Lab 2: Resting Heart Rate and Recovery from Exercise

Purpose

The purpose of this lab is to provide you with experience in the scientific design of experiments. This lab will draw on what you already know about conducting experiments, but it will also help you learn to more formally express and structure good experimental design and methodology. In this lab, you will design and conduct an experiment that helps you understand and mathematically model how the human heart recovers over time after exercise.

Learning Goals

The goals of this lab are to

- Understand how to design and implement a complete experimental protocol
- Measure how the human heart recovers over time after exercise
- Select an appropriate mathematical model for heart rate recovery data

Background

Heart disease is the leading cause of death in the United States. Therefore, it is also one of the most intensively studied areas of health research. **Resting heart rate** (RHR) and recovery of heart rate after exercise are important indicators of overall fitness and heart health. Many factors can influence RHR such as age, gender, physical conditioning, amount of sleep, and medications. The RHR is commonly measured by taking one's pulse manually at the wrist or carotid artery in the neck using the index and middle fingers (NOT the thumb) or it can be measured with specialized heart rate monitors. Also, today many consumer devices, including smartwatches, can accurately measure your pulse.

While RHR is an important indicator of your physical condition, health professionals often want to know how quickly the **heart recovers to its resting rate** after exercise.

Heart rate recovery is used to determine if an individual is physically able to perform tasks associated with specific occupations. The most common test used for this purpose is the Forestry Step Test. The Forestry Step Test is a physical fitness test given to U.S. forestry worker applicants that involves stepping up and down on a box for five minutes and then monitoring the applicant's recovery time to their resting heart rate.

Lab Exercise

This lab is divided into two parts. In the first part, you and your lab partner will need to design an experimental protocol for measuring and recording your

1. resting heart rate.
2. and recovery of heart rate after exercise.

In the second part, you will analyze and model the recovery of the heart rate after exercise and interpret the meaning of your model.

Methods

1. Complete the Pre-Lab (on Canvas) before you come to class including a specific description of your methodology for the lab. You will not be allowed to participate in the lab or turn in a lab report without having completed the pre-lab. Compare the two methods that you designed individually with your lab partner. Decide which method you want to use (or create a modified design).

> **!** Important
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> Have one of the instructors sign of on your final methodology before you actually begin the lab.

2. Determine your resting heart rate. Complete three trials and record these data in your lab notebook as well as in the shared Excel (or Google) spreadsheet available in the laboratory. Your name will be replaced by a "subject ID number" to ensure privacy. Note that you must collect at least 15 seconds of data for each trial in order to calculate the resting heart rate. Record your data in beats per minute (bpm). The pulse should be taken at the carotid artery; the carotid artery is located on the side of the throat below the ear. Be sure and use your index and middle fingers, not your thumb.

3. Conduct a modified Forestry Step Test and measure heart rate recovery following the general guidelines below. Only one person in your lab group needs to conduct the test. Record the data in your lab notebook.

   General Procedure: For this exercise you will use a stair step as the platform. If weather permits, the stairs in front of King Hall can be used. If weather is poor, use the stairwell in King Hall (be sure to leave plenty of space between groups to minimize interference).

   SAFETY: Be sure to start on a landing to reduce tripping hazard. Wear sturdy shoes (not slip-ons).

   You will work with your partner. One of you will perform the exercise while the other records data. The step/platform must be ascended and descended one foot at a time. The lab partner not performing the step test should count:

   "up-one"   "up-two"   "down-one"   "down-two"

   until you get used to the pace. The cycle of on-and-off the step/platform must be completed approximately once each second. Once the rate is chosen it must be constant throughout the test (five minutes). You must take enough data to determine how quickly a person's heart rate recovers to the RHR after exercise. When recording data, be sure you start taking data as soon as the exercise is finished and take data often enough to get a reasonable number of well-spaced data points. Be sure to continue taking data well after recovery to establish baseline.

   Safety Considerations and Precautions: The group member performing the step exercise may want to wear sweats or other athletic clothing. Proper footwear is essential; this exercise may not be performed barefooted or in sandals or other open-toed shoes. If you will be performing the exercise, it is important to have eaten something within the five hours preceding the lab period. It is also not a good idea to eat heavily just before exercising. If you have any medical reason for not performing the step test, you must join with a group that is able to perform the test and work with them. All test subjects should stretch (loosen-up) prior to the test.

4. Make initial graphs of your data to check whether the collected data meet your expectations. This step will help you catch any issues with your data.

> **! Important**
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> Check-in with an instructor before leaving the lab to confirm that you have all the data you need for your lab.
> You will be asked to upload your data and the graph before leaving the lab.
> We will discuss your data in the next lecture.

Deliverables

Your deliverable is a lab report that conforms to all lab report requirements see Lab Resources.

Your results and discussion sections should **_at least_** contain the following items:

1. Construct a histogram of the RHR data for the whole class using guidelines described in the lecture. Be sure to write a very complete and thorough caption to this figure explaining what it shows. You must also describe and reference the figure in the text of the results section including what it means.

2. Determine and analyze the statistical information for the RHR data (mean, median, standard deviation, etc.) using a computational tool such as Python and present your results in a table. Write a meaningful table caption that describes the statistical information. From these data, what is the expected RHR of an ISAT 300 student? Explain the reasoning for your answer in the discussion section.

3. Construct a table and a figure (graph) of your heart rate recovery data using your computational tool. Think about how the data looks and what an an appropriate mathematical model that represents the data would look like:

   - Is it a straight line, a curve, or something else?
   - What would the mathematical equation be?

   Fit the model to your data, we will discuss this in the lecture. Determine the coefficient of determination for your data – often called R^2 - and explain in the caption what it means based on what you learned in statistics. Display the equation and your model equation and R^2 on your graph or include it in the lab report.

   > **i Note**
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   > Fitting curves in Python is a bit more complicated than _Excel_ or _google-sheets_. On the plus side, you are much more flexible in what you do. We will discuss this in the lecture and I am providing some code as well:
   > Lab 2 Starter Code

4. Briefly discuss and interpret the mathematical model that you used to represent your heart rate recovery data once you completed taking and analyzing the experimental data. Do you consider your model a valid representation of the data and what is the reasoning tor your answer?

5. Discuss why there is variation in individual resting heart rates. Do you think you can generalize about resting heart rate for the entire population of humans from this experiment? Why or why not?

6. Discuss sources of uncertainty in your measurements/ your experiment. Which of these do you think significantly affect your experimental results? How could these be minimized?

7. Restate your hypothesis about heart rate recovery. Do your data support your hypothesis? What do you conclude? Why? Be specific and show the data/calculations to support your answer.

> 💡 **Tips for writing your lab report**
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> - When you write the discussion section, reference your results and refer to the figures in the text.
> - Be specific in your discussion of the results rather than providing a vague general discussion. What evidence do you have from the data?
> - It is OK to speculate about reasons for the observed behaviors, but only after you have shown evidence.
>
> - Make sure to discuss sources of uncertainty (see above)!

Acknowledgements

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History

Revision	Description	Author
2025-01-29 (S25)	Added starter code and curve fitting text	Tobias Gerken
2024-02-01 (S24)	Updated to Web, Clarification of deliverables	Tobias Gerken
	Initial Word Version	Tobias Gerken
	PDF Version	