DIVING BRADYCARDIA

Some air-breathing animals can survive for an unusually long time while submerged underwater. These animals still must get their oxygen from the air, but they have developed physiological and biochemical mechanisms which allow them to use the oxygen in a highly efficient manner. The diving reflex in terrestrial vertebrates sometimes consists of bradycardia (slowing of the heart rate) and shunting of the blood from non-essential organs such as skin, muscle, and viscera to the essential organs of brain and heart. A variety of diving vertebrates including alligators, birds, and marine mammals such as seals and whales exhibit this reflex. The receptors that trigger this reflex have not been identified.

Diving capacity varies greatly among different species. Yet, the basic solutions to the problems of diving are similar. To extend diving time animals can:

1) use stored oxygen
2) decrease oxygen consumption
3) use anaerobic metabolism
4) switch to aquatic respiration if possible

One of the most conspicuous adjustments during diving is associated with the use of stored oxygen in the circulatory system. A selective peripheral vasoconstriction ensures so that the oxygen in the blood is delivered to high-priority tissues like the brain and to some extent the heart and adrenals, while the rest of the body has to subsist on local stores of oxygen and/or anaerobiosis. The vasoconstriction causes the peripheral resistance to increase enormously, and to maintain a normal blood pressure cardiac output is reduced. This reduction is attained primarily by a decreased heart rate referred to as bradycardia.

Humans are not as obviously adapted to underwater existence as the diving mammals, but a diving reflex is present in some people. It has been postulated that the diving reflex is partially responsible for the survival of children who have fallen into cold-water lakes and been submerged for extended periods.

In this lab you will measure heart rate under both diving and non-diving conditions. The two objectives of this lab are:
1) To demonstrate that diving bradycardia occurs in yourself or your lab partner as the diving subject.
2) To design and perform your own experiment to determine the physiological triggers which elicit the bradycardia response in humans.

PROCEDURE

Part 1: Diving Responses in Humans

Procedure
1) Sit in a chair next to a basin of cool water (<15°C).
2) Determine an accurate method of measuring heart rate.
3) Establish the baseline heart rate of the subject before diving by calculating the AVERAGE BPM every minute for three minutes. (This is best done by counting the number of beats in a 30 second period and multiplying by 2.) Record your values and the times at which they were taken. Note any fluctuations in heart rate (arrhythmias) that occur during the recording.
4) Submerge your face up to the cheeks in the basin and note the time on the data screen. Do not breathe during this time and try to "dive" for 1 min. Record the temperature of the water.
5) Calculate and record the average heart rate during the entire dive. Note the amplitude of the spike, the speed of any changes in heart rate, and the presence of any arrhythmias.
6) Note the time that the diver surfaces. Record the heart rate and breathing movements every 30 seconds during recovery (for 3 minutes).
7) Compare with the average BPM from the data file from before, during and after the dive. Does bradycardia occur?

Part 2: Physiological Triggers of the Diving Response in Humans

At this point, you (probably) know that bradycardia in humans can be induced by having the face submerged in a basin of cool water. However, you do not know which environmental stimulus (or stimuli) actually "triggers" the response. Your task is to approach this problem experimentally by manipulating one or more of the variables which could be responsible for bradycardia induction.

Because there are numerous possibilities open for you to explore, care must be taken to approach your experiment in a thoughtful and systematic fashion. This means that you must first come up with a clear question before attempting to design an experimental protocol. Don't try to attack every problem at once, but rather focus on finding the answers to one specific question at a time. Be sure to include appropriate controls.

You may consult your instructor(s) for suggestions and guidance as you proceed, but remember, the final design is up to you. Seeking creative solutions to mysterious questions is at the core of all scientific research. Good luck.

DATA ANALYSIS AND INTERPRETATION

1) What changes in cardiac output are evident when a human is "diving". Explain your observations during recovery, the post-dive period.
2) Discuss the underlying physiological mechanisms that might account for your observations. What kind of receptors might mediate the diving response?
3) Discuss the results of your independent experiments. Be sure to include the question to be answered and an account of your experimental procedure.
4) Discuss possible sources of experimental error in your measurements.
5) Discuss your results with other lab groups. Is there variation in the responses between divers? Why might this be so?
6) Clearly and succinctly outline the experimental protocol you used in the exercise. Also include the reasons why you conducted each experiment and the results obtained.

SELECTED READINGS

