NSBRI TAP Classroom Activity

Title: **HEAD-DOWN TILT EXPERIMENT**

Grade Level: 5-8

Content Area: Life Science

National Science Content Standards:
Standard C. Life Science
- Structure and function in living systems (Grades 5-8)
- Regulation (Grades 5-8)

Behavioral Objectives:
- The student uses scientific inquiry methods during field and laboratory investigations.
- The student will construct tables and charts.
- The student knows the relationship between structure and function in living systems.

Lesson Objective:
- In this lesson the students will explore one of the effects of microgravity on the human body. They will experience the effects of fluid shift in the body and make observations and record physiological differences in tissue volume during the body's period of adjustment.

Time:
- Two 45 minute class periods; One 90 minute block period

Materials:
1. A tape measure
2. The seat of a desk
3. Pillow or coat
4. A clock with a second hand
5. Two 3-centimeter long pieces of masking tape
6. Digital camera (before and after photos)

This lesson was developed by participants and staff of the Teacher Academy Project at Texas A&M University with support from the National Space Biomedical Research Institute through NASA NCC 9-58.

Procedure:

Pre-activity Preparation

- Suggest that the girls wear jeans to class on this day.
- Select teams of two. Note: Students can choose who will be test subject.
- Tell the students that they are simulating being astronauts. This may reduce their inhibitions to perform the test.

Activity

1. Choose a test subject from each team.

2. Prepare to measure 1 of the test subject's legs and head by placing a 3-centimeter piece of tape on their calf and forehead.

3. Leave this tape in place throughout this activity.

4. To obtain the "standing calf and head measurements," measure the circumference of the test subject's leg and head in **mm** while the test subject is standing. Measure directly on the tape, be accurate. NOTE: All group members must record this measurement and ALL OTHER DATA. One member of the group will have to do the entire recording for the test subject so that everyone has a dataset.

5. Record measurements (in **mm**) in the "standing" box on the data table.

6. Observe the test subject's facial characteristics and record the characteristics on the data table in the "facial observations standing" box. (Facial observations include looking for the following characteristics: eye-size and shape, color, swelling, ear-color, shape, or sinus stuffiness).

7. Question the test subject about his/her own feelings or sensations. Record these sensations in the "test subject's sensations standing" box on the data table.

8. To determine the test subject's STANDING pulse, have the test subject stand up for 3 minutes. At the end of the 3 minutes, the "pulse taker" should take the test subject's pulse for 15 seconds. Multiply this number by 4 to calculate the pulse rate per minute. Record this pulse on the data table in the "standing pulse rate" box.

9. Ask the subject to lie down on the floor and support their head with the coat or pillow.

10. After 3-5 minutes, measure the subject's calf and head in **mm** in exactly the same spot (over the tape) while the subject is lying flat. Record these measurements in the "lying flat" boxes.

11. Observe the test subject's facial characteristics and record the characteristics on the data table in the "facial observations lying flat" box. (Facial observations include the following characteristics: eye-size and shape, color, swelling, ear-color, shape, or sinus stuffiness).

12. Question the test subject about his/her own feelings or sensations. Record these sensations in the "test subject's sensations standing" box on the data table.

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13. Obtain a LYING FLAT pulse rate for the test subject. At the end of the 3-5 minutes, take his/her pulse for 15 seconds. Multiply this number by 4 to calculate the pulse rate per minute. Record this pulse rate on the data table as the "lying-flat pulse rate".

14. To begin the feet-up portion of this activity, the test subject should continue to lie on the floor and elevate his/her feet and legs on the seat of a desk. A timer should begin timing for 5 minutes.

15. A. After 5 minutes have passed; *while the test subject is still lying down and the feet are on the seat*, re-measure the calf and head in **mm**, on the tape in exactly the same spot. Be accurate. Record this measurement in the "after 5 minutes-head down-feet up" calf and head measurement boxes.
    B. *While the test subject is still lying down,* observe the test subject's facial characteristics and record the characteristics on the data table in the "facial observations after 5 minutes" box. (Facial characteristics such as eye-size and shape, color change, swelling, ear-color, shape, or sinus stuffiness).
    C. *While the test subject is still lying down,* question the test subject about his/her own feelings or sensations. Record these sensations under "test subject's sensations after 5 minutes" box on the data table.
    D. Again, *while the test subject is still lying down* take his/her pulse for 15 seconds. Multiply this pulse by 4 to calculate the pulse rate per minute and record it on the data table under "pulse rate after 5 minutes."

16. After another 5 minutes have passed, *while the test subject is still lying down,* repeat the same procedure as in # 15. Record these results in the "after 10 minutes" boxes. Repeat the same procedure as in # 15 two more times to fill the "after 15 minutes" boxes and the "after 20 minutes" boxes.

17. After recording data at the 20-minute time, the test subject should sit up and when he/she has reoriented to the upright position, rise slowly.

18. Write a half page description of your data, noting trends.

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Head-Down Tilt Experiment – Data Table

Positions	Calf Measurement	Head Measurement	Facial Observations	Test Subject's Sensations	Pulse Rate
Standing					
Lying Flat					
After 5 min.- head down- feet up					
After 10 min- head down- feet up					
After 15 min- head down- feet up					
After 20 min- head down- feet up					

*Note: All measurements are in millimeters (**mm**) and the pulse rate is heart **beats/minute**.

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Extensions:

- Technology may be integrated into this lesson by acquiring a heart rate probe (talk to your AP Biology teacher about probes) and using it to record the required heart rate data. You can compare the results from the technology application to results gained from tactile acquisition (manner in which the pulse was taken in this lesson) of heart rate data.
- Reverse the procedure after the 20 min. check again sitting/standing every 5 min. to see when and if it returns to original.
- Create a spreadsheet of data for the class and then graph as a whole to show composition. Find average and outliers (data not lying within the overall population).

Resources:

Human Physiology in Space (pp.63-66) by R. J. White & B. F. Lujan, NASA Life and Biomedical Sciences and Applications Division, 1994. Available online at: http://www.nsbri.org/HumanPhysSpace/

Lesson reviewed for scientific validity by Dr. Michael Delp, Professor/NSBRI Researcher, Department of Health & Kinesiology, Texas A&M University

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Background Information:

*Note: This information should be presented after performing the lab experience to explain what the body is doing under these new conditions.

All astronauts, when they leave the gravity field of Earth, experience the phenomenon known as the "Puffy-Head, Bird-Legs" Syndrome. The astronauts report a "stuffiness" of the sinuses, together with a feeling of "fullness" in the head, and "puffiness" of the face. Also, measurements taken before space flight, during space flight, and just following space flight have shown that the legs do change their shape in-flight; they decrease in volume and actually look skinnier compared to the preflight leg shape. Astronauts have termed this curious condition "bird legs." After space flight, measurements show that the legs return to a normal shape. These reported sensations in the head and measured changes in the legs support the hypothesis of substantial headward fluid shifts in-flight when gravity is no longer pulling fluids toward the feet.

It is interesting that measurements of leg circumference taken in space on those astronauts with larger legs show a proportionally larger decrease in leg volume than those with smaller legs. This is explained by the fact that the more muscle a person has in his limbs, the more fluid and blood flow is required to "feed" those muscles. The more fluid and blood there is, the more there is to lose. Another interesting and important fact to keep in mind about space flight is that the fluid shift actually begins on the launch pad: because the astronaut is seated in the space shuttle in a reclining position with his/her legs elevated, sometimes for several hours prior to launch.

To simulate the headward shift of body fluids here on Earth, scientists use the bed rest head-down tilt method. In this "model," subjects are recruited to stay lying down in a bed that is tilted five degrees down from the horizontal at the head, while the legs are elevated five degrees above the horizontal. Some studies of this type last only 24 hours, but others have lasted up to about a year.

An interesting point to make here is that during the early portions of this head-down tilt orientation, a subject's stroke volume (the amount of blood pumped by the heart with each heart beat) increases from about 75 ml/beat to about 90 ml/beat. This is entirely expected, because there is a rush of fluids to the upper part of the body and the heart then has more blood to force out during each beat. In addition, to compensate for this increase in stroke volume (to keep the total amount of blood pumped by the heart per minute relatively stable), the subject's heart rate decreases. Therefore, during the portion of this Student Investigation where you are determining the effects of fluid shifts on tissue volume, don't be surprised when you obtain lower values for the subject's heart rate. This is normal.

This exercise is not only space based, but it also has an earthly correlation. Many of the topics that are dealt with in space life sciences have an earth bound correlation. Dr. Michael Delp of Texas A&M University is presently doing studies on this very subject.

Delp and recent Texas A&M graduate Matt McCurdy studied the mechanisms by which astronauts are unable to maintain constant blood pressure. The study, part of McCurdy's undergraduate Honor's thesis and written by McCurdy, appears as a featured article in a special microgravity issue of the Journal of Applied Physiology.

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On Earth, gravity forces blood down into the legs and feet, so blood vessels, made of smooth muscle, constrict to prevent blood from pooling in the legs, which helps maintain proper blood pressure and blood flow to the brain and upper parts of the body. But in space and in the absence of gravity, blood automatically goes to the head. Blood vessels in the legs then relax, and become weak and flaccid from disuse. And if, when astronauts return to Earth, their vessels cannot constrict to force blood up to the brain, some astronauts lose their ability to properly maintain blood pressure and may become unconscious. "It's the equivalent of a weightlifter who normally lifts weights a lot and then stops for a long period of time," Delp says. "You lose the skeletal muscle tone. In space, the astronauts' blood vessels don't stay constricted and they lose their tone, or their ability to generate force."

Delp says that in space, astronauts experience changes in hormone release. Some researchers - including McCurdy and Delp - suggest that these hormone changes enhance the blood vessels' dilatory response, causing the vessels to dilate more than usual and contributing to the astronauts' low blood pressure. In the first study to directly address enhanced dilatory response, McCurdy found that changes in hormone release do not enhance the blood vessels' dilatory response. The inability to maintain blood pressure is of great concern to the elderly, as well. Delp says that the majority of emergency room cases involving an elderly person typically relate in some way to **orthostatic intolerance**. "Typically, they get up and start to pass out, and fall and break a hip," or something else, Delp says.

Delp says the mechanisms responsible for the astronauts' inability to maintain blood pressure are in many ways similar to the ones responsible for the same condition in the elderly. "Even though we're funded by NASA and we're specifically interested in what happens in space," Delp says, "it is a very relevant problem to study for the general health of people."

(Article on Michael Delp can be found at:
http://www.tamu.edu/univrel/aggiedaily/news/stories/00/070700-8.html)

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Student Assessment (Student Copy)

Title: **HEAD-DOWN TILT EXPERIMENT**

1. After completing and graphing this activity, look over the data collected and draw a conclusion about the effects of a head-down tilt orientation to the human body.

2. What is the main factor responsible for the headward fluid shift that occurs in space and, the head-down tilt simulation?

3. The Moon has one-sixth the amount of gravity that the Earth has, and Mars has one-third the amount of gravity that the Earth has. On which of the two, the Moon or Mars, would you experience a greater headward shift of fluid compared with your normal condition on Earth? Why?

4. Draw a picture of the body and show (using arrows) where body fluids are moving/congregating during this activity. What physiological evidence from your data table support where fluids have moved?

5. Give 2 reasons why you might have experienced "experimental error".

6. Based on the data you have collected, how could you improve data collecting?

7. It is stated in the lesson that fluid shift has a earth based model. What is that model and what complications can occur with this situation?

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Student Assessment

Title: **HEAD-DOWN TILT EXPERIMENT**

1. After completing and graphing this activity, look over the data collected and draw a conclusion about the effects of a head-down tilt orientation to the human body.

   Ans. Blood volume decreases in legs
   Blood volume increases in neck (head)

2. What is the main factor responsible for the headward fluid shift that occurs in space and, the head-down tilt simulation?

   Ans. In space the blood moves to the top of the body (headward fluid shift) because of less gravitational pull. In the head-down tilt simulation, gravity pulls the blood to the bottom half of the body.

3. The Moon has one-sixth the amount of gravity that the Earth has, and Mars has one-third the amount of gravity that the Earth has. On which of the two, the Moon or Mars, would you experience a greater headward shift of fluid compared with your normal condition on Earth? Why?

   Ans. The moon; 1/6 Earth gravity on Moon; 1/3 Earth gravity on Mars. Less gravity leads to more fluid shift.

4. Draw a picture of the body and show (using arrows) where body fluids are moving/congregating during this activity. What physiological evidence from your data table support where fluids have moved?

   Ans. The shift or arrow should be pointed to the top of the head.

5. Give 2 reasons why you might have experienced "experimental error".

   Ans. Method of data collection such as human error (not getting a accurate pulse rate) and inconsistency with times that the data is taken (was the data taken at the same interval each time).

6. Based on the data you have collected, how could you improve data collecting?

   Ans. Use an instrument that is more precise in taking measurements of heart rate (heart rate probe).

7. It is stated in the lesson that fluid shift has a earth based model. What is that model and what complications can occur with this situation?

   Ans. The model is orthostatic intolerance in the elderly and a complication of the conditions is the high probability of falling and having a major fracture.

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