Heart Rate and Exercise

CONCEPTS

Physiology

- cardiac output
- resting heart rate
- maximum heart rate
- recovery rate

Engineering

- accuracy vs. precision
- percent change
- correlation
- wireless transmission
- electromagnetic interference

BACKGROUND

The adaptability of the heart can be observed during exercise, when the metabolic activity of muscle tissue increases. The cardiovascular system, consisting of the heart and blood vessels, responds to exercise with an increase in heart rate and strength of contraction with each beat, resulting in a higher *cardiac output* (quantity of blood pumped through the heart per unit of time). Your cardiovascular system can try to meet the demands of what ever physical activity you are performing, but there is an upper limit on how fast your heart can beat. This is called the maximum heart rate.

Physically fit people can deliver a greater volume of blood in a single heartbeat than unfit individuals and can sustain a greater work level before reaching a maximum heart rate. Being more physically fit also leads to a more rapid recovery of resting heart rate.

In this experiment, you will observe how the heart responds to the increased metabolic demand of muscles during exercise.

Important: Do not attempt this experiment if physical exertion will aggravate a health problem. Inform your instructor of any possible health problems that might be exacerbated if you

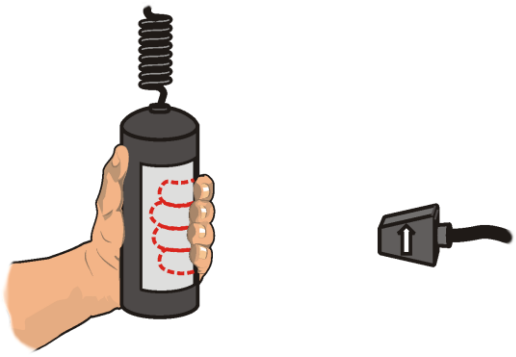

Figure 1

participate in this exercise.

OBJECTIVES

In this experiment, you will

- Determine the effect of exercise on heart rate.
- Correlate resting heart rate and recovery rate with amount of daily exercise.
- Gain experience reducing electromagnetic interference.
- Understand the relationship between accuracy and precision.

PRE-LAB

Build a LabView VI which reads in the impedance change signal from the Vernier hand grip sensors and then

- computes the heart rate in beats per minute
- displays the heart rate value
- detects when the heart rate goes out of range (either too high or too low)
- alerts the user when the heart rate goes out of range

PROCEDURE

Select one or more persons from your lab group to be the subject.

1. Connect the receiver module of the Heart Rate Monitor to LabQuest and choose New from the File menu.
2. On the Meter screen, tap Length. Change the data-collection length to 200 seconds. Select OK.
3. Stand quietly facing your table or lab bench.
4. Measure your heart rate manually by placing your index and middle finger together firmly on your wrist. Have one of your labmates time 15 seconds while you count the number of pulses; record this number. Also have your labmate time 60 seconds while you count the number of pulses; record this number.
5. Set up the Heart Rate Monitor. Follow the directions for your type of Heart Rate Monitor.

   The receiver and one of the handles are marked with a white alignment arrow as shown in Figure 2. Locate these two arrows.

   Have the subject grasp the handles of the Hand-Grip Heart Rate Monitor so that their fingers are in the reference areas indicated in Figure 3. Hold the handles vertically.

   Have someone else hold the receiver near the handles so that the two alignment arrows are pointing in the same direction and are at approximately the same

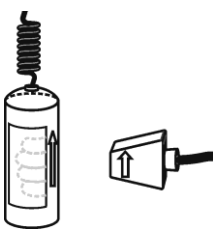

Figure 2

Figure 3

height as shown in Figure 2. **Note:** The receiver must stay within 60 cm of the handles during data collection.

6. For now, keep the LabQuest module close to the receiver and keep your computer monitor on and close to the receiver.

Obtaining a reliable baseline reading

7. Start data collection. There will be a 15 s delay while data are collected before the first point is plotted. Thereafter, a point will be plotted every 5 s.

8. Determine that the sensor is functioning correctly. The readings should be consistent and within the normal range of the individual, usually between 55 and 90 beats per minute.

9. Set up the graphs to display both the heart rate and "signal" in Graph Mode: Click on "Graph" => "Show Graph", and select "All Graphs". "signal" shows the voltage pulses from which heart beats are detected.

10. As you are collecting data and watching both the heart rate and the heart beat pulse signal, perform the following actions. Observe any changes in your signals upon each of these actions. Note: The subject should continue holding the hand grip sensors and sitting still unless highlighted by italicized font; let a labmate carry out the steps in normal font:

    a. *At 30 seconds, turn the sensor handles so that the arrow is perpendicular to the receiver arrow.*

    b. At 40 seconds, turn the sensor handles back to usual position.

    c. At 50 seconds, bring a cell phone phone right next to the receiver and make a phone call (such as Voicemail).

    d. At 70 seconds,

        - turn off cell phone and move it far away from the receiver (at least 2 feet away)
        - move the LabQuest module away as far as the cable extends
        - turn off the computer monitor
        - turn off the overhead lights.

    e. If readings are stable for approximately 10 seconds, stop data collection and continue to the next step. If not make and record adjustments you may have needed to make.

Heart rate recovery after exercise

11. Start data collection. If the baseline appears stable, begin to run in place at 40 s. Continue data collection while running in place for the next 60 s.

12. At approximately 100 s, stop running and stand in place while your heart rate slows toward its resting pre-exercise value. Data will be collected for a total of 200 s.

13. Determine the maximum heart rate.

    Choose Statistics from the Analyze menu.
    Record the maximum heart rate in Table 1.

Choose Statistics from the Analyze menu to turn off statistics.

14. Determine the resting heart rate.

    Tap and drag over the area of the graph where the resting heart rate is displayed (from 0 to approximately 40 s). This will highlight the region of interest.

    Choose Statistics from the Analyze menu.

    Record the mean resting heart rate, to the nearest whole number, in Table 1.

    Choose Statistics from the Analyze menu to turn off statistics.

15. Determine the recovery time.

    For your data, examine the region of the graph beginning with the maximum heart rate and ending with the first data point that matches the initial baseline value (or the last point graphed, if baseline is not achieved). To determine the time for a data point, tap on the point and read its corresponding time value to the lower right of the graph.

16. Determine the recovery time, Δx, by subtracting the initial time for this region from the final time for this region. Record this value in Table 1.

DATA

Be sure to create a table with spaces for data entry which will allow you to meet the objectives of the lab. Also compile data from the class on fitness level of individuals in the class (See discussion section).

DISCUSSIO[1]N

Here are *some but not all* questions to address in your discussion.

- Accuracy vs. precision:

  How do the precision and accuracy of the instrument's heart rate measurements compare with your manual heart rate measurements?

- Wireless transmission and EM interference

  What are some possible sources of unreliability in the data collection?

- Effect of exercise on heart rate

  What was the percent increase in heart rate after exercise?

- Correlation

  How do resting heart rate and the recovery rate correlate with physical fitness level? How does the subject's recovery rate compare to that of your classmates? Is this what you expected? Why or why not?

[1] Fitness level could be measured by the number of minutes per week that a person spends doing physical activity which conditions the heart (Such physical activity can be defined as activity which maintains heart rate at an elevated level – typically 140-170bpm).