BioEd℠

THE SCIENCE OF THE HEART AND CIRCULATION

Heart Rate and Exercise

by

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RESOURCES

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U.S. FOOD AND DRUG ADMINISTRATION
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TEAMING WITH BENEFITS

by Jeffrey P. Sutton, M.D., Ph.D., Director, National Space Biomedical Research Institute (NSBRI)

Dr. Jeffrey P. Sutton

Space is a challenging environment for the human body. With long-duration missions, the physical and psychological stresses and risks to astronauts are significant. Finding answers to these health concerns is at the heart of the National Space Biomedical Research Institute's program. In turn, the Institute's research is helping to enhance medical care on Earth.

The NSBRI, a unique partnership between NASA and the academic and industrial communities, is advancing biomedical research with the goal of ensuring a safe and productive long-term human presence in space. By developing new approaches and countermeasures to prevent, minimize and reverse critical risks to health, the Institute plays an essential, enabling role for NASA. The NSBRI bridges the research, technological and clinical expertise of the biomedical community with the scientific, engineering and operational expertise of NASA.

With nearly 60 science, technology and education projects, the NSBRI engages investigators at leading institutions across the nation to conduct goal-directed, peer-reviewed research in a team approach. Key working relationships have been established with end users, including astronauts and flight surgeons at Johnson Space Center, NASA scientists and engineers, other federal agencies, industry and international partners. The value of these collaborations and revolutionary research advances that result from them is enormous and unprecedented, with substantial benefits for both the space program and the American people.

Through our strategic plan, the NSBRI takes a leadership role in countermeasure development and space life sciences education. The results-oriented research and development program is integrated and implemented using focused teams, with scientific and management directives that are innovative and dynamic. An active Board of Directors, External Advisory Council, Board of Scientific Counselors, User Panel, Industry Forum and academic Consortium help guide the Institute in achieving its goals and objectives.

It will become necessary to perform more investigations in the unique environment of space. The vision of using extended exposure to microgravity as a laboratory for discovery and exploration builds upon the legacy of NASA and our quest to push the frontier of human understanding about nature and ourselves.

The NSBRI is maturing in an era of unparalleled scientific and technological advancement and opportunity. We are excited by the challenges confronting us, and by our collective ability to enhance human health and well-being in space, and on Earth.

NSBRI RESEARCH AREAS

CARDIOVASCULAR PROBLEMS

The amount of blood in the body is reduced when astronauts are in microgravity. The heart grows smaller and weaker, which makes astronauts feel dizzy and weak when they return to Earth. Heart failure and diabetes, experienced by many people on Earth, lead to similar problems.

HUMAN FACTORS AND PERFORMANCE

Many factors can impact an astronaut's ability to work well in space or on the lunar surface. NSBRI is studying ways to improve daily living and keep crewmembers healthy, productive and safe during exploration missions. Efforts focus on reducing performance errors, improving nutrition, examining ways to improve sleep and scheduling of work shifts, and studying how specific types of lighting in the craft and habitat can improve alertness and performance.

MUSCLE AND BONE LOSS

When muscles and bones do not have to work against gravity, they weaken and begin to waste away. Special exercises and other strategies to help astronauts' bones and muscles stay strong in space also may help older and bedridden people, who experience similar problems on Earth, as well as people whose work requires intense physical exertion, like firefighters and construction workers.

NEUROBEHAVIORAL AND STRESS FACTORS

To ensure astronaut readiness for spaceflight, preflight prevention programs are being developed to avoid as many risks as possible to individual and group behavioral health during flight and post flight. People on Earth can benefit from relevant assessment tests, monitoring and intervention.

RADIATION EFFECTS AND CANCER

Exploration missions will expose astronauts to greater levels and more varied types of radiation. Radiation exposure can lead to many health problems, including acute effects such as nausea, vomiting, fatigue, skin injury and changes to white blood cell counts and the immune system. Longer-term effects include damage to the eyes, gastrointestinal system, lungs and central nervous system, and increased cancer risk. Learning how to keep astronauts safe from radiation may improve cancer treatments for people on Earth.

SENSORIMOTOR AND BALANCE ISSUES

During their first days in space, astronauts can become dizzy and nauseous. Eventually they adjust, but once they return to Earth, they have a hard time walking and standing upright. Finding ways to counteract these effects could benefit millions of Americans with balance disorders.

SMART MEDICAL SYSTEMS AND TECHNOLOGY

Since astronauts on long-duration missions will not be able to return quickly to Earth, new methods of remote medical diagnosis and treatment are necessary. These systems must be small, low-power, noninvasive and versatile. Portable medical care systems that monitor, diagnose and treat major illness and trauma during flight will have immediate benefits to medical care on Earth.

For current, in-depth information on NSBRI's cutting-edge research and innovative technologies, visit http://www.nsbri.org.

OVERVIEW

When a person exercises, his or her body must adjust to supply muscle cells with more oxygen. To meet the demand for oxygen during physical activity, a person's heart rate and therefore, the amount of blood pumped per minute, increases. Heart rate slows with rest.

Students will measure their heart rates after a variety of physical activities and compare the results with their resting heart rates, and with the heart rates of other students in their groups.


ACTIVITY

HEART RATE AND EXERCISE

Almost every day, we see, hear or read in the media about the importance of exercise for heart health. Why? What is the relationship between the heart, circulation, and exercise? This activity will help students learn how their hearts respond to physical activity.

Even when you are sleeping, reading, or watching TV, your muscles, brain, and other tissues use oxygen and nutrients, and produce carbon dioxide and wastes. If you get up and start moving, your body's demand for oxygen and the removal of carbon dioxide increases. If you start running, your body demands even more oxygen and the elimination of more carbon dioxide. The circulatory system responds by raising the **heart rate** (how often the pump contracts) and **stroke volume** (how much blood the heart pumps with each contraction), to increase the **cardiac output** (the amount of blood pumped from the left ventricle per minute). During exercise, heart rate can rise dramatically, from a resting rate of 60–80 beats per minute to a maximum rate of about 200 for a young adult.

While you are running, blood flow is diverted toward tissues that need it most.

Continued

SCIENCE EDUCATION CONTENT STANDARDS*

GRADES 5–8

LIFE SCIENCE

Structure and function of living systems

- Different tissues are, in turn, grouped together to form larger functional units, called organs. Each type of cell, tissue and organ has a distinct structure and set of functions that serve the organism as a whole.
- Specialized cells perform specialized functions in multi-cellular organisms. Groups of specialized cells cooperate to form a tissue, such as a muscle.
- The human organism has systems for digestion, respiration, reproduction, circulation, excretion, movement, control and coordination, and for protection from diseases. These systems interact with one another.

SCIENCE IN PERSONAL AND SOCIAL PERSPECTIVES

Personal health

- Regular exercise is important to the maintenance and improvement of health. Personal exercise, especially developing cardiovascular endurance, is the foundation of physical fitness.

SCIENCE, HEALTH & MATH SKILLS

- Measuring
- Observing
- Interpreting data
- Applying knowledge

* National Research Council. 1996. National Science Education Standards. Washington, D.C., National Academies Press.

This activity is adapted with permission from the HEADS UP unit on Diabetes/Cardiovascular Disease (2003). The HEADS UP unit was produced by the Health Education and Discovering Science While Unlocking Potential project of The University of Texas School of Public Health (www.sph.uth.tmc.edu/headsup) and was funded by a Science Education Partnership Award from the National Center for Research Resources of the National Institutes of Health.

Aerobic

You've probably heard this term many times, but do you now what it means? Aerobic comes from the Greek word *aeros* (air) and *bios* (life). Aerobic exercise refers to activities that involve or improve oxygen consumption by the body.

The American Heart Association recommends at least 30 minutes of moderate-to-vigorous aerobic activity per day for most healthy people. Examples of beneficial activities include: brisk walking, stair-climbing, jogging, bicycling, swimming, or activities such as soccer or basketball that involve continuous running.

Even moderate-intensity activities such as walking for pleasure, gardening or dancing may provide health benefits.*

*American Heart Association www.aha.org

For example, muscles in the arteries in your legs relax to allow more blood flow. Meanwhile, muscles in the walls of the arteries that take blood to your stomach and intestines tighten, or constrict, so these organs receive less blood. Breathing rate increases to match greater output by the heart. The whole system works together to give your hard-working muscles what they need at just the right time.

Have you noticed that after you finish a run, your heart rate and breathing rate don't return to normal immediately? Why? It's because the circulatory and respiratory systems have to "catch up." You may not have realized it, but while you were running, the muscles of your body produced so much carbon dioxide and other wastes that the body's systems couldn't keep up with the increased demand for elimination. So even after your run ends, your heart rate and breathing rate remain elevated until the excess wastes are eliminated.

If the heart and circulatory system have to do so much extra work when you exercise, why is exercise good for you? One simple answer is, "Use it or lose it." The heart is a pump made of muscle. It needs regular exercise to remain strong, healthy and efficient. The same is true of the circulatory system. Exercise helps keep the arteries strong and open. The contraction of leg muscles during exercise helps to move the blood along. Without exercise, body chemistry actually changes. These changes can lead to a whole range of unhealthy conditions and diseases. Bottom line: to maintain a healthy heart pump and circulatory system, "use it."

The pumping heart makes the sound we refer to as the "heartbeat." The "lub-dub" of a heartbeat comes from the sounds of blood being pushed against closed, one-way valves of the heart. One set of valves (tricuspid and bicuspid) closes as the ventricles contract. This generates the "lub" of our heartbeat. The other set of valves (pulmonary and aortic) close when the pressure in the ventricles is lower than the pressure in the pulmonary artery and aorta. This leads to the "dub" of our heartbeat.

As the heart beats, it presses the blood against the muscular, elastic walls of the arteries. Each artery expands as blood is forced from the ventricles of the heart. The artery wall then contracts to "push" the blood onward, further through the body. We can feel those "pulses" of blood as they move through the arteries in the same rhythm as the heart beats. The number of pulses per minute is usually referred to as pulse rate. The average pulse rate for a child ranges from 60 and 120 beats per minute.

Photo courtesy of NASA.

Astronaut Sunita Williams gives a "thumbs up" as she trains for the Boston Marathon while onboard the ISS. Not only did Suni run the marathon 216 miles above Earth, she ran with her sister, Dina Pandya, who completed the race in Boston. They finished the 26.2-mile race about nine minutes apart, with Dina crossing the finish line at 4:14:30 and Suni finishing on the ISS at 4:23:10.

Invention of the Stethoscope

This is the 1819 model of R.T.H. Laennec's first stethoscope, which he made himself and gave to a number of colleagues. The pieces are made of wood and brass, and fit together to form a one-piece stethoscope that is about 12 3/4-inches long.

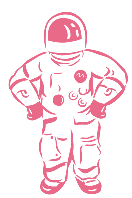
The first stethoscope was a simple rolled paper tube used by Rene Theophile Hyacinthe Laennec to listen to the heartbeat of an obese female patient. "I rolled a quire of paper into a kind of cylinder and applied one end of it to the region of the heart and the other to my ear, and was not a little surprised and pleased to find that I could thereby perceive the action of the heart in a manner much more clear and distinct than I had ever been able to do by the immediate application of my ear."*

*Laennec R.T.H. De l'Auscultation Médiate ou Trait du Diagnostic des Maladies des Poumon et du Coeur. 1st ed. Paris: Brosson & Chaudé; 1819.

Photograph © TESSERACT-Early Scientific Instruments, www.etesseract.com.

It's the Number

During exercise, red blood cells move more quickly to deliver oxygen through the system. But even when a person exercises, red blood cells do not carry MORE oxygen than they do at any other time. The hemoglobin in the blood fully loads up with oxygen each time it passes through the lungs, regardless of whether a person is resting or exercising. Only by moving more quickly through the circulatory system do r ed blood cells carry more oxygen to the tissues.



AstroBlogs!

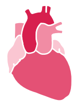
An AstroBlog entry for this activity can be found on page 8.

Did You Know?

Air is only about 21% oxygen (O_2) and 0.4% carbon dioxide (CO_2). When we breath, all of the gases in air enter our lungs. A tiny percentage of O_2 is removed. Similarly, the air we exhale contains a tiny bit more CO_2, which represents waste from our bodies.

Have students find out about other gases in air and how they affect us.

THE HEART IN SPACE AND ON EARTH



The heart does not have to work as hard in space as it does on Earth, because in space, the heart does not have to pump blood against the pull of gravity. In addition, astronauts are less active physically in space than they are on Earth. Measurements taken after space flights have shown that heart muscle mass can decrease by up to 10% during a mission. Astronauts try to counteract this reduction in heart muscle (and other muscles) by exercising on treadmills or stationary bicycles while in space. Of course, they have to strap themselves to the exercise equipment. Otherwise, they would float away!

Similar reductions in heart and other muscle mass can occur on Earth during extended illnesses or injuries that require bed rest. As late as the 1960s, heart attack patients were kept in bed for a long recovery to allow their hearts to "heal." Actually, this treatment had the opposite effect. The remaining active heart muscle became smaller and weaker due to lack of use, thus making the patient even more susceptible to future heart attacks. The approach today is to involve heart attack patients as soon as possible in rehabilitation programs that include exercise.

Photo courtesy of NASA.

Astronaut Michael E. Lopez-Alegria, Commander and Science Officer, NASA ISS Expedition 14, exercises on the Cycle Ergometer with Vibration Isolation System (CEVIS) as part of his endurance training program onboard the ISS.

TIME

Two class periods of 45–60 minutes, one to collect data and one to process, present and interpret measurements

MATERIALS

Teacher (see Setup)

- Stopwatch or watch with a second hand
- CD player or other player for music
- Two music selections without words (one song with a strong, up-tempo beat, and a second song that is slow and relaxing)

Each student will need:

- Access to a clock or watch with a second hand (or one stopwatch per team of students)
- Copy of student sheet
- Optional: Lab notebook

SAFETY

Do not have students find their pulse in the neck. Too much pressure on the carotid artery can stimulate a reflex mechanism that slows down the heart. Have students use their wrists (see Procedure, Item 2). Be aware of risks to students with respiratory illnesses, such as asthma. Make sure students understand that all activities are to be carried out in an orderly fashion. Always follow all district and school laboratory safety procedures.

SETUP & MANAGEMENT

Read all instructions before beginning. Select appropriate music. Data collection can be done individually by students or in teams of two, but data analysis should be done by students in groups of four.

Continued

PROCEDURE

1. Ask students if they think heart rate can vary, or if it always is the same. Ask, *What kinds of situations might cause heart rate to change?* [exercise, nervousness, lying down, standing up, walking up stairs, etc.]
2. Show students how to measure heart rate (beats per minute) by feeling blood surge through an artery. Have each student find his or her pulse by placing slight pressure on the wrist with the middle and ring fingers (see illustration, right sidebar). Tell students not to use the thumb, as it has a pulse of its own.

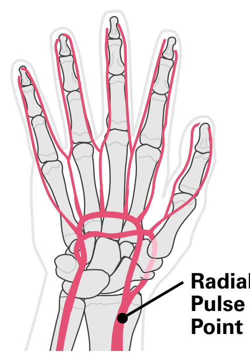
   Allow students to practice counting their pulse rates several times while you count off 15-second intervals. Instruct students to multiply their pulse count by four to determine how many times their hearts beat in one minute.
3. Distribute the student sheet to each student.
4. Review the activity sheet with students, stopping periodically to ask questions and make sure they understand the content.
5. Ask students to complete the prediction section for the first activity. Explain that predictions should be made in order, and for only one activity at a time. (The outcome of each activity may influence their predictions for the next.)
6. Have students sit quietly for minute. Then, instruct them to count their pulses while you time them for 15 seconds. To establish their resting, or beginning, pulse rates, students should multiply by four the number of pulses they counted in 15 seconds. Have them record this number on their activity sheets.
7. Instruct the class to sit quietly and listen to soft music for one minute. Then, have all students measure/record their pulse rates once again. Continue to lead students, as a class, for the first three activities on the sheet. During the deep breathing exercise, make a point of telling students when to inhale and exhale, to be sure they maintain a very slow rate. Instruct students to continue this pattern of slow breathing as they take their pulses.
8. Explain that students should complete the remaining activities listed on the sheet, in order. Each student may work with a partner, if desired. Remind students to record their pulse rate predictions at each step. Students should apply previous experiences when making each new prediction. Be sure students have sufficient time to regain their resting pulse rates before beginning each activity. You may wish to have students record the time it takes for them to return to their resting heart rates. (Pulse rates will recover more quickly if students are seated.) Some students may notice that their heart rates fall below their resting heart rates before returning to normal.

   Be sensitive to students who may feel uncomfortable doing jumping jacks or sit-ups in front of the class.
9. Instruct students to complete the data collection, analysis and conclusion portion of the activity sheet.
10. Have students form groups of four. Each group should share its data, create a presentation of its collective results (graph, table, picture, etc.), and give its presentation to the class.
11. Ask, *What have you learned about heart rate?* Students should have been able to observe that heart rate increases with increased levels of activity. Ask students, *What happened to your breathing during activities that increased your heart rate?* Students should have noticed that with physical activity, breathing rate and volume of air taken in increased. Help students to understand the connection between the body's need for more oxygen during exercise and the

Safety Note

Do not have students use the carotid artery in the neck to find their pulse. Applying too much pressure there could stimulate a reflex mechanism that can slow down the heart.

Radial Pulse Point



The safest and most common site to check pulse is on the thumb-side of the wrist (radial pulse).* Use the middle finger and ring finger together to apply slight pressure at the location shown above.

* Pulse site recommended for the general public by the National Heart, Lung, and Blood Institute, National Institutes of Health.

Taking the Pulse of Infants

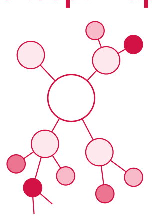
One of the easiest pulse sites to locate on small children and infants is the inside of the upper arm, between the elbow and shoulder (brachial pulse).

How Much Is Too Much?

You may have heard about athletes undergoing "blood doping" (taking medicines to stimulate overproduction of blood cells), or even having transfusions of red blood cells. These practices, intended to provide an athletic advantage, are prohibited in competitive sport. Their effects are very short-term, and they can harm the athlete's health.

Some athletes train at high altitudes (usually above 2,500 meters) to obtain a similar advantage in a fair way. At high altitudes, the body naturally adjusts to the reduced availability of oxygen by increasing the numbers of circulating red blood cells.

Update Concept Maps



EXERCISE

- Walking and running are excellent exercises to keep the circulatory system healthy and burning off extra calories. However, running presents a higher risk of injury than some other aerobic activities, such as brisk walking.[1]
- Walking, cycling, jogging and simulated stair climbing let you work out at a productive level, but don't require a lot of practice or equipment. They simply require you to get moving! Activities such as aerobic dancing, bench stepping, hiking, swimming and water aerobics also provide a great workout, but they take practice before one will get a consistent workout. The degree to which sports such as basketball, racquetball or volleyball benefit your circulatory system depends on how intensely you play.
- Even your immune system responds to exercise. Each year, more than 425 million cases of colds and flu occur in the U.S. But people who exercise regularly catch significantly fewer colds, and their infections last fewer days![2]

[1] www.acsm.org/AM/Template.cfm?Section=Current_Comments1&Template=/CM/ContentDisplay.cfm&ContentID=7994 (American College of Sports Medicine)
[2] www.acsm.org/AM/Template.cfm?Section=Current_Comments1&Template=/CM/ContentDisplay.cfm&ContentID=7997

heart's effort to deliver oxygen (by pumping blood more quickly).

12. To conclude the activity, have students write a journal entry describing connections between the intensity of activity and heart rate. Students should complete the following statements, and may want to draw pictures to accompany their words.
    - I discovered...
    - I learned...
    - I never knew...
    - I was surprised...
    - I enjoyed...
13. Have students add any new knowledge or ideas to their group concept maps.

EXTENSIONS

- Ask students, *Why would an athlete have a slower resting heart rate than a non-athlete?* Remember that the average resting heart rate for an adult is 72.

Consider the following average resting heart rates in beats per minute (bpm).

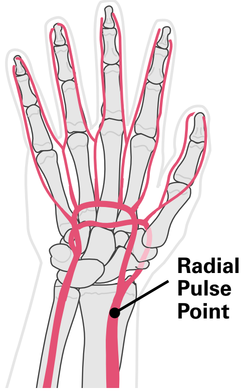
- Weightlifter 65 bpm
- Football Player 55 bpm
- Swimmer 40 bpm
- Marathon Runner 40 bpm

Ask, *Why would a slower heartbeat during rest indicate a healthier heart?* Explain that regular exercise strengthens the heart, and that a well-conditioned heart can pump the same amount of blood with fewer beats. In addition, cardiovascular exercise increases the size of cardiac muscle cells and the size of the heart chambers, so the heart actually increases in size. Therefore, even though the amount of beats per minute is lower, a healthy, fit heart pumps more blood per minute than a heart that is not accustomed to exercise. For the best health, exercise must be a lifestyle, not a temporary fitness "kick." Studies have found that non-activity for as little as three weeks can reduce heart muscle size and stroke volume (amount of blood pumped from the left ventricle in one contraction).

- Have students read and discuss "The Science of Cardiac Research" on page 7.

HEART RATE

Heart Rate



You can measure your heart rate by taking your pulse. Each pulse that you feel in your wrist represents one heartbeat. What do you think happens to your heart rate after different kinds of physical activity? You're about to find out, as you observe the response of your pulse rate to a variety of activities.

Sit quietly for one minute. Then, measure your resting heart rate by counting your pulse for 15 seconds. Multiply the total by 4 to obtain the number of beats per minute. To feel your pulse, *lightly* press your ring and middle fingers against the inside of your wrist (see illustration, left). *Do not use your thumb.*

____________ **beats in 15 seconds x 4 =** ____________ **beats/minute**

Make a prediction before you begin each activity below. Carry out each activity for one minute. Then, stop and immediately take your pulse for 15 seconds (multiply by 4 to obtain the number of beats per minute).

Before starting each new activity, sit quietly until your heart rate is close to your resting heart rate. Calculate the difference between your pulse rate after each activity and your resting pulse rate. Record the difference in the appropriate column (Increase, Decrease or Same).

TYPE OF ACTIVITY	PREDICTION ABOUT PULSE RATE (CHECK ONE BOX)			PULSE RATE IMMEDIATELY AFTER ACTIVITY	DIFFERENCE BETWEEN RESTING PULSE RATE AND RATE AFTER ACTIVITY (BEATS PER MINUTE)		
(Conducted for 1 Minute)	Increase	Decrease	Same	(Beats Per Minute)	Increase	Decrease	Same
1. Listen to soft, slow music.							
2. Listen to fast music.							
3. Breathe deeply.							
4. Walk briskly around the room.							
5. Do jumping jacks.							
6. Do sit-ups.							
7.*							

*Record Activity of Your Choice.

1. What effects do the different activities have on your heart rate?

2. Compare your data to your predictions. Then, compare your personal data with the data collected by your fellow group members. What did you discover? Were there any surprises? How will you present your findings to the class?

Cardiac Research

NSBRI Web site: www.nsbri.org

If one part of a car isn't properly maintained, it can affect the performance of the entire vehicle—especially if it's driven on a long trip. The same can be said for the human body. That's why, when it comes to fitness in space, it's important to create a program for the whole body.

To keep astronauts healthy on long missions, researchers with the National Space Biomedical Research Institute (NSBRI) are developing an exercise program that addresses many of the physical changes caused by microgravity. In one experiment conducted on Earth, participants stayed in a bed tilted at a six-degree angle, with their feet positioned at the higher end of the bed. In this position, the heart works about 15–20% less than it does under normal living conditions. In addition, blood pressure changes and work capacity is lessened. All of these things also happen to astronauts during long-term spaceflights.

The study involved 24 subjects divided into three groups. One group (the control group) stayed in bed and did no exercise. The remaining two groups performed exercise training while in bed. Half of the training subjects received a dietary supplement.

Strength training (rowing, lifting weights) forces muscles to contract enough to briefly interfere with blood flow into muscles. Endurance training exercise (swimming, running and cycling) forces large-muscle groups to contract regularly.

The test subjects exercised using a rowing machine (strength and endurance training in one) with their knees level to their hearts. Subjects also trained with the same regimen athletes use to achieve maximal physical benefit: a program consisting of base training, followed by threshold, interval and recovery training.

The base-training session consisted of moderate rowing exercise performed at a level where subjects could still carry on a conversation, but with slight shortness of breath. With threshold training (one to two days per week), subjects worked at their maximum sustainable effort. For example, at this level, professional marathon runners run hard, but do not sprint.

Photo courtesy of UT Southwestern Medical Center at Dallas.

To preserve astronaut health on long missions, scientists are researching the benefits of an exercise program to counteract space-related heart, lung, muscle and bone problems.

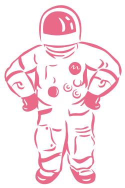
The interval-training segment was a high-intensity exercise effort in which subjects pushed their hardest for one to three minutes, building power and explosive energy. Each interval training session was followed by a recovery session, during which subjects exercised at low intensity. The regimen included one long, slow distance effort. Scientists found that this kind of exercise routine preserved heart size and function, muscle size and bone strength.

Researchers now are developing a single exercise routine for astronauts that will prevent damage to their cardiovascular systems, bones and muscles. On Earth, doctors already are using this type of exercise regimen with patients, and are seeing very satisfying results.

The NSBRI, funded by NASA, is a consortium of institutions studying the health risks related to long-duration spaceflight. The Institute's science, technology and education projects take place at more than 60 institutions across the U.S.

AstroBlogs

Create a "blog-wall" in your classroom to stimulate students' thinking and encourage students to express their ideas in writing. Periodically, post a copy of one of the AstroBlog entries below to spark students' interest. Suggested use with specific activities is noted with each entry.



AstroBlogs

It's another beautiful day in space! I just finished my lunch. Did you know that we eat tortillas instead of sliced bread up here? Why? Well, if you drop a few crumbs on Earth, they just fall to the floor. If I drop a few crumbs in space, they float around the spacecraft and get in everyone's noses or eyes, or worse, into the machinery. Not cool. But tortillas don't crumble. And besides, I like them with my fajitas, with lots of hot sauce to get my blood moving.

Speaking of blood, did you know that even my blood will change while I'm floating in microgravity? Yep! I get a little dehydrated up here. In fact, my blood plasma volume will drop as much as 20% during a space mission. Then my body reduces my red blood cells so my blood isn't too "thick." We have to work hard to keep hydrated. Luckily, our bodies will return to normal after we're back on Earth for a while. I can eat crumbly potato chips then, too!*

* www.esa.int/esaHS/ESAGO90VMOC_astronauts_0.html. Note: Another resource is Donald E. Watenpaugh. Fluid Volume Control During Short-term Spaceflight and Implications for Human Performance. *J. Exp. Biol.* 2001 204: 3209-32.