Bio 3B Laboratory
Mammalian Dive Response

Objectives

- Understand the general relationship between heart rate and facial immersion known as the "dive response"
- To understand how change in heart rate and redistribution of blood flow can lead to a reduction in metabolism and an increase in the length of a dive
- To investigate the effect of apnea, facial cooling and water immersion on heart rate

Introduction

The long, deep dives of marine mammals require several adaptations. Among these are bradycardia, a slowing of the heart rate, and redirection of blood flow to essential tissues (Elsner and Lande, 1998). The reduction in heart rate during diving was first described in the late nineteenth century by Frenchman Paul Bert as the mammalian "dive response." Since that time it has been documented in many diving birds and mammals (Elsner and Gooden 1983; Kooyman 1989). The redistribution of blood flow assures that the brain and heart are constantly supplies with oxygen, even as the heart rate (and hence cardiac output) is reduced. This allows longer dive duration without the risk of asphyxia.

Interestingly, the dive response occurs to some extent almost all mammals and birds investigated, suggesting that it may be a basic adaptive mechanism defending against hypoxia (Elsner and Gooden 1983). The magnitude of the heart arte reduction is greater in diving animals. Kooyman (1989) reports heart rate reduction up to 80% during diving in seals. Although poor divers compared to marine mammals, the dive response is present in humans. In humans, the dive response has been associated with several stimuli including facial immersion, apnea, and facial chilling (Gooden 1994). In this lab we will investigate the effect of some of these on heart rate in average Saddleback College students.

Procedure

Each research team will need a method for measuring heart rate. For this purpose, you will be assigned a physiograph. The NARCO Bio-systems Model MK III-S Physiograph is versatile machine. Depending upon the type of couplers and transducers used, the physiograph can record force, heart rate, blood pressure, and respiratory rate as well as many other physiological variables. Transducers measure a physiological variable and transform that into an electrical signal. The electrical signal is then transferred to the physiograph, resulting in a deflection of the pen. There are several transducers that can be used with the physiograph. In this lab you will use either a pulse plethysmograph or electrocardiograph (EKG) transducers.

Physiograph Operation

1. Remove the protective dust cover.
2. Set the power switch to the OFF position.
3. Plug the cord into a grounded electrical outlet.
4. Check the paper supply.
1. Make sure that the writing pen is installed. If not, install the pen by inserting it horizontally into the groove under the retaining spring. Each retaining spring should rest firmly on the pen.
5. Check the ink supply for each recording channel. Ask your instructor about the procedure for filling the inkwells.
6. Pen tips are raised and lowered by the metal bar they rest on.
7. Check the plug-in modules to be used in the experiment.
8. Turn the power switch to ON.
9. Set the paper speed button to the ON position and choose an appropriate paper speed.
10. To start the paper, push the paper speed OFF button down.

Physiograph Shutdown Procedure

1. Make sure inkwell assemblies are lowered.
2. Press all channel amplifier RECORD switches to OFF.
3. Set all plug-in module POWER switches to OFF.
4. Set main power switch to OFF.
5. Disconnect all transducers and input cables.
6. Lower the pens onto the ink dam.
7. Replace dust cover.

Measurement of Heart Rate under Different Conditions

Begin by recording heart rate of a subject using either electrocardiograph (EKG) electrodes or the pulse plethysmograph. Once you are confident of your ability to record heart rate accurately, you may begin your experiments.

You will need a clean basin placed on the table next to the physiograph. Fill the basin about 2/3 full with water. The subject will be asked to place his or her face into the water during a breath hold. You will need a towel to dry the subject's face following the submersion.

Once you have everything set up you may being to collect data. You will start be recording heart rate of each subject during a breath hold of 30 seconds. Then the subject will submerse his face in water for thirty seconds. Look carefully at the recordings. You should compute the heart rate (beats per minute, bpm) during the first ten seconds, the second ten seconds and the last ten seconds. You should also compute the average heart rate during the entire apnea. You

should make at least 3 measurement on each subject, and you should have at least 5 subjects in your initial study (or as many as possible, depending on the total number of students in the class).

For you next experiment, you must look at the effect of one of the following variables on heart rate. You must make the same computations as above.

1. The effect of facial cooling- use an ice pack, a room temp pack, a warm towel in a plastic bag on the forehead and eye region.
2. The effect of breath hold- look at apnea during diving compared to breathing through a snorkel during diving.

Record your data in the table provided.

Data Analysis and Write-Up

We will combine the data for all groups and the various treatments. You must decide how you will analyze the data. This should be based upon a hypothesis. You should write a complete scientific paper based upon your experiment.

Literature Cited

Elsner R and Gooden B (1983) Diving and asphyxia: A comparative study of animals and man. *Physiological Society Monograph 40*. Cambridge University Press, Cambridge, 175 pp.

Gooden BA (1994) Mechanisms of the human diving response. *Int Physiol Behav Sci* 29 1: 6-16.

Kooyman GL (1989) Diverse divers: physiology and behaviour. *Zoophysiology* Vol 23. Springer-Verlag, Berlin, 201 pp.

Data Table for Heart Rate Diving Study (HR is heart rate in beats per minute)

Treatment	Average HR	HR 1st ten sec	HR 2nd ten sec	HR 3rd ten sec