Experiment HE-3: Exercise, Blood Pressure, and Oxygen Saturation Levels

Preparations for this experiment need to be reviewed with the students in the week prior to performing the experiment. Also, some materials used in the experiment need to be prepared before the experiment is performed.

Equipment Required

PC or Mac Computer

IXTA, USB cable, IXTA power supply

BP-220 Non-invasive blood pressure transducer and black tygon tubing

PPG-320 Pulse Oximeter

BNC-BNC cable

Male-Male DIN8 cable

Surgical tape

Step (23-30 cm in height) or a treadmill or a stationary exercise bicycle

Metronome (electronic or mechanical, if step test is used)

Stopwatch

Preparations Needed before Lab Day

Selecting Subjects and Bringing Clothing for Lab.

1. The number of subjects that can participate in this experiment will depend on the number of stations that are available, the length of the laboratory period, and the number of students in the lab section. It will take about one hour for each subject to complete the experiment.
2. If possible each subject should be paired up with another subject of the same gender, same body size, and different relative degrees of fitness.
3. Each subject should bring a t-shirt, a pair of gym shorts, a pair of cotton socks, a pair of athletic shoes, and a towel to lab on the day of this experiment.

Warning: Theses exercises 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.

Assistants and Their Duties.

1. At least one other student, who is not a subject, should join each pair of subjects to form a lab group. While one of the subjects is performing the exercises, the other subject and student in the group will perform the various duties needed to run the experiment successfully.

Work Sample Lab

2. One member of the group should:
    - Time the rest, exercise, and recovery periods;
    - Tell the subject when to get ready for rest, exercise, or recovery periods;
    - Tell the subject when to start and stop exercising;
    - Tell the other assistants when to record the subjects' vital numbers.
3. Another member of the group should:
    - Set the metronome for the rhythm needed in a step test; or set the speed on the treadmill; or the resistance and speed on the exercise bicycle;
    - Operate the computer system that records oxygen saturation, heart rate and blood pressure;
    - Operate the blood pressure cuff at the end of each rest, exercise, or recovery period.

Blood Pressure Transducer and Pulse Oximeter Setup

1. Locate the BP-220 non-invasive blood pressure (NIBP) transducer and extention tubing, and the pulse oximeter.

Figure HE-3-S1: The BP-220 non-invasive blood pressure transducer.

2. Plug the tubing connector of the BP-220 into the channel labeled A2 on the front of the TA.
3. Plug the PPG-320 pulse oximeter into the PT port on the from of the TA.
4. Set the Offset for the BP-220.

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Figure HE-3-S2: The pulse oximeter and the BP-220 non-invasive blood pressure transducer connected to the TA.

Calibration of the Non-Invasive Blood Pressure Transducer

Procedure

1. Lay the cuff of the BP-220 on the lab table.
2. Click on the Record button, located on the upper right side of the LabScribe Main window. The signal should begin scrolling across the screen.
3. Click on the AutoScale button at the upper margin of the Pulse and Blood Pressure channels. Your recording should look similar to the data shown.
4. Record data while the cuff is laying on the table for about 10 seconds.
5. Select Save As in the File menu, type a name for the file. Click on the Save button to save the data file.

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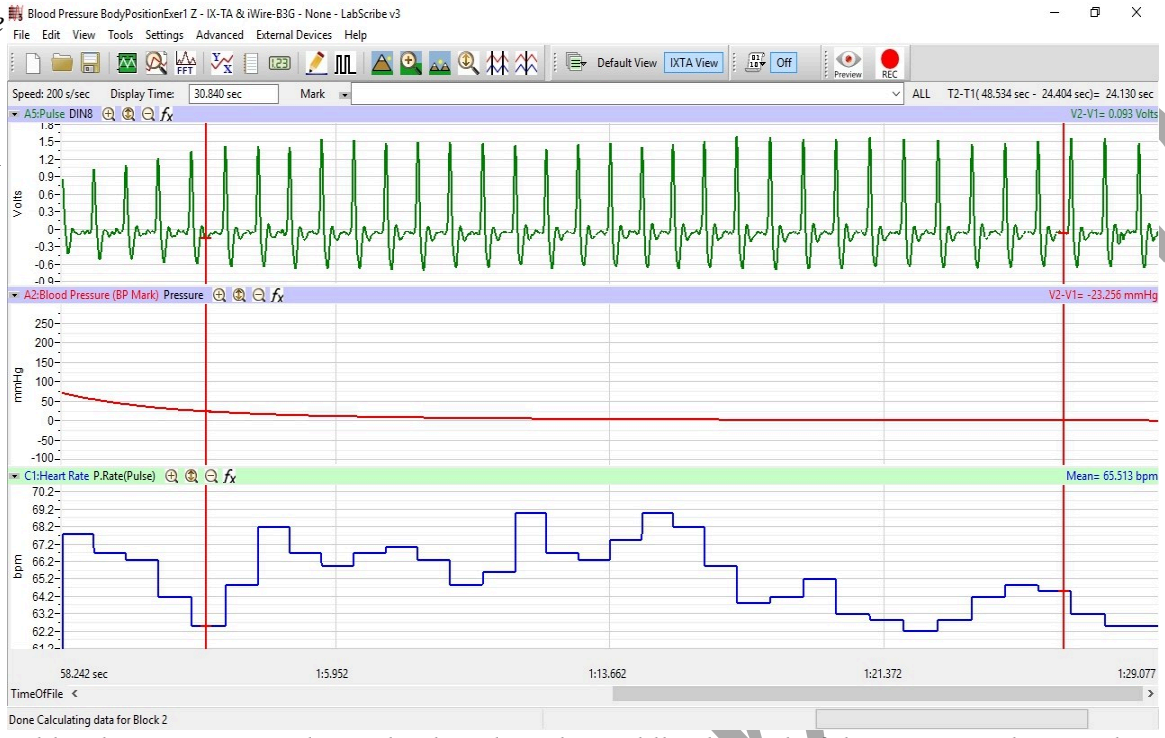

Figure HE-3-S3: The output of the BP-220 non-invasive blood pressure transducer displayed on the middle channel of the Main window. Pulse is shown on the top channel and heart rate on the bottom.

Units Conversion

1. Scroll to the beginning of the calibration data for the BP-220 non-invasive blood pressure transducer.
2. Use the Display Time icons to adjust the Display Time of the Main window to show the 10 second set of data on the Main window.
3. Click the 2-Cursor icon so that two cursors appear on the Main window. Place one cursor on the beginning of the flat section of data and the second cursor on the flat section of data collected approximately 10 seconds later.
4. Click V2-V1 on the blood pressure channel, then select Units, and select Set Offset.
5. On the units conversion window, put a check mark in the box next to Apply the calculated offset for this block to all blocks. Set the Mean Value between Cursors to: "0" in the box at the top.
6. Click on the OK button in the lower right corner.

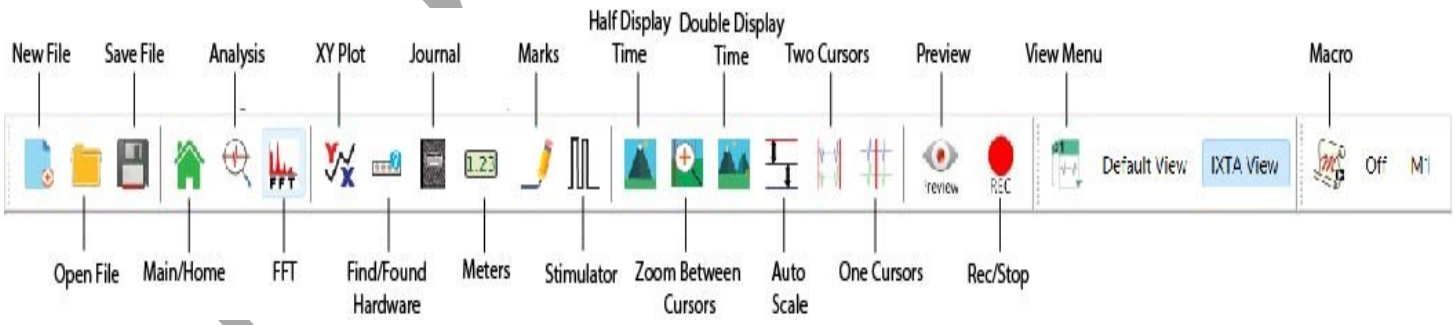

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Figure HE-3-S4: The LabScribe toolbar.

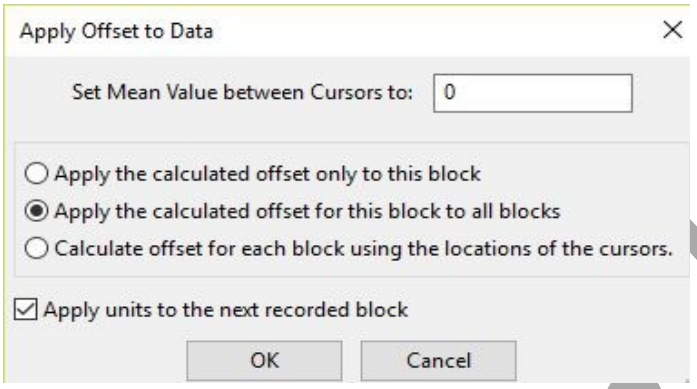

Figure HE-3-S5: The Units Offset dialogue window with the mean values set to "0".

Exercise and Rest Periods in the Experiment

1. Each subject will perform three 3-minute periods of exercise. In addition to the 5-minute rest period before the first 3-minute exercise period, there are 5-minute recovery periods between the exercise periods and a 5-minute recovery period after the last exercise period.
2. The amount of work completed in each exercise period will increase progressively:

For Walking on a Treadmill

- The speeds are 2.0, 2.6, and 3.2 miles per hour.
- The incline used should be zero degrees.

For Cycling on a Stationary Bicycle

- The subject should attain speeds of 60, 90, and 120 rotations per minute.
- The resistance should be medium.

For Stepping in Place:

- The step rates are 12, 18, and 24 steps per minute.
- Each step is a four-beat cadence, so the metronome will be set to 48, 72, and 96 beats per minute, respectively.
- The movements for each of the four beats in a step are:
    - 1st beat: Left foot up on step.
    - 2nd beat: Use the left leg to lift body, and place right foot on step.
    - 3rd beat: Lower the left foot to the ground.

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    - 4th beat: Lower the right foot to the ground.
- The subject can begin stepping with his or her right foot if more comfortable with that arrangement.

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Experiment HE-3: Exercise, Blood Pressure, and Oxygen Saturation Levels

Preparations for this experiment need to be reviewed with the students in the week prior to performing the experiment. Also, some materials used in the experiment need to be prepared before the experiment is performed.

Exercise and Rest Periods in the Experiment

1. Each subject will perform three 3-minute periods of exercise. In addition to the 5-minute rest period before the first 3-minute exercise period, there are 5-minute recovery periods between the exercise periods and a 5-minute recovery period after the last exercise period.
2. The amount of work completed in each exercise period will increase progressively:

For Walking on a Treadmill

- The speeds are 2.0, 2.6, and 3.2 miles per hour.
- The incline used should be zero degrees.

For Cycling on a Stationary Bicycle

- The subject should attain speeds of 60, 90, and 120 rotations per minute.
- The resistance should be medium.

For Stepping in Place:

- The step rates are 12, 18, and 24 steps per minute.
- Each step is a four-beat cadence, so the metronome will be set to 48, 72, and 96 beats per minute, respectively.
- The movements for each of the four beats in a step are:
    - 1st beat: Left foot up on step.
    - 2nd beat: Use the left leg to lift body, and place right foot on step.
    - 3rd beat: Lower the left foot to the ground.
    - 4th beat: Lower the right foot to the ground.
- The subject can begin stepping with his or her right foot if more comfortable with that arrangement.

Exercise 1: Heart Rate, Blood Pressure, and Oxygen Saturation Levels at Rest

Aim: To determine the resting heart rate, blood oxygen saturation level, and blood pressure of the subject.

Approximate Time: 15 minutes

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Procedure

1. Select a subject and have him or her sit in a chair.
2. Place the cuff of the non-invasive blood pressure sensor around the upper portion of the left arm, between the elbow and the shoulder. Place the O2 sensor of the pulse oximeter the distal segment of the subject's left ring finger. Secure the cable of the O2 sensor to the back of the subject's hand with a piece of surgical tape.
3. Instruct the subject to relax with his or her hands in the lap for five minutes.
4. Type **Resting BP/HR/%O2Sat** in the Mark box.
5. At the end of the five minute relaxation period, click the Record button to begin the recording. Click the mark button.
6. Record for twenty seconds before clicking the AutoScale buttons on any of the channels and before inflating the blood pressure cuff.
7. Click the AutoScale buttons on the Pulse, Heart Rate, and Oxygen Saturation channels. Inflate the blood pressure cuff until the finger pulse wave on the Pulse channel disappears.

Figure HE-3-L1: The pulse wave, oxygen saturation level, cuff pressure, and heart rate recorded before, during, and after the occlusion of the brachial artery displayed in the Main window. Pulses disappear as the pressure in the cuff exceeds the pressure in the artery, and reappear as the pressure in the cuff is released.

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8. Once the pulse wave disappears, release the cuff pressure at the rate of 5 mmHg per second. Continue to release the cuff pressure until the aneuroid gauge reads 20 mmHg.
9. Click the Stop button.
10. Remove all the pressure from the cuff. The subject should flex and extend their fingers to encourage blood circulation. Make sure the subject keeps his or her hands and arms warm, to promote good peripheral circulation, while waiting for the next exercise to begin.
11. Select Save As in the File menu, type a name for the file. Click on the Save button to save the data file.
12.

Data Analysis - Oxygen Saturation and Heart Rate at Rest

1. Scroll to the section of data recorded while the subject was resting and before the blood pressure cuff was inflated.
2. Use the Display Time icons to adjust the Display Time of the Main window to show at least sixty seconds of data that is relatively free of artifacts.
3. Click on the Analysis window icon.

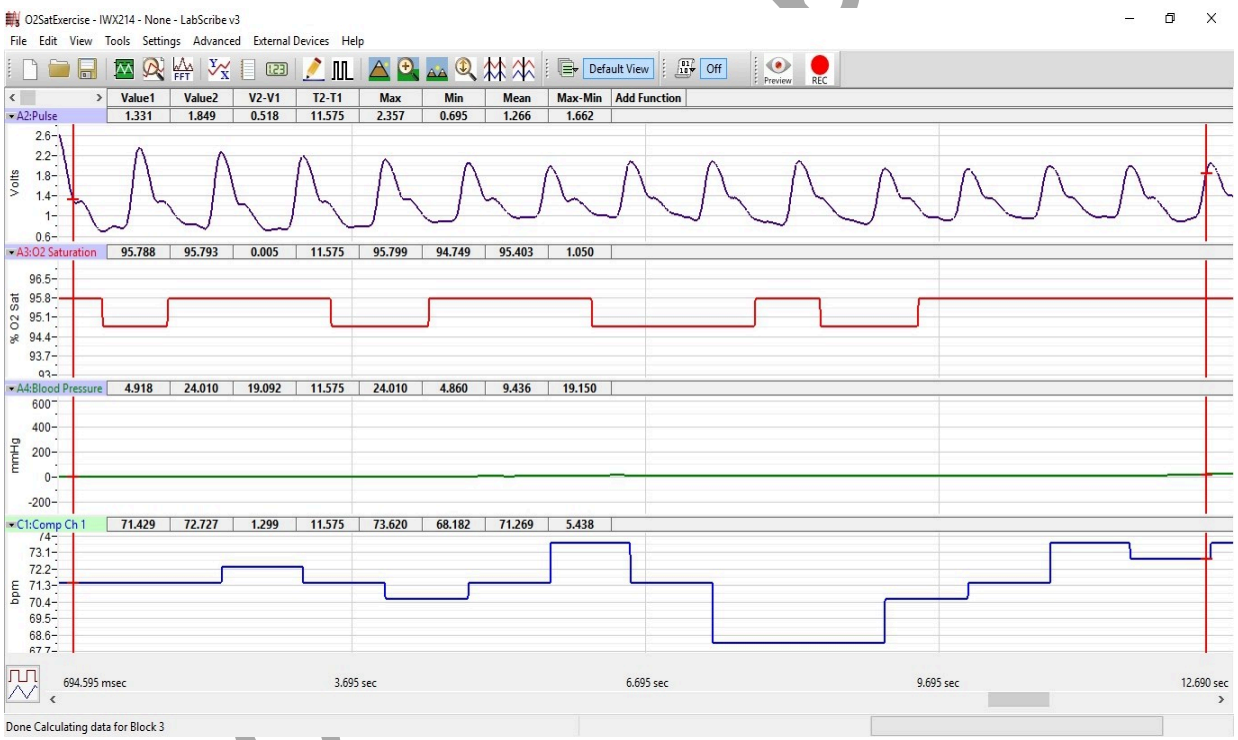

Figure HE-3-L2: The pulse wave, oxygen saturation level, cuff pressure, and heart rate recorded before the occlusion of the artery displayed in the Analysis window. The mean oxygen saturation level at rest equals 95.4.

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4. Look at the Function Table that is above the uppermost channel displayed in the Analysis window. The mathematical functions, Value1, Value2, V2-V1, T2-T1, Max, Min, Mean, and Max-Min should appear in this table. Values for these parameters on each channel are seen in the table across the top margin of each channel.
5. Once the cursors are placed in the correct positions for determining the volumes and rates of each breath cycle, the values of the parameters in the Function Table can be recorded in the on-line notebook of LabScribe by typing their names and values directly into the Journal, or on a separate data table.
6. The functions in the channel pull-down menus of the Analysis window can also be used to enter the names and values of the parameters from the recording to the Journal. To use these functions:
    - Place the cursors on either side of the section of data to be analyzed.
    - 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 Lung Volumes Channel pull-down menu.
    - Transfer the values for the volumes and rates to the Journal using the Add Ch. Data to Journal function in the Lung Volumes Channel pull-down menu.
7. Measure the following parameters from the O2 Saturation channel for the region of data selected:
    - Maximum Oxygen Saturation Level, which is the value for Max on the O2 Saturation channel.
    - Minimum Oxygen Saturation Level, which is the value for Min on the O2 Saturation channel.
    - Mean Oxygen Saturation Level, which is the value for Mean on the O2 Saturation channel.
    - Change (Δ) in Oxygen Saturation Level, which is the value for Max-Min on the O2 Saturation channel.
8. Record the values for these parameters in Table 2.
9. Use one of the techniques described in Steps 5 or 6 to record the values for the following parameters in the Journal:
    - Maximum Heart Rate, which is the value for Max on the Heart Rate channel.
    - Minimum Heart Rate, which is the value for Min on the Heart Rate channel.
    - Mean Heart Rate, which is the value for Mean on the Heart Rate channel.
    - Change (Δ) in Heart Rate, which is the value for Max-Min on the Heart Rate channel.
10. Record the values for these parameters in the data table.
11. Click the Save button to save the file.
12. Click on the Main icon in the LabScribe toolbar to return to the Main window.

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Data Analysis - Blood Pressure at Rest

1. Click the Main window icon to return to the Main window. Scroll to the section of data recorded while the pressure in the cuff was being released.
2. Use the Display Time icons to adjust the Display Time of the Main window to show the data from just before the reappearance of the pulse wave to just after the pulse wave in which the dichrotic notch reappears.
3. Click on the Analysis window icon.

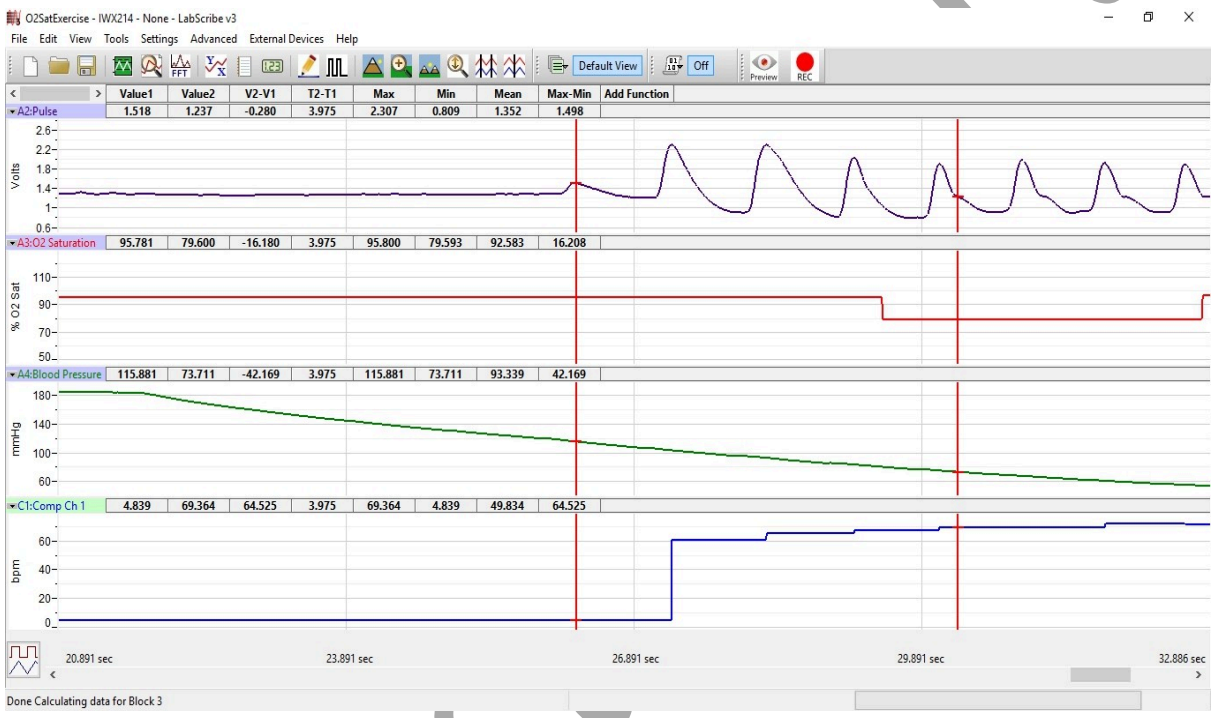

Figure HE-3-L3: The pulse wave, oxygen saturation level, cuff pressure, and heart rate recorded during and after the occlusion of the artery displayed in the Analysis window. The subjects blood pressure at rest equals 116/74.

4. On the Pulse channel, place one cursor on the peak of the first pulse wave that reappears after the pressure in the cuff is released. Place the second cursor on the dichrotic notch of the first wave in which the dichrotic notch reappears after the pressure in the cuff is released.
5. Use one of the techniques described in the previous section to record the values for the following parameters in the Journal:
    - Systolic Blood Pressure, which is the value for Value1 on the Blood Pressure channel.
    - Diastolic Blood Pressure, which is the value for Value2 on the Blood Pressure channel.
    - Pulse Pressure, which is the value for V2-V1 on the Blood Pressure channel.
6. Record the values for these parameters in the data table.
7. Select Save in the File menu.

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8. Determine the subject's blood pressure class from Table 1. List it in Table 2.

Table HE-3-L1: Classification of Blood Pressure Levels According to the Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (JNC 7)

Class	Systolic Pressure (mmHg)	Diastolic Pressure (mmHg)
Hypotensive	<90	<60
Normal	<120	and <80
Prehypertensive	120-139	or 80-89
Hypertensive Stage 1	140-159	or 90-99
Hypertensive Stage 2	>160	or >100

Exercise 2: Oxygen Saturation, Heart Rate, and Blood Pressure During and After Light, Moderate, and Vigorous Exercise.

Aim: To determine the effect of light exercise on the oxygen saturation, heart rate, and blood pressure of a subject.

Approximate Time: 30 minutes

Procedure

1. When the measurements from the rest period have been completed, the timekeeper should inform the lab group when the first exercise period will begin.
2. Depending on the exercise routine used in this experiment, set the device that controls the pace of the workout to the proper setting.

First Exercise Period:

For Walking on a Treadmill:

- The speed should be set to 2.0 miles per hour and turned on 15 seconds before the exercise period begins.
- The subject should stand with one foot on each side of the belt before the exercise period begins.
- The subject should hold the arm with the O2 sensor and the blood pressure cuff still to reduce the possibility of motion artifacts on the recording.

Warning: Standing on the belt when the treadmill is turned on could cause injury to the subject or damage to the treadmill.

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For Cycling on a Stationary Bicycle:

- The subject should be on the bicycle 20 seconds before the exercise period begins and holding the arm with the O2 sensor and the blood pressure cuff still to reduce the possibility of motion artifacts on the recording.
- The subject should maintain a speed of 60 rotations per minute throughout the exercise period.
- The subject should begin pedaling at the beginning of the exercise period and reach the designated speed as soon as possible.

For Stepping in Place:

- The metronome should be set to 48 beats per minute and turned on 20 seconds before the exercise period begins.
- The subject should be standing in front of the step at that time.
- The subject should hold the arm with the O2 sensor and the blood pressure cuff still to reduce the possibility of motion artifacts on the recording.

Warning: 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.

3. The timekeeper should give the group a 10-second countdown before the beginning of the exercise period. When the timekeeper says "Start!", the subject should begin exercising and the Record button on LabScribe Main window should be clicked.
4. Type **1 Minute, Light Exercise** in the Mark box. At one minute into the exercise period, click the mark button.
5. Type **2 Minute, Light Exercise** in the Mark box. At two minutes into the exercise period, click the mark button.
6. Thirty seconds before the end of the exercise period, the timekeeper should alert the group to be ready to take the subject's blood pressure.
7. Type **End of Light Exercise** in the Mark box. At three minutes into the exercise period, click the mark button, and instruct the subject to stop exercising, sit down and relax. Continue recording.
8. As soon as possible after the end of the exercise period, measure the subject's blood pressure:
    - Check the position of the blood pressure cuff on the arm.
    - Inflate the cuff until the pulse wave disappears.
    - Release the pressure from the cuff at the rate of 2-3 mmHg per second until the pressure reads 40 mmHg.
9. Continue recording.
10. Type **1 Minute, Recovery 1** in the Mark box. At one minute into the recovery period, click the mark button.

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11. Mark the recording of the recovery period at 2, 3, 4, and 5 minutes into the recovery period using notations similar to the one used in Step 10.
12. Between the 4-minute and 5-minute (end) marks of the recovery period, measure the subject's blood pressure again.
13. As soon as the blood pressure measurement at the end of the first recovery period is completed, prepare to begin the second exercise period.

Second Exercise Period:

For Walking on a Treadmill:

- The speed should be set to 2.6 miles per hour and turned on 15 seconds before the exercise period begins.

For Cycling on a Stationary Bicycle:

- The subject should be seated on the bicycle and ready to maintain a speed of 90 rotations per minute throughout the exercise period.

For Stepping in Place:

- The metronome should be set to 72 beats per minute and turned on 20 seconds before the exercise period begins, and the subject should be standing in front of the step at that time.

14. Repeat Steps 3 through 12 of these directions for the second exercise and recovery periods.
15. As soon as the blood pressure measurement at the end of the second recovery period is completed, prepare to begin the third exercise period.

Third Exercise Period:

For Walking on a Treadmill:

- The speed should be set to 3.2 miles per hour and turned on 15 seconds before the exercise period begins.

For Cycling on a Stationary Bicycle:

- The subject should be seated on the bicycle and ready to maintain a speed of 120 rotations per minute throughout the exercise period.

For Stepping in Place:

- The metronome should be set to 96 beats per minute and turned on 20 seconds before the exercise period begins, and the subject should be standing in front of the step at that time.

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16. Repeat Steps 3 through 12 of these directions for the third exercise and recovery periods.
17. As soon as the blood pressure measurement at the end of the third recovery period is completed, click the Stop button on the LabScribe Main window.
18. Select Save in the File menu.

Data Analysis - Oxygen Saturation and Heart Rate

1. Scroll to the data recorded between the beginning of the first exercise period and the one-minute mark of the first exercise period.
2. Use the Display Time icons to adjust the Display Time of the Main window to show the sixty seconds of data in the window.
3. Click on the Analysis window icon.
4. Use the same techniques employed in Exercise 1 to measure and record the following parameters from the O2 Saturation channel for the region of data selected:
    - Maximum Oxygen Saturation Level, which is the value for Max on the O2 Saturation channel.
    - Minimum Oxygen Saturation Level, which is the value for Min on the O2 Saturation channel.
    - Mean Oxygen Saturation Level, which is the value for Mean on the O2 Saturation channel.
    - Change (Δ) in Oxygen Saturation Level, which is the value for Max-Min on the O2 Saturation channel.
5. Record the values for these parameters in the Journal and on the data table.
6. Use the same techniques employed in Exercise 1 to measure and record the following parameters from the Heart Rate channel for the region of data selected:
    - Maximum Heart Rate, which is the value for Max on the Heart Rate channel.
    - Minimum Heart Rate, which is the value for Min on the Heart Rate channel.
    - Mean Heart Rate, which is the value for Mean on the Heart Rate channel.
    - Change (Δ) in Heart Rate, which is the value for Max-Min on the Heart Rate channel.
7. Record the values for these parameters in the Journal and on the data table.
8. Select Save in the File menu.
9. Scroll to the other minute marks in all the exercise and recovery periods and repeat Steps 2 through 8.

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Data Analysis - Blood Pressure

1. Click the Main window icon to return to the Main window. Scroll to the section of the blood pressure data recorded at the end of the first exercise period and the beginning of the first recovery period. Find the data recorded as the pressure in the blood pressure cuff was being released.
2. Use the Display Time icons to adjust the Display Time of the Main window to show the data from just before the reappearance of the pulse wave to just after the pulse wave in which the dichrotic notch reappears. This section of data can also be selected by:
    - Placing the cursors on either side of the required data; and
    - Clicking the Zoom between Cursors button on the LabScribe toolbar to expand the data to the width of the Main window.
3. Click on the Analysis window icon.
4. Use the same techniques employed in Exercise 1 to measure and record the following parameters from the O2 Saturation channel for the region of data selected:
    - Systolic Blood Pressure, which is the value for Value1 on the Blood Pressure channel.
    - Diastolic Blood Pressure, which is the value for Value2 on the Blood Pressure channel.
    - Pulse Pressure, which is the value for V2-V1 on the Blood Pressure channel.
5. Record the values for these parameters in the Journal and on the data table.
6. Select Save in the File menu.
7. Scroll to the other blood pressure recordings made at the ends of the other exercise and recovery periods and repeat Steps 2 through 6.

Questions

At Rest

1. Which subject in the pair had the highest oxygen saturation level?
2. Which subject in the pair had the lowest heart rate?
3. Which subject in the pair had the lowest blood pressure?

In the Light Exercise Period

4. Which subject in the pair showed the greatest percentage change in oxygen saturation level from the resting level?
5. Which subject in the pair showed the greatest percentage change in heart rate from the resting heart rate?
6. Which subject in the pair showed the greatest percentage change in blood pressure from the resting blood pressure?

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In the Vigorous Exercise Period

7. Which subject in the pair showed the greatest percentage change in oxygen saturation level from the resting level?
8. Which subject in the pair showed the greatest percentage change in heart rate from the resting heart rate?
9. Which subject in the pair showed the greatest percentage change in blood pressure from the resting blood pressure?

Overall

10. Does the fitter subject always have the higher oxygen saturation level at rest, the lower oxygen saturation level at any level of exercise, the lower heart rate at rest or exercise, and the lowest blood pressures at rest or exercise?
11. Determine the maximum heart rate of each subject:

    Max Heart Rate-Male (BPM) = 220 - Age (Years)

    Max Heart Rate-Female (BPM) = 226 - Age (Years)

For example, the maximum predicted heart rate of a 25 year old woman is 201 beats per minute:

    226 - 25 = 201BPM

12. Which subject in the pair had a heart rate for vigorous exercise closer to his or her maximum heart rate?

Table HE-3-L2: O_2 Saturation Level, Blood Pressure, and Heart Rate at Different Levels of Exercise.

Condition	Oxygen Saturation (%)				Heart Rate (BPM)				Blood Pressure (mmHg)			
	Max	Min	Mean	Δ	Max	Min	Mean	Δ	Systolic	Diastolic	Pulse	BP Class
Resting												
Exercise 1, 0-1 Min												
Exercise 1, 1-2 Min												
Exercise 1, 2-3 Min												

Work-Sample Lab

Recovery 1, 0-1 Min											
Recovery 1, 1-2 Min											
Recovery 1, 2-3 Min											
Recovery 1, 3-4 Min											
Recovery 1, 4-5 Min											
Exercise 2, 0-1 Min											
Exercise 2, 1-2 Min											
Exercise 2, 2-3 Min											
Recovery 2, 0-1 Min											
Recovery 2, 1-2 Min											
Recovery 2, 2-3 Min											
Recovery 2, 3-4 Min											
Recovery 2, 4-5 Min											
Exercise 3, 0-1 Min											
Exercise 3, 1-2 Min											
Exercise 3, 2-3 Min											
Recovery 3, 0-1 Min											

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Recovery 3, 1-2 Min											
Recovery 3, 2-3 Min											
Recovery 3, 3-4 Min											
Recovery 3, 4-5 Min											

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