

THE SCIENCE OF THE
HEART AND
CIRCULATION



What Is Blood Pressure?

by

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RESOURCES

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www.umm.edu/news/releases/laughter2.htm

U.S. FOOD AND DRUG ADMINISTRATION

<http://www.fda.gov/hearthealth>

TEAMING WITH BENEFITS

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

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.



Dr. Jeffrey P. Sutton

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

Blood pressure, the force of blood against the walls of blood vessels, is responsible for the movement of blood through the arteries. When blood pressure is measured, two numbers are recorded. The first number represents the pressure while the heart is contracting to pump blood through the arteries. The second number represents the pressure while the heart is relaxing and refilling.

Students will measure their own blood pressure and learn about the health effects of high blood pressure.



WHAT IS BLOOD PRESSURE?

Students now have learned about the heart, the blood vessels, and blood. But what about blood pressure? Blood behaves like any other liquid and exerts pressure against the vessels in which it is contained. Blood pressure is the force of blood against the walls of blood vessels,

specifically the arteries, and is responsible for the movement of blood through the arteries. Blood pressure is much higher in arteries than in veins and capillaries.

Most students have had their blood pressure “taken” with a blood pressure cuff attached to a measuring device (sphygmomanometer). In this common practice, a cuff is secured just above the bend in a person’s elbow and inflated to increase pressure against the artery of the upper arm (brachial artery). A stethoscope is placed on the inside of the elbow to listen for the whooshing or pounding sound of blood flowing through the brachial artery. The cuff is inflated until no pulse or sound can be detected with the stethoscope. At this point, blood flow has stopped. Then, air is slowly released from the cuff, and the stethoscope is used to listen for the first sounds of blood flowing again through the brachial artery.

The force of blood flowing through the artery at this point, known as systolic pressure, is slightly greater than the pressure being exerted against the artery by the cuff. The systolic pressure indicates the amount of pressure in the artery while the heart’s ventricles are contracting. Systolic pressure is the larger (and first) of the two numbers in a reading.

Blood Pressure and Gravity

On Earth, the heart must pump against two factors: 1) the normal resistance of the arteries to blood flow and 2) gravity. Additional pressure is required to push blood to the brain and other parts of the body above the heart. The pull of gravity actually aids blood flow down to the lower limbs. But then, leg muscles must help to squeeze blood back up through the veins, to the heart, against the force of gravity. In space, gravity does not affect blood movement in any direction.

SCIENCE EDUCATION CONTENT STANDARDS* GRADES 5–8

PHYSICAL SCIENCE Motion and forces

- The motion of an object can be described by its position, direction of motion and speed. Motion can be measured and represented on a graph.

LIFE SCIENCE

Structure and function of living systems

- Living systems at all levels of organization demonstrate the complementary nature of structure and function. Important levels of organization for structure and function include cells, organs, tissues, organ systems, whole organisms and ecosystems.
- The human organism has systems for digestion, respiration, reproduction, circulation, excretion, movement, control and coordination, and for protection from disease. These systems interact with one another to protect us from diseases.

SCIENCE, HEALTH & MATH SKILLS

- Measuring
- Collecting data

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



AstroBlogs!

Continue the “blog-wall” with an AstroBlog entry written for Activity 8. It’s located on page 5.

A Laughing Matter

Laughter has been linked to the healthy function of blood vessels. Researchers at the University of Maryland Medical Center found that watching funny movies caused volunteers’ blood vessels to relax, thereby promoting increased blood flow.

www.umm.edu/news/releases/laughter2.htm

For instance, it is the “120” in a blood pressure reading of “120 over 80.”

Once systolic blood pressure is measured, air is slowly released from the cuff until the beating or whooshing sounds no longer can be heard through the stethoscope. Then, another reading is taken to measure diastolic pressure, which is the pressure in the artery while the heart is relaxing and refilling. Diastolic pressure is the smaller (and second) number reported in a blood pressure reading (it is the “80” in a reading of “120 over 80”).

One of the first accurate tools for measuring blood pressure was a mercury manometer (measures pressure with a column of mercury, similar to a thermometer). That’s why today, blood pressure always is reported as millimeters of mercury, even when it is measured by an aneroid device (calibrated dial with a needle) or a digital monitor.

A blood pressure measurement of 100 mm Hg indicates a force of blood pushing against the arteries sufficient to hold up a column of mercury that is 100 millimeters high. And a blood pressure reading of 120/80 (or 120/80 mm Hg), means the systolic and diastolic pressures are 120 and 80 millimeters of mercury, respectively. Knowing what these two values mean is important to health and well-being. Normal blood pressures vary by age (see table, above right).

When a person has pressure in the arteries that is considerably higher than normal during inactivity, we say he or she has high blood pressure (also called hypertension). A doctor must make this diagnosis, but readings higher than 140/90 usually signal high blood pressure. A rise in heart rate, increased blood volume, or a narrowing of the blood vessels all can cause high blood pressure by increasing the force of blood against the artery walls. Uncontrolled

Age-Appropriate Blood Pressure Ranges in mm Hg

Age	Systolic	Diastolic
Birth	50–70	25–45
Neonate (0–1 month)	60–90	20–60
Infant (1–8 months)	87–105	53–66
Toddler/pre-school (9 months–5 years)	95–105	53–66
School age (6 years)	97–112	57–71
Adolescent (15 years)	112–128	66–80
Adult (18+ years)	120	80

Source: *Pediatric Advanced Life Support Provider Manual*, American Heart Association.

high blood pressure is sometimes called the “silent killer,” because the individual who has it feels normal. High blood pressure can damage the arteries, heart, brain, kidneys or eyes in a number of ways.

Many factors contribute to hypertension. Some, such as genetics or age, cannot be changed. A person is more likely to develop high blood pressure if his or her parents have the condition. And the chances for developing hypertension increase with age. High blood pressure also can be caused by medical conditions, such as kidney disease and diabetes. Fortunately, we can control some of the risk factors for high blood pressure. For instance, we can get regular exercise, limit the consumption of alcohol, salt and saturated fats (fats that are solid at room temperature), maintain a healthy body weight, and reduce stress.*

Since there are so many negative health effects of high blood pressure, it may seem desirable to have low blood pressure (called hypotension). And it is true that people who exercise regularly tend to have lower blood pressure than those who are not as fit. However, blood pressure that is too low may signal the presence of underlying problems, such as a heart condition, low blood sugar, or even dehydration. Some experts say that readings below 90 systolic or 60 diastolic indicate low blood pressure, but since there are

* <http://www.americanheart.org/presenter.jhtml?identifier=4650>

Continued



so many factors involved, these numbers can be misleading. What is normal for one person might be considered low for someone else.

TIME

10 minutes for setup; two 45–60 minute sessions

MATERIALS

Teacher (see Setup)

- Electronic blood pressure monitor with a self-inflating cuff (sold in drugstores)

Each student will need:

- Lab notebook

SAFETY

Make sure all students are seated while taking blood pressure. Over-inflation or excessive duration of inflation of the blood pressure cuff may cause discomfort or injury. Always follow all district and school laboratory safety procedures. It is a good idea for students to wash their hands with soap and water before and after any science activity.

SETUP & MANAGEMENT

Obtain an electronic blood pressure monitor with a self-inflating cuff. Do not use a manual blood pressure monitor because students easily could over-inflate the cuff and cause injury. Read and follow the manufacturer's instructions, which can vary between models.

Place the monitor in a central location, where students can take turns measuring their blood pressure. While students are waiting their turn at the blood pressure center, teams may begin to research and discuss the provided questions (see Procedure, Item 6).

If a blood pressure monitor is not available, ask students to measure their blood pressure, under the supervision of their parents/guardians, at a public blood pressure kiosk, usually found in drug or grocery stores.

Have students work in teams of two.

PROCEDURE

1. Ask, *Have you ever had your blood pressure taken? If so, what do you think was being measured?* Explain that when a health care provider takes a patient's blood pressure, he or she briefly restricts the flow of blood through one of the patient's arteries by applying pressure to the artery. The health care provider then slowly reduces the pressure until he or she hears (using a stethoscope) the sound of blood forcing its way through the vessel. The measurement taken at this point is called the systolic pressure. The health care professional continues to reduce the pressure until he or she no longer hears any sounds. The measurement taken at this point is called the diastolic pressure.

Explain that the top number in a blood pressure reading (systolic) represents the pressure when blood is forced from the ventricles, and the bottom number (diastolic) represents the pressure when the ventricles are at rest, or between beats (filling with blood). Remind students that even when blood is not being forced from the heart, it continues to flow. There always is a certain amount of pressure maintained in the blood vessels.

2. With a student volunteer, demonstrate how to take a blood pressure reading. Have the student sit in a chair with feet flat on the floor and with shirt sleeves rolled up. Place the monitor cuff just above the bend of the student's upper arm. Ask the student to raise his or her arm to the level of the heart. Place your arm underneath the student's arm to support it. Ask the student to relax his or her arm. Take a reading according to the manufacturer's instructions for the monitor.
3. Mention that several factors might lead to an inaccurate blood pressure reading. These include physical activity (standing up quickly, walking

Can High Blood Pressure be Cured?

High blood pressure is the most common disease of the circulatory system. For most people, it cannot be "cured." But it can be controlled by changes in lifestyle (exercise and diet) and/or by medications. Some medicines relieve pressure by causing the arteries to relax and open up. Others lower blood pressure by reducing the heart's output, or by causing the body to lose salt and water. Of course, each medicine has side effects, and a healthy diet and exercise always are important factors in the treatment of high blood pressure.

www.americanheart.org/downloadable/heart/119626772541850%20WhatIsHBPMedication%209_07.pdf

A Silent Killer

According to the American Heart Association, almost one-third of adult Americans have high blood pressure. And about a third of those people don't even know they have it! They may have high blood pressure for years, unaware that it is damaging their heart, blood vessels and other tissues.

www.americanheart.org/presenter.jhtml?identifier=2114

Reliable Sources

Reliable information about heart health and related topics is available online at the following Web sites.

American Heart Association

www.americanheart.org

Centers for Disease Control and Prevention

www.cdc.gov

MedLine Plus*

<http://medlineplus.gov>

National Heart, Lung, and Blood Institute

www.nhlbi.nih.gov

U.S. Food and Drug Administration

www.fda.gov/hearthealth

*Health information is available in more than 40 languages.

fast, etc.), posture, medications, emotions, temperature and diet. Ask, *Why would blood pressure be an important measure of a person's overall health? Do you think it is more dangerous to have high or low blood pressure? Why?* Remind students of earlier lessons about the heart and valves. Just as too much air pressure can damage an over-inflated tire, high blood pressure, over time, places additional stress on the heart, valves,

arteries and other organs of the body.

4. Have teams of two students visit the blood pressure center, one team at a time. Students should take turns using the blood pressure monitor and recording their pressure readings in their lab notebooks. Be sure students record their results by writing the higher number on top and the lower number below (for example, 115/75). You may want teams to begin working on their research questions (see Item 6, below) while they wait to use the blood pressure monitor.
5. Discuss healthy ranges for blood pressure (see table, p. 2). Remind students that if their readings do not fall within the healthy range, they may want to have their blood pressures checked by a health care professional. You may wish to construct a class graph of students' blood pressure measurements.
6. Have each student team investigate one of the following questions related to blood pressure. Each team should conduct its research on the Internet and/or in the library, and then present its findings to the class during the next class period. Teams may want to



Astronaut Jeffrey N. Williams, Science Officer and Flight Engineer, NASA ISS Expedition 13, holds up two finger cuffs on a Continuous Blood Pressure Device. Small, portable medical devices created for use by astronauts also can be used here on Earth.

develop their own topics for investigation. Students should include lists of the sources they consulted.

- What is the relationship between eating high-fat foods and blood pressure?
- How does family history (for example, whether one of your parents has high blood pressure) affect your chances of developing high blood pressure at some time?
- How does diabetes affect a person's chances of having high blood pressure?
- What effect does walking or running three times per week have on blood pressure?
- Do stress levels influence blood pressure? If so, what is the effect?
- How does heavy alcohol consumption affect blood pressure?
- How does eating a lot of salty food affect blood pressure?
- What types of foods, if any, help to maintain blood pressure in a healthy range?



AN ASTRONAUT'S POINT OF VIEW

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

Exercise! You can't imagine how important it is to those of us who travel through space. We don't just exercise for a half hour or an hour. Sometimes we exercise several hours a day! Why so much?

Well, first, we need to keep strong. Floating around inside the shuttle is easy, but working outside, in a pressurized suit with tools, is really hard. You have to be fit to do this kind of work. More important, exercise helps to slow down, or even reverse, some of the changes that micro-gravity causes in my circulatory system. Exercise even*

helps to relieve the stuffy head I get when extra blood collects in the upper part of my body.

When astronauts exercise, we often collect information about our heart and breathing rates, our muscle mass and our strength. That data is really important for planning long-term spaceflights. Speaking of which, did you know we are working towards launching the first human mission to Mars? That trip will last more than two years. We need to know how to exercise in space, so that we don't end up being Martian couch potatoes when we get there!

* www.esa.int/esaHS/ESAGO90VMOC_astronauts_0.html

