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II. EXPERIMENTAL OBJECTIVES

1) Record and compare changes in pulmonary airflow before, during, and after a brief period of moderate exercise.
2) Record and compare changes in respiratory rate and changes in heart rate before, during, and after the exercise period.
3) Compare and note any changes in Lead II electrocardiogram recorded before, during, and after moderate exercise.
4) Record and compare changes in skin temperature associated with the brief periods of moderate exercise and recovery.

III. MATERIALS

- BIOPAC Airflow Transducer (SS11LA)
- BIOPAC Disposable Mouthpiece and Bacteriological Filter (AFT1)
- *Optional*: BIOPAC Autoclavable Reusable Mouthpiece (AFT8)
- BIOPAC Noseclip
- BIOPAC Temperature Transducer (SS6L)
- BIOPAC Tape
- BIOPAC Electrode Lead Set (SS2L)
- BIOPAC Disposable Electrodes (EL503) 3 electrodes per Subject
- BIOPAC Electrode Gel (GEL1) and Abrasive Pad (ELPAD) *or* skin cleanser or alcohol prep
- Biopac Student Lab System: BSL 4 software, MP36 or MP35 hardware
- Computer System Windows 8, 7, Vista, XP, Mac OS X 10.5 – 10.8
- Stopwatch or watch/clock with a second hand.

IV. EXPERIMENTAL METHODS

A. SETUP

FAST TRACK Setup

1. Turn the computer **ON**.
2. Turn **OFF** MP36/35 unit.
3. **Plug the equipment in** as follows:
   Airflow Transducer (SS11LA) — CH 1
   Electrode Lead Set (SS2L) — CH 2
   Temperature Transducer (SS6L) — CH 3
4. Turn **ON** the MP36/35 unit.
5. Select a willing **Subject**.

WARNING
Any person with a history of heart failure or respiratory conditions, such as asthma, should not be a **Subject**.

Setup continues….

Detailed Explanation of Setup Steps

Fig. 15.4

The **Subject** should:

- Be able to perform moderate exercise for up to 10 minutes.
- Wear clothes that allow the electrode placement shown in Fig. 15.7. A tank top is preferable.

6. Insert **Subject's** personal filter and mouthpiece into the "Inlet" side of the transducer (Fig. 15.5).
   - If your lab does not use disposable filters, attach a sterilized mouthpiece (AFT8) directly to the "Inlet" side of the transducer (Fig. 15.6).

IMPORTANT: Each **Subject** must use a personal filter, mouthpiece and noseclip. The first time they are used, the Subject should personally remove them from the plastic packaging. It is advisable to write **Subject's** name on the mouthpiece and filter with a permanent marker so they can be reused later (i.e. Lesson 12 and 13).

If your lab sterilizes the airflow heads after each use, make sure a clean head is installed prior to **Subject** use.

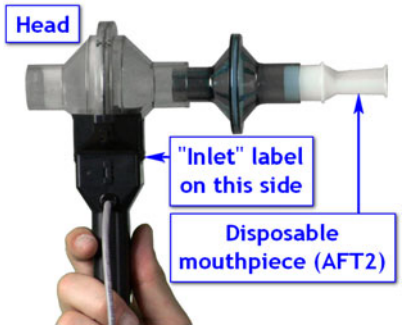


Fig. 15.5 SS11LA with unsterilized head

Fig. 15.6 SS11LA with sterilized head

7. Clean and abrade skin.

If the skin is oily, clean electrode sites with soap and water or alcohol before abrading.

If electrode is dry, apply a drop of gel.

Remove any jewelry on or near the electrode sites.

8. Attach three electrodes on **Subject** as shown in Fig. 15.7.
9. Clip the Electrode Lead Set (SS2L) to the electrodes following the color code (Fig. 15.7).
   - RIGHT Shoulder = WHITE lead
   - RIGHT abdomen = BLACK lead (ground)
   - LEFT abdomen = RED lead

This electrode placement creates a Lead II configuration that is less prone to EMG artifact than the forearm and leg placement.

For optimal electrode contact, place electrodes on skin at least 5 minutes before start of Calibration.

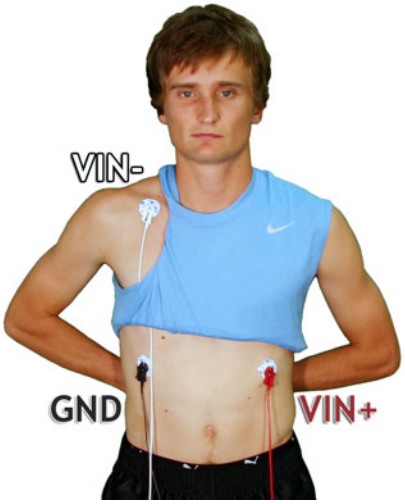


Fig. 15.7 Aerobic Exercise electrode placement

Setup continues…

- The pinch connectors work like a small clothespin, but will only latch onto the nipple of the electrode from one side of the connector.
- Minimize the leads pulling on the electrodes; connect the electrode cable clip to a convenient location on Subject's clothes. Arrange leads so Subject can exercise freely.
- **Subject's** clothing must not interfere with electrodes. Male subjects can remove top.

10. Tape Temperature Transducer (SS6L) to **Subject's** right fingertip (Fig. 15.8).

The Temperature Transducer, at end of cable, should be taped to a fingertip on the right hand. The tape should hold the transducer firmly against the skin, but not so tight that it cuts off circulation.

Connect the cable clip to a convenient location on the Subject's clothes. Arrange wires and cables so **Subject** can exercise freely without pulling on the temperature transducer. Portions of the cable can be taped to the **Subject** if necessary.

Fig. 15.8 Temperature Transducer

Note: This lesson will record relative, not absolute temperature. The baseline skin temperature (before exercise) will be set to 32.2° C (90° F). The system will then accurately measure changes in temperature.

11. Start the Biopac Student Lab Program.

Start Biopac Student Lab by double-clicking the Desktop shortcut.

12. Choose lesson "**L15 – Aerobic Exercise Physiology**" and click **OK**.
13. Type in your filename.
14. Click **OK**.

No two people can have the same filename, so use a unique identifier, such as **Subject's** nickname or student ID#.

A folder will be created using the filename. This same filename can be used in other lessons to place the **Subject's** data in a common folder.

Optional: Set Preferences.

- Choose File > **Lesson Preferences**.
- Select an option.
- Select the desired setting and click **OK**.

This lesson has optional Preferences for data and display while recording. Per your Lab Instructor's guidelines, you may set:

Grids: Show or hide gridlines
Temperature Scale: Choose Scale as Fahrenheit or Celsius.

Resting Skin Temperature: Adjust the default resting skin temperature.

Lesson Recordings: Specific recordings may be omitted based on instructor preferences.

END OF SETUP

B. CALIBRATION

The Calibration procedure establishes the hardware's internal parameters (such as gain, offset, and scaling) and is critical for optimal performance. **Pay close attention to the Calibration procedure**.

FAST TRACK Calibration

1. **Subject** prepares for calibration:
   - Attaches noseclip.
   - Holds Airflow Transducer in left hand and begins breathing normally through it (Fig. 15.9).
   - Sits or stands in a relaxed position.
2. Click **Calibrate**.
3. **Wait** for Calibration to stop.
4. Verify recording resembles example data.
   - If similar, click **Continue** and proceed to Data Recording.
   - If necessary, click **Redo Calibration**.

   At the prompt, enter the Subject's age. This is used to calculate the maximum heart rate during exercise.

END OF CALIBRATION

Detailed Explanation of Calibration Steps

Verify that the noseclip is snug and the **Subject's** mouth is tightly sealed around mouthpiece.

Subject must try to relax both arms as much as possible to minimize EMG artifact.

Fig. 15.9

Subject must remain relaxed and breathe normally through the airflow transducer throughout Calibration.

Calibration lasts twenty seconds.

The "Airflow" data should show variation with each respiratory cycle. The ECG waveform should have a baseline at or near 0 mV, no excessive EMG artifact, and no excessive baseline drift. The Skin Temperature should reside around 32.2° C (90° F) with little variation.

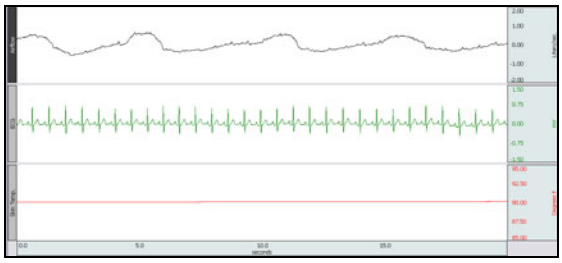


Fig. 15.10 Example Calibration data

<u>If recording does not resemble the Example Data…</u>

- If data is noisy or flatline, check all connections to MP unit.
- If the Airflow signal shows little amplitude variation, verify there are no air leaks:
  - Mouthpiece and filter are firmly attached.
  - Noseclip is snug.
  - **Subject's** mouth is sealed around mouthpiece.
- If the ECG displays excessive baseline drift or EMG artifact (Fig. 15.11):
  - Verify electrodes are making good contact with the skin and that the leads are not pulling on the electrodes.
  - Make sure Subject is in a relaxed position
- If the Skin Temperature is not reading 32.2° C (90° F,) make sure the sensor tip is making contact with the finger tip and that the tape is firmly attached.

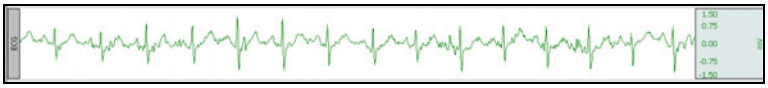
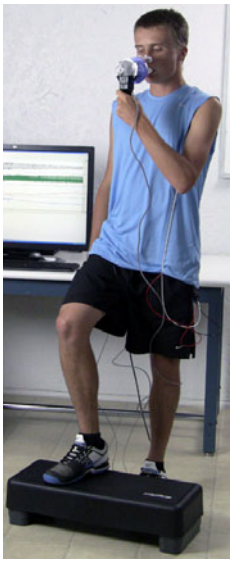


Fig. 15.11 Example of EMG artifact

C. DATA RECORDING

FAST TRACK Recording	Detailed Explanation of Recording Steps
1. Prepare for the recording. • Click **Tasks** to review recording steps (see sample video).	This lesson will require some flexibility in how the data is recorded: ▪ You may continuously record through the exercise and resting period. ▪ Alternately, you may use the Suspend/Record button to record data at various intervals; this method reduces the file size. Four channels of data will be displayed during the recording: Airflow, ECG, Skin Temperature and Heart Rate (BPM).
	Your instructor will specify the type and duration of exercise. This lesson describes a continuous recording method and includes data samples from a stepping-in-place exercise.
	 **Fig. 15.12 Exercise**
	Details… ▪ **Subject** should be at his/her resting heart rate. ▪ Noseclip must be snug and the **Subject's** mouth tightly sealed around the mouthpiece. ▪ Electrodes must be making good contact with skin and the leads must not be pulling on the electrodes. ▪ **Subject** must try to relax both arms as much as possible to minimize EMG artifact.
2. Calculate the **Subject's** maximum heart rate for exercise. **Subject's** calculated maximum heart rate: _____	Calculate and record the **Subject's** maximum heart rate *before* the **Subject** starts to exercise using the following formula: *To be safe*, use 80% of the maximum heart rate: **0.8 [220 – (age)] = Maximum Heart Rate for Subject** The **Subject** should not exceed this rate during exercise.
3. Click **Record**.	After clicking **Record**, a thermometer style bar graph will appear on the right side of the graph window. It is simply a visual aid for monitoring the **Subject's** BPM and only displayed while data is being recorded.

Recording continues…

4. Twenty seconds into recording, **Recorder** presses F2.
5. **Director** instructs **Subject** to begin exercising.
6. Record for approximately five minutes or until **Subject** reaches maximum heart rate.
   - If **Subject** begins to sweat, press **F3**.
   - If intensity of exercise changes, press **F4**.
   - When Subject stops exercising, Recorder presses **F5**.

WARNING
The Director should monitor heart rate and ensure that the Subject does not exceed the maximal heart rate calculated above.

7. Continue to record (for up to five minutes) while **Subject** is recovering from exercise.
8. Click **Suspend**.
9. Verify recording resembles the example data.
   - If similar, click **Continue** and proceed to optional recording section, or click **Done** if finished.
   - If necessary, click **Redo**.

Recording continues…

Event marker summary:

F2-Begin exercising

F3-Sweating

F4-Change in intensity

F5-Stop exercising

Custom marker: Press the **Esc** key and type a label.

NOTE: Marker labels can be added or edited after recording.

The "Airflow" data should show variation with each respiratory cycle. The ECG waveform may contain EMG artifact and baseline drift. The Skin Temperature may show slow variations. The Heart Rate (BPM) data should show variations and may display some sporadic values. Data can vary significantly, depending on **Subject** and the type of exercise performed. All event markers should be present (use horizontal scroll bar to search all data).

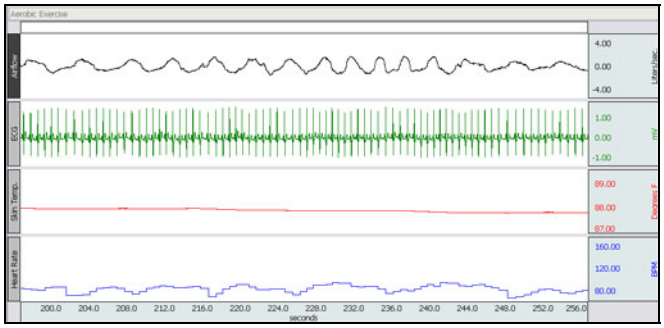


Fig. 15.13 Example data

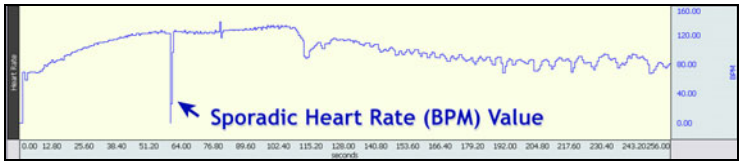


Fig. 15.14 Example of a sporadic Heart Rate (BPM) value

If recording does not resemble the Example Data…

- If data is noisy or flatline, check all connections to MP unit.
- If an event marker is missing, it can be inserted manually by right-clicking in the event region and choosing "Insert New Event" from the contextual menu. They can be moved by holding down the Alt key and dragging.
- If the ECG displays excessive baseline drift or EMG artifact, or if the Heart Rate (BPM) data shows excessive sporadic values:
  - Verify all electrodes are making good contact with the skin and that the leads are not pulling on the electrodes. If necessary tape electrode leads to **Subject**.
  - **Subject** must try and relax arms as much as possible. Consider changing the type of exercise to minimize EMG activity in chest and arms.

Click **Redo** and repeat Steps 3 – 9 only if absolutely necessary as the **Subject** must return to a resting heart rate before repeating the procedure.

Note that once **Redo** is clicked, the most recent recording will be erased.

OPTIONAL ACTIVE LEARNING PORTION

With this lesson you may record additional data by clicking **Continue** following the last recording. Design an experiment to test or verify a scientific principle(s) related to topics covered in this lesson. Although you are limited to this lesson's channel assignments, the electrodes or transducers may be moved to different locations on the **Subject**.

Design Your Experiment

Use a separate sheet to detail your experiment design, and be sure to address these main points:

A. ***Hypothesis***

Describe the scientific principle to be tested or verified.

B. ***Materials***

List the materials you will use to complete your investigation.

C. ***Method***

Describe the experimental procedure—be sure to number each step to make it easy to follow during recording.

Run Your Experiment

D. ***Set Up***

Set up the equipment and prepare the subject for your experiment.

E. ***Record***

Use the **Continue**, **Record** and **Suspend** buttons to record as much data as necessary for your experiment.

Click **Done** when you have completed all of the recordings required for your experiment.

Analyze Your Experiment

F. Set measurements relevant to your experiment and record the results in a Data Report.

10. After clicking **Done**, choose an option and click **OK**.

If choosing the **Record from another Subject** option:

- Repeat Setup Steps 5 – 10, and then proceed to Calibration.

Recording continues…

11. Remove the electrodes and transducers.

Carefully remove the tape holding the temperature transducer in place.

Remove the electrode cable pinch connectors and peel off all electrodes. Discard the electrodes. (BIOPAC electrodes are not reusable.) Wash the electrode gel residue from the skin, using soap and water. The electrodes may leave a slight ring on the skin for a few hours which is quite normal.

END OF RECORDING

V. DATA ANALYSIS

FAST TRACK Data Analysis

1. Enter the **Review Saved Data** mode.

- Note Channel Number (CH) designations:

Channel	*Displays*
CH 1	**Airflow**
CH 2	**ECG**
CH3	**Skin Temp.**
CH41	**Heart Rate**

- Note the measurement box settings:

Channel	*Measurement*
CH 1	**P-P**
CH 1	**BPM**
CH 3	**Mean (Temperature)**
CH 41	**Mean (Heart Rate)**

Data Analysis continues…

Detailed Explanation of Data Analysis Steps

If entering **Review Saved Data** mode from the Startup dialog or lessons menu, make sure to choose the correct file.

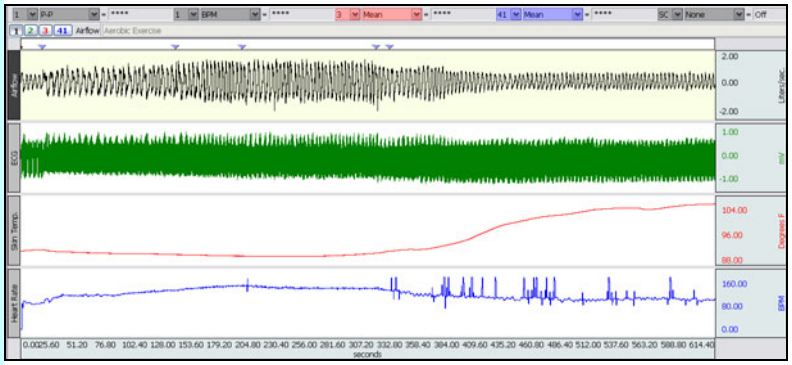


Fig. 15.15

The measurement boxes are above the marker region in the data window. Each measurement has three sections: channel number, measurement type, and result. The first two sections are pull-down menus that are activated when you click them.

Brief definition of measurements:

P-P (Peak-to-Peak): Subtracts the minimum value from the maximum value found in the selected area.

BPM: For this lesson, stands for "**B**reaths **P**er **M**inute." First calculates the difference in time between the end and beginning of the area selected by the I-Beam tool (same as ΔT,) and divides this value into 60 seconds/minute.

Mean: Displays the average value in the selected area.

The "selected area" is the area selected by the I-Beam tool (including the endpoints).

Useful tools for changing view:

Display menu: Autoscale Horizontal, Autoscale Waveforms, Zoom Back, Zoom Forward

Scroll Bars: Time (Horizontal); Amplitude (Vertical)

Cursor Tools: Zoom Tool

Buttons: Overlap, Split, Show Grid, Hide Grid, -, +

Hide/Show Channel: "Alt + click" (Windows) or "Option + click" (Mac) the channel number box to toggle channel display.

2. Zoom in on the data from time 0 to just after the first event marker ("Begin Exercising",) then choose Display > AutoScale Waveforms.)

This is the period when the **Subject** was at rest.

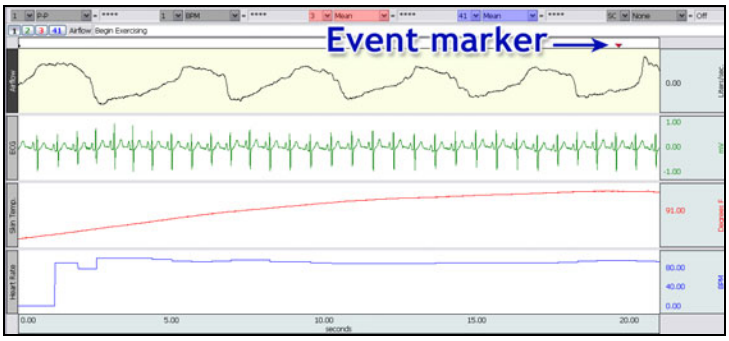


Fig. 15.16 Example of data prior to exercise

3. Using the I-Beam cursor, select an area of one complete breath cycle. Choose a breath cycle past the two second mark (Heart Rate is invalid). Record the Airflow amplitude (CH 1 – P-P,) Breathing Rate (CH 1 – BPM,) Skin Temp. (CH 3 – Mean) and Heart Rate (CH 41 – Mean).

A

The airflow transducer records inhalation as positive values, no airflow as 0, and exhalation as negative values. Therefore, the start of inhalation is recorded as the ascending positive waveform starting at 0. The end of exhalation is where the recording ends at 0 from a negative value. One complete breath cycle is from the start of one inhale to the start of the next inhale.

Notes:

- Choose a breath cycle that does not correspond to any sporadic Heart Rate values. (Your selected area should resemble Fig. 15.19.)
- Turn ON Grids to help identify the zero point.
- Airflow data can be difficult to interpret, because the **Subject** may not breathe in and out smoothly. Any brief pauses or slowing in breathing will cause the airflow to read at or near zero. Data interpretation is more difficult when the Subject is in a resting state (shallow, slow, breathing).

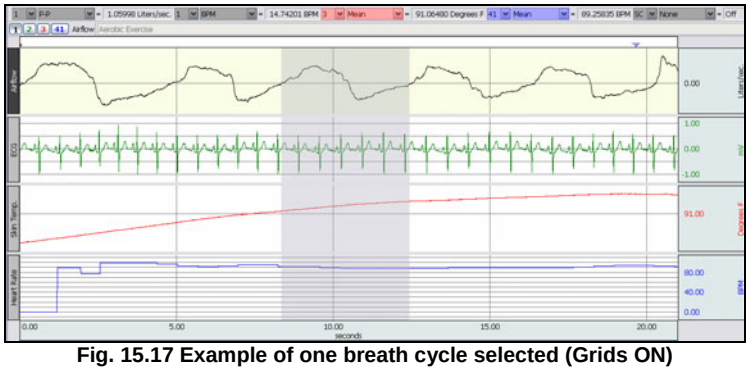


Fig. 15.17 Example of one breath cycle selected (Grids ON)

Data Analysis continues…

4. Scroll to the data just after the "Begin Exercising" event marker and select the first complete breath cycle. Record the Airflow amplitude, Breathing Rate, Skin Temp. and Heart Rate.

   B

5. Repeat Step 4 at approximately* 30-second intervals during the exercise portion.

   B

6. Scroll to the post-exercise recording and take measurements to complete Table 15.3.

   C

7. Answer the questions at the end of the Data Report.
8. **Save** or **Print** the data file.
9. **Quit** the program.

END OF DATA ANALYSIS

Select Display > Autoscale Waveforms if data goes out of view.

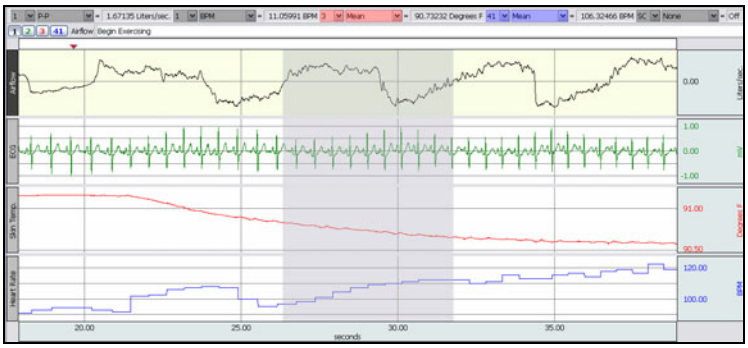


Fig. 15.18 Example of first breath cycle during exercise

Note*: Choose the nearest breath cycle that does not contain sporadic Heart Rate values.

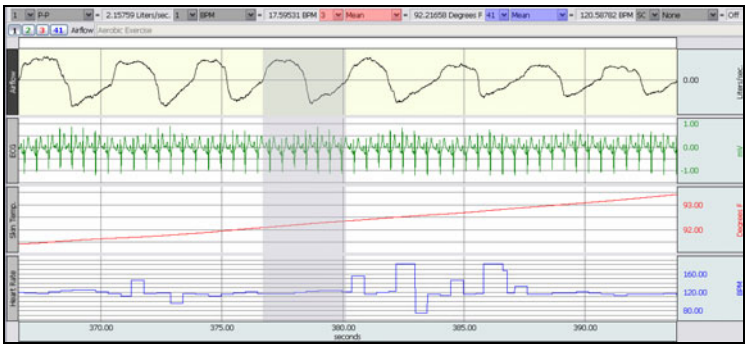


Fig. 15.19 Breath cycle selected does not include sporadic BPM values

An electronically editable **Data Report** is located in the journal (following the lesson summary,) or immediately following this Data Analysis section. Your instructor will recommend the preferred format for your lab.

END OF LESSON 15

Complete the Lesson 15 Data Report that follows.

AEROBIC EXERCISE PHYSIOLOGY

- *Cardiovascular and Respiratory Adjustments*
- *ECG During and Post-Exercise*
- *Ventilation During and Post-Exercise*
- *Heat Exchange*

DATA REPORT

Student's Name: _____

Lab Section: _____

Date: _____

I. Data and Calculations

Subject Profile

Name:_____ Height:_____

Age:_____ Gender: Male / Female Weight:_____

Calculated maximum heart rate:_____

A. Pre-exercise

Complete Table 15.1 with the requested measurements for data in the 5-second interval before exercise.

Table 15.1

Airflow Amplitude (1 P-P)	Breathing Rate (1 BPM)	Skin Temp. (3 Mean)	Heart Rate (41 Mean)

B. During Exercise

Complete Table 15.2 with the requested measurements for data during exercise.

**Note* Time references are the starting points of the exercise recording and do not correspond to the data window's horizontal time scale. You may not have collected 5 minutes of data.

Table 15.2

Time* (min)	Time* (secs)	Airflow Amplitude (1 P-P)	Breathing Rate (1 BPM)	Skin Temp. (3 Mean)	Heart Rate (41 Mean)
0	0				
	30				
1	60				
	90				
2	120				
	150				
3	180				
	210				
4	240				
	270				
5	300				

C. **Post-Exercise**

Complete Table 15.3 with the requested measurements for data after exercise.

**Note* Time references are the starting points of the post-exercise recording and do not correspond to the data window's horizontal time scale. You may not have collected 5 minutes of data.

Table 15.3

Time* (min)	Time* (secs)	Airflow Amplitude 1 P-P	Breathing Rate 1 BPM	Skin Temp. 3 Mean	Heart Rate 41 Mean
0	0				
	30				
1	60				
	90				
2	120				
	150				
3	180				
	210				
4	240				
	270				
5	300				

II. Questions:

D. Using your data, compare changes in pulmonary airflow that occurred during exercise and during the recovery period.

E. Is pulmonary airflow synonymous with pulmonary ventilation? Justify your answer.

F. Use the data in Tables 15.2 and 15.3 to describe changes in respiratory rate and heart rate that occur during and after moderate exercise. Explain the physiological basis of the observed changes.

G. How long did it take for heart rate, respiratory rate, and pulmonary airflow to return to resting (pre-exercise) levels?

H. Compare the electrocardiogram recorded during the pre-exercise, exercise, and post-exercise periods, and describe any observed changes.

I. Compare changes in skin temperature recorded before, during, and after exercise. Explain the physiological basis of the observed changes.

J. When exercising, does wiping off sweat help cool the body? Why or why not?

K. By what cellular chemical process is most of the ATP requirement for exercising skeletal muscles met?

L. What is meant by the term “oxygen debt”?

M. A high oxygen debt is associated with a low blood pH. Why and how?

N. Explain why and how dynamic exercise increases cardiac output.

O. List four other cardiovascular responses to dynamic exercise.

III. OPTIONAL Active Learning Portion

A. ***Hypothesis***

B. ***Materials***

C. ***Method***

D. ***Set Up***

E. ***Experimental Results***

End of Lesson 15 Data Report