Experiment HE-2: Recovery from Exercise

Equipment Required

PC or Mac Computer

IXTA, USB cable, IXTA power supply

PPG-320 Pulse plethysmograph

Step (30cm (12in) in height)

Metronome (electronic or mechanical)

Stopwatch

Pulse Sensor Setup

1. Locate the PPG-320 pulse plethysmograph. Plug the connector to the PPG-320 into the PT port on the front of the TA.
2. Place the plethysmograph on the volar surface (where the fingerprints are located) of the distal segment of the subject's middle finger or thumb, and wrap the Velcro strap around the end of the finger to attach the unit firmly in place.

Preparation before Exercise Begins

1. Each subject will perform a 3-minute period of stepping. There will be a 5-minute rest period before the 3-minute exercise period, and a recovery period after stepping that will be as long as it takes the subject's heart rate to return to the resting value. Lab partners should keep time for the rest, exercise, and recovery periods.

Warning: The Step Test should not be attempted by individuals with a very poor level of physical fitness, or individuals taking a beta blocker medication or any medication affecting heart rate.

2. The step rate will be 24 steps per minute.
3. Each step is a four-beat cadence, so the metronome will be set to 96 beats per minute.
4. The movements for each of the four beats in a step are:
    - 1st beat: Right foot up on step.
    - 2nd beat: Use the right leg to lift body, and place left foot on step.
    - 3rd beat: Lower the right foot to the ground.
    - 4th beat: Lower the left foot to the ground.
5. It is important to secure the step against the side of a lab bench or up against a wall to prevent it from slipping from under the feet of the subject.

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Figure HE-2-S1: The PPG-320 pulse plethysmograph connected to the TA.

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    - 2nd beat: Use the right leg to lift body, and place left foot on step.
    - 3rd beat: Lower the right foot to the ground.
    - 4th beat: Lower the left foot to the ground.
5. It is important to secure the step against the side of a lab bench or up against a wall to prevent it from slipping from under the feet of the subject.

Exercise 1: Heart Rate at Rest

Aim: To measure the heart rate of a resting subject.

Approximate Time: 15 minutes

Procedure

1. Instruct the subject to sit quietly and rest with his or her hands in the lap for five minutes.
2. Type **Sitting at Rest** in the Mark box.
3. At the end of the five minute rest period, click on the Record button. The signal should begin scrolling across the screen.
4. Click the mark button to mark the recording.
5. Click on the AutoScale All button.
    - If the signal on the Pulse channel is upside down when compared to trace in figure, click on the downward arrow to the left of the channel title and select the Invert function. the trace should now look similar to the one in the figure.

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- If the pulse signal is small or noisy, adjust the tension on the strap holding the pulse sensor to the finger.

6. Record the subject's resting heart rate for one minute. Then, click Stop to halt the recording.
7. Select Save As in the File menu, type a name for the file. Click on the Save button to save the data file
8. Remove the pulse sensor from the subject's finger.

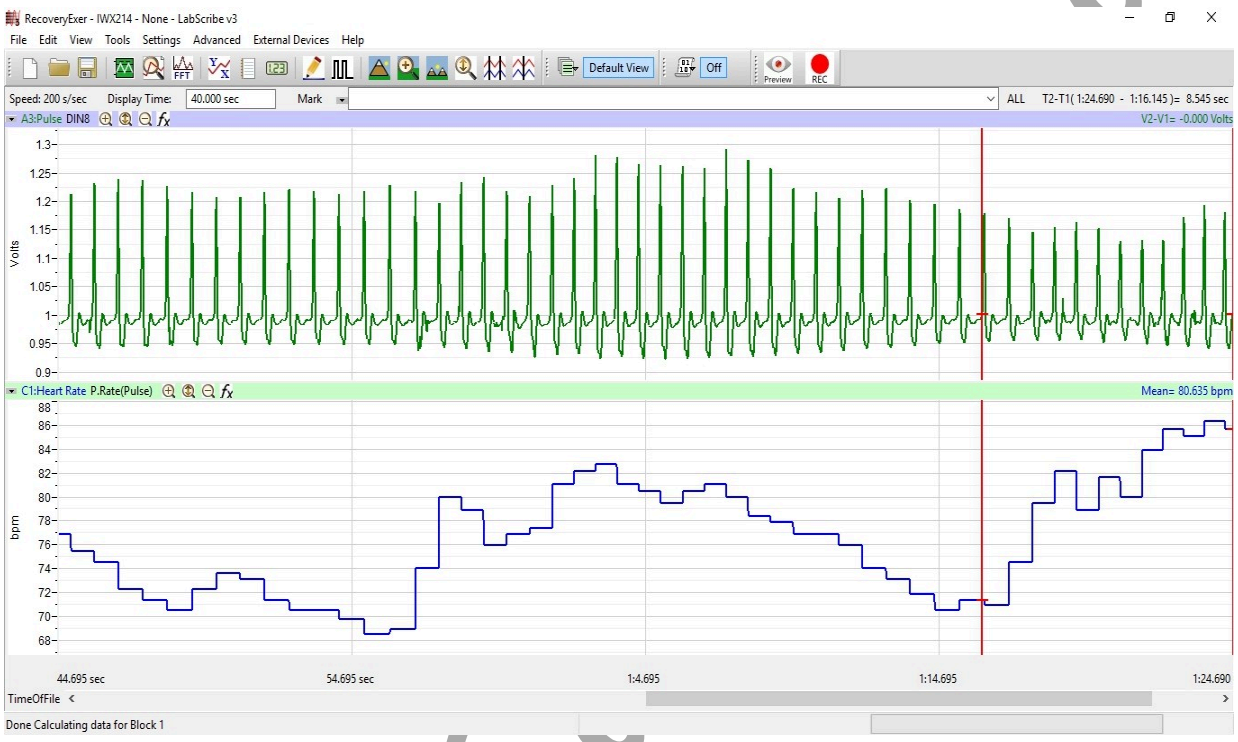

Figure HE-2-L1: Pulse and heart rate from a resting subject displayed in the Main window.

Data Analysis

1. Scroll to the beginning of the recording of the subject's heart rate while at rest. Display a ten second section of data that is free of artifacts in the Main window.
2. Use the Display Time icons to adjust the Display Time of the Main window to show ten seconds of data on the Main window.
3. Data can be collected from the Main window or the Analysis window. If you choose to use the Analysis window, click on the Analysis window icon in the toolbar.
4. The mathematical function, Mean, should appear on screen. Value for Mean Heart Rate is shown to the right of the Heart Rate graph.

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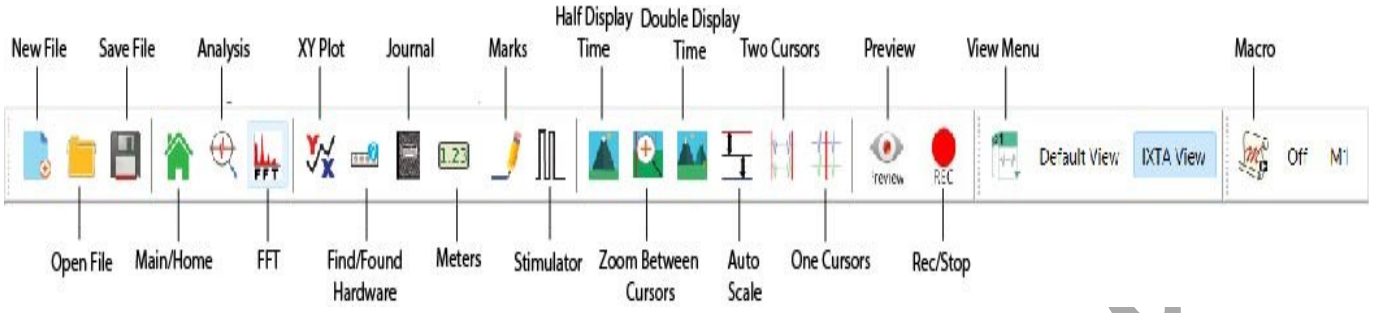

Figure HE-2-L2: The LabScribe toolbar.

5. Place a cursor near the beginning of the data displayed on the Analysis window, and place the other cursor near the end of the data displayed on the window. The cursors are in the correct positions for determining the mean resting heart rate of the subject from the ten seconds of data on the window.
6. Record the mean resting heart rate of the subject in the on-line notebook of LabScribe by typing the name and value of the parameter directly into the Journal. You can open and close the Journal by clicking on its icon on the LabScribe toolbar.

Figure HE-2-L3: Pulse and heart rate from a resting subject displayed in the Analysis window.

7. The functions in the channel pull-down menus of the Analysis window can also be used to enter the names and values of parameters from the recording to the Journal. To use these functions:
   - Transfer the names of the mathematical functions used to determine the volumes and rates to the Journal using the Add Title to Journal function in the Heart Rate Channel pull-down menu.

- Transfer the values for the volumes and rates to the Journal using the Add All Data to Journal function in the Heart Rate Channel pull-down menu.

8. Record the mean resting heart rate in Table 3.

Exercise 2: Heart Rate During Recovery

Aim: To measure the changes in the heart rate of the subject while he or she recovers from exercise.

Approximate Time: 30 minutes

Procedure

1. After the subject's resting heart rate is recorded, the subject should stand in front of the step and await the signal of the timekeeper.
2. Once the timekeeper calls "Start!", the subject should begin stepping at the rate of 24 steps/minute for 3 minutes.
3. While the subjects are stepping, the lab partners can enter pertinent data into the Journal.
4. 30 seconds before the end of the stepping exercise, the timekeeper should alert the subject and other lab partners to be ready attach the pulse sensor. Type **Recovery from Exercise** in the Mark.
5. The timekeeper should give the subjects and the lab partners a 10 second countdown before calling "Stop!" At the end of the 3-minute stepping exercise, each subject should immediately sit in a chair and attach the pulse sensor to the same finger with about the same tension used earlier.
6. As soon as the subject is seated and the pulse sensor is in place, click on the Record button. Click on the AutoScale All button.
7. Continue to record the subject's pulse until his or her heart rate returns to the resting level. Click on the Stop button.
8. Select Save in the File menu.

Data Analysis

1. Scroll to the beginning of the recording of the subject's heart rate during the recovery period. Display a ten second section of data that is free of artifacts in the Main window.
2. Use the Display Time icons to adjust the Display Time of the Main window to show ten seconds of data on the Main window.
3. Position a cursor on either side of the 10 seconds of data. The value for Mean of the Heart Rate channel is the subject's mean heart rate at the start of the recovery period.
4. Record this value in the Journal using one of the two techniques described in Exercise 1. Enter the value for this mean heart rate in Table 3.

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5. Use the same techniques described earlier to measure the mean heart rate at one minute intervals from the beginning of the recovery period. Record these values in the Journal and on the data table.

Fitness Ratings

1. For each subject, use the measurements made in the Data Analysis section to fill in Table 3.
2. From the data in this table, determine:
    - The difference between the subject's resting and maximum heart rates.
    - The difference between the subject's maximum and 1-minute recovery heart rates.
    - The time for the subject to recover from maximum heart rate to a heart rate equal to the resting rate.
3. Compare the subject's 1-minute recovery heart rate to the first table of fitness ratings (Table 1).
4. Compare the subject's time to recover to his or her resting heart rate to the ratings in a second fitness table (Table 2).
5. Enter measurements and ratings into the Journal by typing them directly into the Journal window.

Questions

1. How does the difference between the resting and maximum heart rate of a subject relate to his or her fitness?
2. How do the resting and maximum heart rates of all the subjects compare? Do the subjects' levels of fitness correlate to the resting heart rates, the maximum heart rates, and/or the differences between the two heart rates?
3. How does the difference between the maximum and recovery heart rate of a subject relate to his or her fitness?
4. How do the maximum and recovery heart rates of all the subjects compare? Do the subjects' levels of fitness correlate to the maximum heart rates, the recovery heart rates, and/or the differences between the two heart rates?
5. How does the time taken to recover to resting heart rate relate to the fitness of each subject? How do the times to recovery for all the subjects compare?
6. How do the two techniques of determining fitness (1-minute recovery and time to recovery) compare to each other? Are they consistent?
7. Do you agree with the fitness ratings obtained from this experiment? Explain.
8. Examine the data of a fit subject. Predict what his or her maximum heart rate might be, if he or she exercised for 5 minutes instead of 3 minutes.
9. Examine the data from a less fit subject. Predict what his or her maximum heart rate might be, if he or she exercised for 5 minutes instead of 3 minutes.

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Table HE-2-L1: Fitness Rating based on HR at 1-Minute Recovery after a 3-Minute Aerobic Step Test.

Fitness Rating	Gender	Heart Rate (BPM)
Excellent	Male	<71
	Female	<97
Good	Male	71-102
	Female	97-127
Fair	Male	103-117
	Female	128-142
Poor	Male	118-147
	Female	143-171
Very Poor	Male	148+
	Female	172+

Table HE-2-L2: Fitness Rating based on the Time to Recover to Resting Heart Rate.

Time to Recover to Resting Heart Rate	Rating
0-30 secs	Excellent
31-60 secs	Good
61-90 secs	Fair
91-120 secs	Poor
121+ secs	Very Poor

Table HE-2-L3: Heart Rates at 1-Minute Intervals into Recovery

	Rest	Max										
Time (mins)		0	1	2	3	4	5	6	7	8	9	10
HR (BPM)												

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