

The Mammalian Diving Reflex

Background: The mammalian diving reflex is a behavior found in mammals which optimizes respiration to allow staying underwater for extended periods of time. It is exhibited strongly in aquatic mammals like seals, otters(pools) and dolphins. The diving reflex exists in weaker versions in other mammals, including humans, particularly in babies up to 6 months old. Penguins and diving birds have a similar reflex.

Every animal's diving reflex is triggered specifically by cold water contacting the face. Upon contact with cold water the heart rate is reduced (a condition called bradycardia). The majority of research on the diving reflex has been done on seals.

The Weddell seal of Antarctica is a great example as they can hold their breath for extended periods (20 minutes to an hour) and can dive to depths of 500 meters. During each dive, their heart rate and cardiac output decrease dramatically as blood is shunted away from the extremities and directed to the vital organs.



A much smaller version of the diving reflex occurs in all mammals and is easy to observe in humans. When cold water below 10° C contacts the face or inside of the nose, sensory neurons are activated that increase parasympathetic activity. Breathing is inhibited and heart rate decreases, producing the diving reflex. This response is not observed during normal breath holding in air or during simulated dives in warm water. The diving reflex can also be influenced by learning. Cold water swimmers or experienced skin divers may have a larger diving reflex than other subjects.

OBJECTIVES:

In this experiment, you will test the hypothesis that the diving reflex is elicited by cold water contacting the face by:

- Calculating the heart-rate before and during a normal breath hold.
- Calculating the heart-rate before and during a simulated dive in cold water.

Materials:

- Ice cubes
- Paper towels
- Timing device capable of measuring seconds (your phone/clock on wall)

Part 1a: Resting Heart Rate

1. Select one member of the group as the first test subject.
2. Have the test subject sit in a relaxed position in a chair.
3. They will find their heart rate by taking their pulse at the carotid artery. The test subject should place their index and middle fingers on their neck to the side of their windpipe.
4. Once their pulse is found have one partner start the timer while the test subject silently counts the number of beats in 30 seconds.
5. Multiply this number by 2 to get your heart rate per minute.
6. Enter the resting pulse rate into the data table.
7. Repeat this process with at least one other lab partner.
8. Enter the resting pulse rate(s) into the data table.



Test Subject Names	Resting Pulse Beats Per Minute	Pulse While Holding Breath Beats Per Minute
One:		
Two:		
Three:		
Average:		

Part 1b: Heart Rate While Holding Breath

1. Have the first test subject sit in a relaxed position in a chair.
2. Have the test subject find their pulse.
3. Once their pulse is found have one partner give the signal to take a deep breath and hold it while they start the timer for 30 seconds.
4. While the test subject is holding his or her breath for 30 seconds they should silently count the number of beats.
5. If you feel light headed or cannot hold your breath for the full 30 seconds it is okay to stop early as long as you also stop the clock.
6. Multiply this number by 2 to get your heart rate per minute.
7. Enter the pulse rate while holding breath into the data table.
8. Repeat this process with at least one other lab partner.
9. Enter the pulse rate while holding breath into the data table.

Part 2a: Heart Rate with Nose Ice

1. Have the test subject number one sit in a relaxed position in a chair.
2. One or two ice cubes should be placed in a damp paper towel
3. Have the test subject hold the paper towel against the underside their nose with one hand while find their pulse at the carotid artery with the other.
4. Once their pulse is found have one partner start the timer while the test subject silently counts the number of beats in 30 seconds while breathing normally.
5. Multiply this number by 2 to get your heart rate per minute.
6. Enter the resting pulse rate with nose ice into the data table.
7. Repeat this process with at least one other lab partner with each person making a fresh batch of nose ice.
8. Enter the resting pulse rate(s) with nose ice into the data table.

Test Subject Names	Pulse with Nose Ice Beats Per Minute	Pulse While Holding Breath with Nose Ice Beats Per Minute
One:		
Two:		
Three:		
Average:		

Part 2b: Heart Rate While Holding Breath with Nose Ice

1. Have the first test subject sit in a relaxed position in a chair.
2. One or two ice cubes should be placed in a damp paper towel
3. Have the test subject hold the paper towel against the underside their nose with one hand while find their pulse at the carotid artery with the other.
4. Once their pulse is found have one partner give the signal to take a deep breath and hold it while they start the timer for 30 seconds.
5. While the test subject is holding his or her breath for 30 seconds they should silently count the number of beats.
6. If you feel light headed or cannot hold your breath for the full 30 seconds it is okay to stop early as long as you also stop the clock.
7. Multiply this number by 2 to get your heart rate per minute.
8. Enter the breath holding with nose ice pulse rate into the data table.
9. Repeat this process with at least one other lab partner.
10. Enter the breath holding with nose ice pulse rate(s) into the data table.

Data Analysis:

Calculate the percent change in heart rate in part one (resting vs holding breath) and then again for part for part two (with and without nose ice) and fill in the data table for each test subject using the formulas:

$$\text{Percent Change in Heart Rate in Part One} = ((\text{HR holding breath} - \text{HR resting}) / \text{HR resting}) \times 100$$

$$\text{Percent Change in Heart Rate in Part Two} = ((\text{HR holding breath with nose ice} - \text{HR nose ice}) / \text{HR nose ice}) \times 100$$

Test Subject Names	Percent Change in Pulse Part One	Percent Change in Pulse Part Two
One:		
Two:		
Three:		
Average:		

Graphing your results:

Present your data in the form of two bar graphs. Each graph should have a title, labeled x and y axis, a key, and use a proper scale so that it fills the majority of the graph paper.

- Graph one: Graph each test subject's individual test results from each section as a cluster of bars grouped by section. Then calculate and graph a lab group average for each section.
- On the second graph display each test subject's percent change from part one and two along with the average for part one and the average for part two for your lab team.

QUESTIONS

1. Did the average heart rate of the test subjects change after holding their breath?
2. If so, describe how the heart rate changed (use numbers from your data table to support your answer).
3. Did the average heart rate of the test subjects change during the simulated dive in cold water?
4. If so, describe how it changed (use numbers from your data table to support your answer).
5. Did you observe a diving reflex? Why or Why Not?
6. Explain which experiment tested the hypothesis that the diving reflex is elicited by cold water contacting the face.
7. Construct a hypothesis for this experiment. Use the If... Then... Because... format.



