

The Connection between Respiration and Heart Rate

Introduction

The purpose of this lesson is for students to determine the direct relationship between respiration and heart rate in their body. This lesson is applicable to middle school science students, and will certainly connect to their prior experiences of various forms of exercise. A secondary purpose is for students to draw conclusions about how smoking, diseases of the heart or lungs, and blood diseases can alter the relationship between respiration and heart rate. This lesson may or may not fit into one class period, depending on class time.

Student Background Knowledge

Students should be familiar with blood flow through the heart and body and the process of gas exchange in the lungs. Also, students should know that humans inhale oxygen and exhale carbon dioxide, and how those gases relate to glycolysis (energy production) in the body. Finally, students should also know how to create graphs.

Teacher Background Knowledge

The teacher should be familiar with the knowledge that students should have as well. As far as the actual lesson, teachers should know that there is a direct positive relationship between respiration rate (number of breaths) and heart rate. The more the heart beats, the more breathing occurs. As the heart beats faster, it uses more energy and sends more oxygen to the body. If a person is exercising the oxygen is used very quickly in order to provide the muscles with needed energy to move. Thus the heart beats faster to pump more oxygen to the muscles. In order to meet the increased demand for oxygen, the brain signals the lungs and diaphragm to inhale and exhale with a greater frequency, thus obtaining more and more oxygen. The oxygen is exchanged for carbon dioxide in the lungs, and is then quickly sent to the heart in order to be pumped to the body. This process of oxygen-based energy production is called aerobic respiration. If anything interferes with the delicate process of gas exchange and the subsequent beating of the heart, oxygen will not be delivered to the muscles and organs as quickly. If oxygen is not delivered as quickly, the body uses a form of energy production that does not require oxygen: anaerobic respiration. This process is a short-term solution, since the energy created is short-lived and produces lactic acid as a waste product. Students (and the teacher) have likely experienced lactic acid when exercising. If a person exercising ever feels a burning sensation (“feel the burn” as coaches say), the body is not getting enough oxygen and has switched to anaerobic respiration at that muscle. On another note (a great example, but quite a horrific picture called “Oposthotonus” by Sir Charles Bell, 1809 which is included in this lesson), tetanus is a disease which infiltrates muscle and nerve fibers, causing all the muscles to contract at the same time! Tetanus also interferes with respiration (since muscles contract so tightly), thus a person dies because they cannot get enough oxygen to meet the extreme need for energy caused by the simultaneous muscle contractions. The lactic acid burn must be scorching.

This is an excellent lesson to remind students about red blood cells and hemoglobin as well. Students do not necessarily need to understand the process of glycolysis (they will in high school), they just need to know that glycolysis is the process of making energy for the body, and that the process requires oxygen.

Objectives

Students will investigate the connection between heart beat and respiration rate, will use the scientific method to predict and draw conclusions from an experiment, will review the processes of gas exchange in the lungs and blood flow through the body, will compare and contrast normal vs. abnormal respiration and its effect on the body, and will determine how to make healthy choices when exercising in order to maintain a properly functioning body. Vocabulary words to learn: *respiration, glycolysis, lactic acid, sickle cell anemia, aerobic respiration, anaerobic respiration*

Alignment to TEKS

This lesson is designed to align to the following TEKS objectives:

SCI.7.1.A Demonstrate safe practices during field and laboratory investigations

SCI.7.2.A. Plan and implement investigative procedures

SCI.7.2.B Collect data by observing and measuring

SCI.7.2.C Analyze and interpret information to construct reasonable explanations from direct and indirect evidence

SCI.7.2.E Construct graphs, tables, maps, and charts using tools including computers to organize, examine, and evaluate data

SCI.7.2.D Communicate valid conclusions

SCI.7.3.F Connect Grade 7 science concepts with the history of science and the contributions of scientists

SCI.7.4.A Collect, analyze, and record information using tools

SCI.7.4.B Collect and analyze information to recognize patterns

SCI.7.9.A Identify the systems of the human organism and describe their functions

SCI.7.9.B Describe how organisms maintain stable internal conditions while living in changing external environments

SCI.7.11A Analyze changes in organisms that may result from internal stimuli

SCI.7.11.B Identify responses in organisms to external stimuli found in the environment

SCI.7.10.C Distinguish between dominant and recessive traits and recognize that inherited traits of an individual are contained in genetic material

Materials

- 1) Stopwatches (at least 1 per group)
- 2) Graph paper
- 3) Rulers
- 4) Colored pencils/markers
- 5) Picture of "Oposhotonus" by Sir Charles Bell, 1809
- 6) Lab sheets (1 for each person or group)
- 7) "Feel the Burn" activity sheet
- 8) Tetanus reading passage (**NEED**)
- 9) Sickle cell picture
- 10) Sickle cell reading passage (**NEED**)

Lesson Plan

- 1) Warm-up: Why do the PE coaches yell “Feel the burn!” when you exercise?
- 2) Using graphic organizers, have small groups of students recall information about gas exchange in the lungs (oxygen for carbon dioxide) and the path of blood through the heart and body. Have students represent their answers in a large group discussion so that everyone in the class recalls the topics. Do the same for oxygen (i.e. make sure everyone knows oxygen is needed to make energy).
- 3) Distribute lab materials (stopwatches, rulers, graph paper, lab sheets) and allow students to complete lab. Students might have trouble initially finding their pulse, so if necessary, lead a class demonstration beforehand to show students where the radial and carotid arteries are located.
- 4) Have each group share their observations of the graphs with the class.
- 5) Pose the question: What is the relationship between heart rate and breathing rate? Have the groups discuss/make posters with answers/write group answer on the board/etc.
- 6) Have each group present and justify their answer. (The teacher should hopefully get responses along the lines of: as heart rate increases, breathing rate increases. The more you exercise, the faster your heart beats, and then the faster you breathe.)
- 7) Make a large poster/overhead/writing somewhere that states: As heart rate increases, breathing rate increases.
- 8) Pass out “Feel the Burn” activity sheets and allow students to complete the activity.
- 9) Have each group state their ideas about why they cannot exercise for long periods without breathing (posters, etc.) Have a large class discussion to arrive at this conclusion: when you do not breathe, you do not produce a lot of energy. If you do not produce energy, you cannot exercise.
- 10) Introduce 2 vocabulary words: *respiration* and *glycolysis*.
- 11) Small group discussion: thinking of respiration, glycolysis, and heart rate, please state the relationship between heart rate and breathing.
- 12) Large group discussion that results in: The faster you respire, the more oxygen you breathe in. The heart pumps the oxygenated blood to the body. The more oxygen available, the more energy can be produced through glycolysis. When

exercising, the body needs more energy. Therefore, it needs more oxygen (increased breathing rate) delivered faster (increased heart rate).

(IF YOU NEED TO BREAK THIS LESSON INTO 2 PARTS BECAUSE OF TIME, THIS IS A GOOD PLACE TO BREAK)

- 13) Ask: How many people felt or have ever felt a burning in their muscles while exercising? Have students (if they choose) to describe their experiences.
- 14) Pass out the story about tetanus symptoms, the picture “Oposthotonus”, the story of sickle cell, and the picture of a sickle cell to each group.
- 15) The group’s job is to match the description of the disease to the picture provided.
- 16) Make sure that all groups have matched the pictures with the correct passage.
- 17) In a large group discussion, the students should discuss what they think each disease does to the body.
- 18) Introduce the names of the diseases: *tetanus and sickle cell anemia*
- 19) If you have library/internet/reference book capability, have the students look up and report on the diseases: symptoms, how it affects the body, and cures (if any). If not, tell the students about each disease.
- 20) Pose question: what do tetanus and sickle cell anemia have to do with respiration and heart rate?
- 21) Small group discussion with students writing ideas on paper, the board, etc.
- 22) Large class discussion that the teacher should guide towards tetanus and sickle cell both impact the amount of oxygen reaching the muscles the amount of energy that is produced in glycolysis.
- 23) To make a big connection, ask students to flex all of their muscles at the same time. When the students cannot flex anymore, ask the class to discuss why they had to stop. (Burning feeling will be a likely answer). Ask students to reflect on their short experience compared to the picture of the soldier with tetanus who could not relax his muscles.
- 24) Introduce *aerobic vs. anaerobic respiration, lactic acid*
- 25) Pose the same question: what do tetanus and sickle cell anemia have to do with respiration and heart rate? Now, however, students know the scientific terms to answer the question.

26) Closure. Have each individual student complete the following questions:

a) Respiration is

b) When a cell makes energy, the process is called _____, and requires the chemical _____ which we get from the air.

b) As heart rate increases, respiration rate _____.

c) Heart rate and respiration rate are connected because

d) Diseases such as tetanus and sickle cell anemia are related to heart rate and respiration rate because

e) _____ respiration requires oxygen. _____ respiration does not require oxygen.

Homework: Imagine you are a doctor trying to ease the suffering a person inflicted with either a) tetanus or b) sickle cell anemia. How could you make that person more comfortable while they are being treated?



ESL/ELL/LEP/Other Modifications:

- Make sure to cover how to graph, and perhaps have practice data to make practice graphs.
- For any classes, if the teacher has access to stethoscopes, please use them for students to record heart rates during the exercise lab. Finding a pulse is the alternate to stethoscopes.
- Lower level reading passages
- Pictures with English and native language captions

Assessment possibilities:

- Lab sheets
- Posters
- Daily participation grades
- Presentations
- Closure
- Homework