BioEd℠

THE SCIENCE OF

MUSCLES AND BONES

Muscles and Bones: Nutrition

by

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RESOURCES

For online presentations of each activity and downloadable slide sets for classroom use, visit http://www.bioedonline.org or http://www.k8science.org.

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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 www.nsbri.org.

OVERVIEW

Students learn about the nutritional needs of healthy bones and muscles, and how to make good food choices, especially in terms of getting enough calcium.

ACTIVITY

Muscles and Bones: Nutrition

Food provides energy to the body for growth, maintenance and activity. It also supplies building blocks for bones, muscles and other tissues of the body. Making the right food choices can promote and maintain good health throughout life.

Most teenagers do not eat enough foods that promote bone and muscle health. To develop and maintain strong bones, their diets should include plenty of calcium-rich foods, like low-fat dairy foods and green leafy vegetables. Vitamin D, which is made in the skin when it is exposed to mild doses of sunlight, helps the body to absorb calcium. Vitamins A and C also are necessary for proper bone development.

Bone is remodeled throughout life. Old bone is removed and new bone is formed. During childhood and teenage years, new bone is added faster than old bone is removed. As a result, bones become larger and denser. Bone formation occurs faster than bone removal until about age 30. After this age, breakdown of bone begins to occur at a faster rate than bone formation. Bone loss accelerates with age and can be particularly rapid in women in the years around menopause. This can lead to osteoporosis, or "porous bone," a condition in which bones are not rebuilt as quickly as they are broken down. These weakened bones are more likely to fracture. Teenagers can help prevent osteoporosis later in life by including enough calcium in their diets and by exercising.

Protein, found in meats, fish, dairy products and beans, is used by the body to build muscles and the scaffolding within bones. In addition, protein can serve as an energy source for growth and movement. Energy also comes from carbohydrates (breads, pasta, vegetables and sugars), fats and oils.

The "Nutrition Facts" label on packaged foods can be used to make better food choices. This label lists the amounts of nutrients present in grams or as a percentage of the recommended Daily Value. A food product that claims to be a "good source of calcium" must contain at least 100 milligrams (mg) of calcium per serving. This is about one tenth of the total amount of calcium needed by a person each day.

SCIENCE, HEALTH & MATH SKILLS

GRADES 5–8

- Gathering information
- Comparing
- Charting
- Drawing conclusions
- Inferring

CONCEPTS

- Good eating habits help maintain bone and muscle strength.
- Some foods, such as complex carbohydrates, are good energy sources.
- Other foods provide building materials for bones and muscles.

TIME

10 minutes for set-up; 45–60 minutes to conduct the activity.

Astronauts' Muscles and Bones

Conditions in space, where bones do not have to work against the pull of gravity, cause astronauts to lose bone density and muscle size and strength. While this does not affect their performance in space, it can make them too weak to carry out routine tasks when they return to the gravity environment on Earth. Countermeasures to help maintain bones and muscles include resistance exercises, such as rowing or using a stationary bicycle, and maintaining a carefully balanced diet.

The History of Food Labels

1906 - Federal government begins regulation of food safety and quality.

1913 - Food packages are required to state the quality of their contents.

1938 - Every processed, packaged food is required to have a label containing the name and weight of the product and a list of ingredients.

1966 - The Fair Packaging and Labeling Act passes. All products shipped across state lines are required to have accurate labels.

1973 - Nutrition labels are required on all foods that have one or more added nutrients and on foods that claim to have a specific nutritional property or dietary use.

1984 - Labels are required to include sodium content.

1990 - All food labels are required to list nutritional information, standard serving sizes and uniform health claims.

Source: US Food and Drug Administation.

NUTRIENTS: SUBSTANCES IN FOOD NEEDED BY THE BODY

Carbohydrates, a major source of energy, are found in fruits, vegetables, grains and flour. Fiber, starches and sugars all are carbohydrates. Most US students tend to eat too many snacks and prepared foods that are high in sugars, instead of choosing vegetables, breads and pasta that contain less sugar and more starches and fiber.

Fats are rich sources of energy. Cooking oils, lard, butter, margarine and shortening are almost pure fat. Foods that contain large amounts of fat include some red meats, dairy products, chocolate, cakes, cookies, fried snacks (chips, crackers, etc.) and nuts. Fatty foods should be eaten sparingly because the body will store any unused energy as additional body fat. Fats from plants (like olive or canola oil) or fish generally are healthier than butter, fatty meat, lard or margarine.

Proteins are building blocks for the body. Muscles, hair, skin and nails are mostly protein, as is the flexible collagen network within bones. Proteins help carry out essential chemical reactions within every cell. The body can use protein as a source of energy. Meats, fish, poultry, eggs, low-fat dairy products, beans, peas and nuts are good sources of protein.

Vitamins are substances needed by the body in small amounts. Vitamin D, for example, helps the intestine absorb calcium into the blood, so it can be delivered to bones. Vitamin C is needed to make collagen, which is used in building bones and connective tissues. Eating a variety of fruits and vegetables every day helps ensure that the body has all of the vitamins it needs.

Minerals have a number of roles. Calcium, the most abundant mineral in the body, makes bones hard and is important to muscles and the nervous system. Good sources of calcium are low-fat dairy products, dark green leafy vegetables, tofu, sardines with bones and calcium-fortified juices and cereals. Phosphorous also is important for bone health.

MATERIALS

Each group will need:

- Several Nutrition Facts labels from a variety food packages

Each student will need:

- Copy of student sheets

SETUP & MANAGEMENT

Have students bring in nutrition labels from food packages. Put a mixture of labels from different kinds of foods in plastic bags and place them in a central location. Have students work in groups of 3–4.

PROCEDURE

1. Have each student make a list of everything he or she ate during the past 24 hours (including snacks).
2. Distribute the "Healthy Choices" page. Point out the basic food groups shown on the page and have students identify the food group category in which each item on their lists belongs. Some items may fall into more than one food category. Encourage students to discuss these foods within their groups to decide where they belong. For example, a large portion of lasagna might count as one serving from the bread/pasta group, one serving from the dairy group (cheese) and one serving from the meat group (ground beef or sausage).
3. Have each student make a chart and list all of the food groups in separate columns. Students then should record in the appropriate column what they ate over the past 24 hours and the number of servings eaten for each item listed. Have students compare their totals to the recommended numbers of servings.
4. Ask, *How many of you had the recommended amounts of fruits, vegetables and dairy products? Did anyone exceed the recommendations for fats*

and sweets? How about breads and pastas? Distribute the "Calcium for You" page, which focuses on calcium—a nutrient important for strong bones. Have students refer to their "Healthy Choices" sheets and identify any foods that they ate that are sources of calcium. Next, have them calculate the number of milligrams of calcium that they included in their diet over the past 24 hours.

5. Ask students, *Is there room for improvement in your eating habits?* Have the Materials Manager from each group collect a bag of nutrition labels from the materials table. Have each group observe their food labels and rank the foods from best to worst in terms of the nutrients needed for bones and muscles (calcium, protein, Vitamins D, C, and A). Then have groups share their lists with the rest of the class.
6. Conclude by asking students to suggest simple changes they could make to improve their diets. Record their ideas. You may want to discuss the word "diet" with students. Even though it is frequently used to describe an eating program to promote weight-loss, "diet" also can mean the usual things that a person eats.

EXTENSION

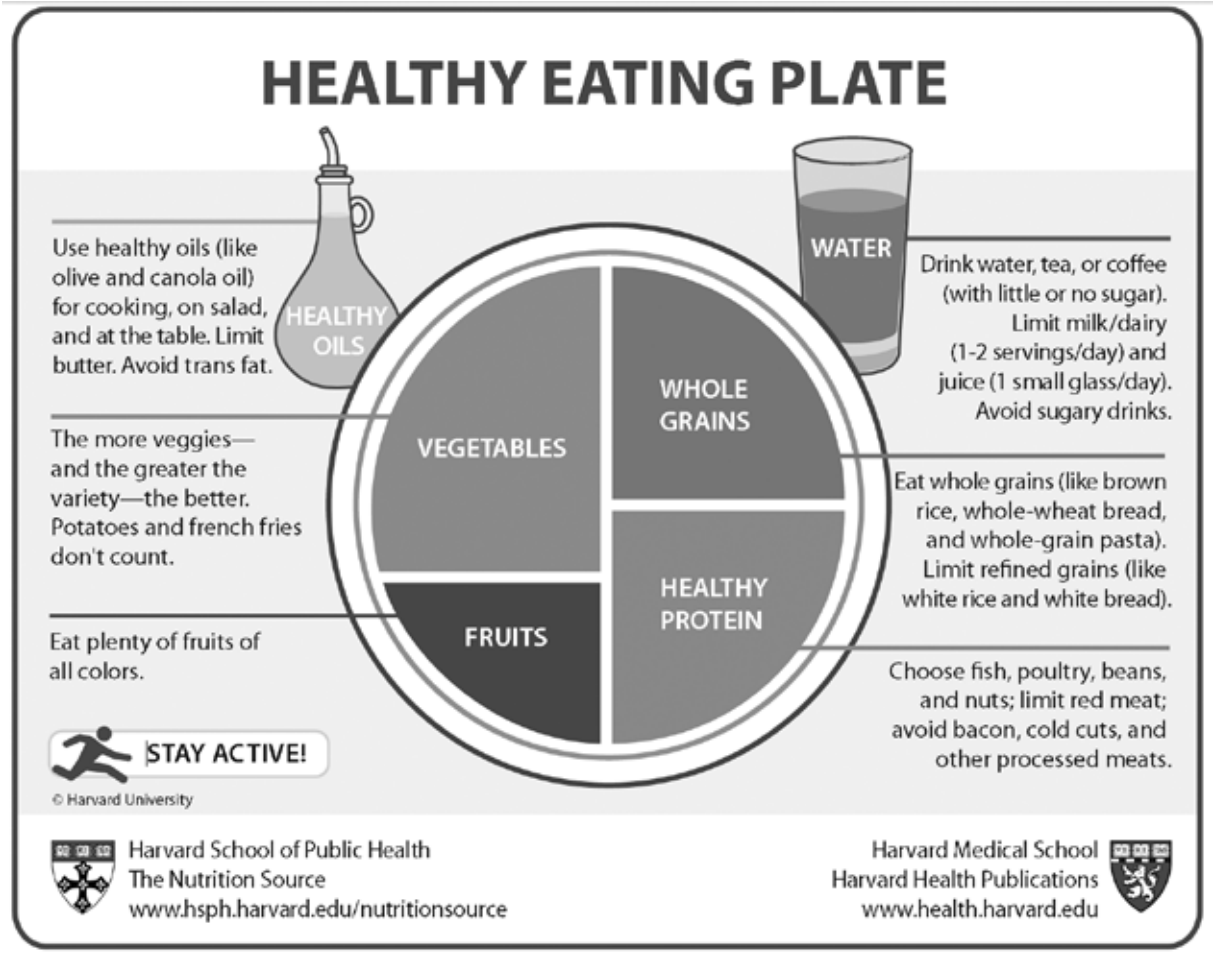
- Have students consult the Internet for additional information on diet and nutrition. "The Nutrition Source" from Harvard's School of Public Health (www.hsph.harvard.edu/nutritionsource/), U.S. Food and Drug Administration (www.fda.gov), National Institutes of Health (www.nih.gov), and the U.S. Department of Agriculture (www.nal.usda.gov/fnic/foodcomp) are good places to start. ◆

Osteoporosis

Men as well as women can suffer from osteoporosis—the development of weak, "porous" bone. An inadequate supply of calcium over a lifetime is believed to contribute to the development of osteoporosis. Approximately 6 out of 10 teenage boys and 8 out of 10 teenage girls do not have enough calcium in their diets.

ACTIVITY
HEALTHY CHOICES

1. List all the foods you have eaten in the past 24 hours, by meal (including snacks), on a separate sheet of paper.
2. Compare the foods in each meal to the recommendations in the Healthy Eating Plate below. Keep in mind that many foods combine items from two or more groups.
3. On another sheet of paper, make a chart with each food group shown in the diagram. List the foods you ate under the appropriate food groups on the chart.
4. Compare the amounts and kinds of foods that you ate to the recommendations. How did you do?



ACTIVITY

CALCIUM FOR YOU

Sources of Calcium in Food

(approximate mg)

Dairy Foods	mg/serving
Milk (1 cup)	300 mg
Cheese (2 slices)	200 mg
Cottage cheese (1 cup)	140 mg
Yogurt without fruit (1 cup)	415 mg
Yogurt with fruit (1 cup)	315 mg
Ice cream or ice milk (1 cup)	150 mg
Frozen yogurt (1 cup)	200 mg
Pudding or custard (1 cup)	150 mg

Non-Dairy or Combination Foods	mg/serving
Collard greens (1 cup)	357 mg
Sardines with bones (3 oz)	350 mg
Tofu (1/2 cup)	300 mg
Cheese pizza (1/4 of a 12 inch pizza)	250 mg
Macaroni and cheese (1 cup)	250 mg
Grilled cheese sandwich (1 sandwich)	250 mg
Lasagna (1 cup)	250 mg
Calcium-enriched orange juice (3/4 cup)	225 mg
Pancakes or waffles (2 waffles or 3 pancakes)	100 mg
Soup prepared with milk (1 cup)	150 mg
Calcium-enriched cereal (1 cup)	150 mg
Dry roasted almonds (1/4 cup)	100 mg
Chili con carne with beans (1 cup)	100 mg
Taco with cheese (1 taco)	100 mg
Cooked broccoli (1 cup)	90 mg
Tortillas (3)	80 mg
Scrambled, boiled or fried eggs (2 eggs)	80 mg
Baked beans (1/2 cup)	80 mg
Milk chocolate (1 1/2 ounce bar)	80 mg
Bread (1 slice)	40 mg

Source: www.fda.gov

1. Take a look at the foods list you made for the "Healthy Choices" sheet. Refer to the "Sources of Calcium" lists above and to the right on this page and identify any calcium-rich foods on your list. Record these foods on the table below—along with the number of servings you ate. (Use a separate sheet of paper if necessary.)

2. Find the number of milligrams (mg) of calcium per serving for each of the foods you identified and record it on the table below. You may need to estimate the amount of calcium in some foods based on the ingredients of similar foods. Multiply the number of servings by number of mg of calcium to find the total amount of calcium that you received with each food. Add the totals for each food to figure out how much calcium your body took in during the past 24 hours.

3. The recommended amount of calcium for teenagers is 1,200 milligrams per day. How does this compare to your amount?

Calcium-rich Foods	Number of Servings	Amount of Calcium (mg)	Total Calcium (mg)
		Total Calcium in 1 Day	