the three

2 Six Articles to Encourage Continued Exercises

To benefit from exercise, long-term continuation is the key. It will take a few months for those who have not been exercising to get used to a new active life. With the help of the 6 articles shown on the right, find your own way to continue exercising.

- Article 1. Make an exercise plan.
- Article 2. Make friends with whom you can enjoy exercising.
- Article 3. Switch items for a change.
- Article 4. Set attainable goals.
- Article 5. Treat yourself to a reward.
- Article 6. Trace your progress.

3 Importance of Body Talk

Physical activities are often likened to a double-edged sword, since they have drawbacks as well as benefits (arthritis, sprains, bone fractures, etc.). To enjoy exercise safely and maintain your health, it is important to listen to your body (muscles, bones, joints, brain, lungs, heart) and mind (this is known as “body talk”).

When your body is in poor shape, consult a medical doctor or an exercise professional before starting your exercise program.



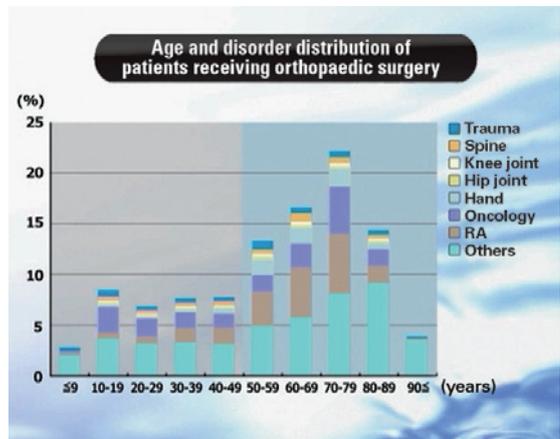
Measures against Locomotive Syndrome for a Healthy Long-Life

Space medicine teaches us the importance of exercise against gravity

When returning from space to Earth, astronauts experience difficulty in standing and walking under the presence of gravity. Standing and walking on Earth require moving the body against gravity. Therefore, astronauts in space do preventive exercise every day, and preventive exercises working against gravity have proven effective. Space medicine teaches us that difficulty in standing and walking against gravity is preventable.

On Earth, with the arrival of the super-aged society, the number of individuals aged 50 or more receiving orthopaedic surgery is rising alarmingly in Japan. The disorders are osteoporosis-related bone fractures, disk degeneration-related spine disorders, and cartilage degeneration-related disorders in knee and hip joints, and so on. Such disorders and bone fractures hamper individuals in standing and walking, and could result in requiring nursing care services.

The locomotive syndrome (“locomo” for short) refers to conditions for which the elderly have been receiving nursing care services, or high-risk conditions for which they may soon require nursing services, due to problems of the locomotive organs. One in five individuals who need nursing care services relates to this syndrome in Japan. Space medicine teaches us the key to preventing “locomo”.



The number of individuals aged 50 or more receiving orthopaedic surgery is rising alarmingly.

Measures against “locomo” to remain capable of standing and walking



Space teaches us the importance of maintaining sound locomotive organs, such as muscle function, bones and joints for living on Earth. After a relatively lengthy process of evolution, the human race acquired a bipedal body structure on which to stand and walk on two legs. The human race has developed sufficient muscle strength and balance control ability to withstand gravity. In this aged society, measures against “locomo” are required for us to remain capable of standing and walking.



Locomotive Syndrome (“Locomo”)

A condition in which health care and assistance are required due to disorders of locomotive organs or a condition with a high risk of the same.



Measures against “Locomo” are required to remain capable of standing and walking.

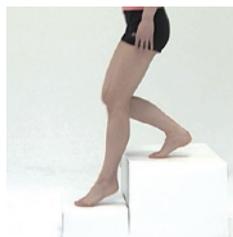
1 Know that we live in the presence of gravity



There is no gravity while in space.



Raise the body.



Gently lower the body.

In our lives on Earth, we raise our body against gravity and lower it gently while supporting the body against gravity.

Living daily life means defying gravity.

■ Controlling the movement of an object



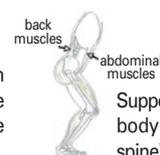
Lifting an object, and putting it down gently.

■ Shock absorption



Stepping down in a manner gentle to the body (knee joint).

■ Posture stabilization



Supporting the body (lumbar spine) firmly.



2 Become aware of being about to give in to gravity in daily life

You can determine whether it has become slightly strenuous for you to live under gravity using the following list of locomotion check items:

- Unable to balance yourself against gravity
- Insufficient power to stand on one leg
- Inability to slouch against gravity
- Remaining in a slouching position is hard on the back
- Lacking power to raise the body against gravity
- Raising the body is hard on the knees



Checking for locomotion syndrome ("loco-check"):

- It is hard for me to bring 2 kg of purchases home.
- I find it difficult to do a little heavy household work.
- I tend to stumble or slip at home.
- I have become unable to put a sock on while standing on one leg.
- I need a handrail when going upstairs.
- I cannot finish crossing at the crosswalk while the traffic light is green.
- I cannot walk for as long as about 15 minutes.

If one or more item/s apply to you, you are at risk of locomotive syndrome.

3 Hints not to give in to gravity, even in old age

The following three requirements apply for locomotion training ("Loco-tra"):

- 1 | It should strengthen the back and leg muscles.
- 2 | It should improve the body balance.
- 3 | The burden applied to the knee joints and back should be light.

Any efforts that satisfy all three requirements are effective as anti-locomotive syndrome measures. Train to fit your objectives (walking, traveling, sports, etc.). Adjust your training intensity to fit your walking capability (severity of "locomo"). If you feel pain, consult a medical institute.

The following two exercises are recommended "locomo" measures you can do at home:

●● Standing on one leg with eyes open ●●

Alternate legs, holding each for a minute at a time, three times a day.

Ensure that you have something to hold on to in order to avoid losing your balance.

Raise one leg slightly off the floor.

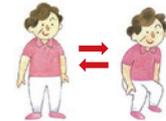


●● Squatting ●●

For safety, please do this exercise with a chair or sofa behind you.

Ensure your knees do not go past the tips of your toes. / Bend your knees towards the second toe.

Stand with your feet apart and your toes facing about 30 degrees outwards. Place your weight to the center of your feet.



- Do these in a manner suited to your severity of "locomo".
- You may combine these with other kinds of training.
- Lower your hips slowly as if sitting down in a chair.
- Start by lowering your hips just slightly. Bend your knees not more than 90 degrees.
- Repeat 5 to 6 times per set and 3 sets per day.

Living in the Presence of Gravity in an Aged Society



Astronaut Wakata exercising in space

"Locomo" is a condition of elderly people who are about to give in to gravity. Know and be aware of gravity, and live without yielding to it. Measures against "locomo" are exercises that you can do easily. Let's support each other so that we can continue practicing "locomo" measures.

Key items allowing individuals to live independently in an aged society
"Locomo" measures and toilet



■ If you can raise your body, then you can go to the toilet alone.



- "Locomo" calling is a call made to an elderly person by a family member living away or some other person in the community.
- Such support makes it is easy to continue "loco-tra"

Promote Your Participation in Social Activities through Rehabilitation

As we age, our physical fitness declines and the occurrence of disease or injury may trigger an inability to stand up and walk. Furthermore, activities of daily living such as going to the toilet or bathing may be impaired, or it may become difficult to swallow food. Recovering from such a state to spend fulfilling days, or preventing such a state, is the primary objective of rehabilitation.

Space Life and Rehabilitation



Astronauts exercising on the ISS

Astronauts exercise 2 hours per day during long-duration expeditions. After landing back on Earth, they also undergo rehabilitation to recover their muscle strength and the ability to walk while controlling their balance.

Human beings live while standing on two feet against gravity, namely the force of attraction to this huge celestial body, the Earth. In order to avoid becoming what is known as bedridden, gravity must be overcome. Conversely, when a human stays in space with almost no gravity, the muscles weaken, especially in the lower body, and bones become brittle because there is no need to bear the body weight.



Space food is designed not to scatter inside the space vehicle, while the toilet is devised such that bodily waste is sucked out.

Aside from this, since every little action in space has to be performed differently on Earth, life in space requires various contrivances and some getting used to.

1 Rehabilitation Tips

One key to rehabilitation is physical exercise, including muscle strengthening exercises and stretching. It is also important to learn how to integrate information from various sense organs and move the body properly. Alternatively, rehabilitation also involves increasing the number of things one can perform unaided, by utilizing various apparatus and equipment or by preparing the environment to be helpful and convenient. In addition, drug therapy and physical medicine involving electricity and heat are also used.

Speech disorders and eating and swallowing difficulties also fall within the scope of rehabilitation, while nutrition is also important to rebuild the body.



Walk while maintaining balance with the help of handrails on both sides. When you have mastered it, try walking using a single handrail, or a cane

Just as the activities of astronauts are supported by various staff, your rehabilitation will be supported by medical doctors, nurses and rehabilitation specialists such as physical therapists, occupational therapists, speech therapists, prosthetists, case workers, etc., and dentists, dental hygienists and nutritionists.





2 Importance of initiation

After having a disease such as a stroke that suddenly results in an inability to move limbs, a serious injury or a surgical operation, it is important to get up from bed as early as possible and try to reduce the amount of time spent lying down. For disorders where symptoms progress gradually, such as joint deformity or Parkinson's disease, consult a specialist doctor early.



3 Fall prevention

If you fall down, the gravitational attraction from the Earth results in an awfully strong impact when you collide with the ground or floor. Falling is a major reason necessitating nursing care, since throwing your hands out to protect your body or falling on your buttocks may result in a bone fracture or pain; furthermore, a bump on the head may cause a dysfunction of the brain (subdural hematoma, for example).

●● Cause of falling ① ●●

Walking ability declines with any disorders involving the nerves, muscles, bones, and joints, as well as a weakening of the heart and lungs. The (side) effects of drugs you take customarily may also be a cause of falling.



●● Cause of falling ② ●●

Falling quite often happens in rooms and it is known that cluttered floors, slippery mats, and dim lighting tend to result in falling accidents. Falls down staircases tend to occur when descending.



Typical bone fractures caused by fall

Fall Prevention Rehabilitation

In physical therapy, how to fall, how to stand up and how to use a cane and a wheeled walker are practiced. It is also important to check whether the length of the cane is appropriate and the rubber at its tip is in good condition, and select an appropriate type of walk aid apparatus. Each room must be checked for proper furniture layout and lighting, and have handrails installed as necessary. In

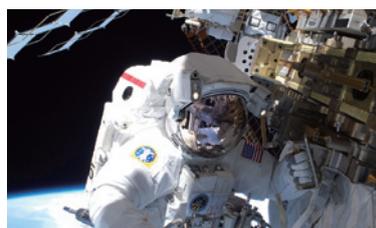
the "fall prevention program," exercise instructions are provided and bone density measurements are performed.

Practical items

- 1 | Balance exercise
- 2 | Toe grip exercise
- 3 | Water exercise
- 4 | Walking exercise (Selecting walking aids, image training)
- 5 | Enhancing the living environment



If a falling accident triggers a loss of self-confidence in walking and moving bodies for daily living, physical activity decreases, resulting in a decline in muscle strength and endurance, progression of osteoporosis, or mental deterioration (post-fall syndrome). Try not to stay indoors all day.



Astronauts performing extravehicular activities
In a space outfit equipped with a life-support system, an astronaut can also perform activities outside of a space vehicle.

Even if you eventually need nursing care, it is possible to increase the scope of what you can do on your own by using various aids such as adaptive equipment and services.



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HP of space medicine http://iss.jaxa.jp/med/index_e.html

JAXA HP http://www.jaxa.jp/index_e.html

Cooperation by:

The Japanese Society of Physical Fitness and Sports Medicine

The Japanese Orthopaedic Association

The Japanese Association of Rehabilitation Medicine

Photos courtesy of JAXA and NASA.