Student version

Title: “Impact of exercise on cardiopulmonary function, a practice in integration”

Goal: Place cardiovascular and pulmonary variables in a functional context.

Materials: Blood pressure cuff and spirometer

Deliverables/grading:

This project will use student-collected data to put into practice cardiovascular and pulmonary physiology. Students will complete a pre-activity worksheet, an activity worksheet, and a post-exercise question set. Students will be graded according to correctness of responses and completeness of activity.

Background required: Cardiovascular and pulmonary physiology

Group project: 2-3 people per group will work collaboratively to complete the project. One student will aid in data collection, and the other two students will have physiologic values measured.

Assignment summary:

In this project, you will measure the cardiovascular and respiratory response to exercise. The physiological response to exercise will be collected at rest and following exercise. You will compare your prediction to the collected data. Following data collection, you will assess the impact of exercise on cardiopulmonary function. Following data collection, students will interpret the meaning of the results and give context to the results obtained by addressing a question set.

Activity instructions:

Familiarize yourself with the terms and abbreviations used throughout this assignment.

ABBREV	QUANTITY	UNITS
MAP	Mean arterial pressure	mm Hg
CO	Cardiac output	L/min
PP	Pulse pressure	mm Hg
SBP	Systolic blood pressure	mm Hg
DBP	Diastolic blood pressure	mm Hg
HR	Heart rate	beats per minute
SV	Stroke volume	L/beat
TPR	Total peripheral resistance	mm Hg*L/min
TV	Tidal volume	L/breath
V_f	Ventilation frequency	breaths/min
ERV	Expiratory reserve volume	L
IRV	Inspiratory reserve volume	L
RV	Residual lung volume	L

ABBREV	QUANTITY	UNITS
IC	Inspiratory capacity	L
FRC	Functional residual capacity	L
TLC	Total lung capacity	L
VC	Vital capacity	L
T_{vent}	Total ventilation	L/min

Part 1

Make predictions using the pre pre-activity worksheet and address questions.

Part 2: Cardiovascular and pulmonary response to exercise

Data collection:

Students will collect cardiovascular and pulmonary measurement at rest and following exercise.

Measurements at rest:

The subject should be seated upright, legs uncrossed. The subject should refrain from conversation or distraction for an adequate amount of time, ≈ 5 minutes. Once the time limit is reached, cardiovascular and pulmonary measurements will be collected concurrently.

Exercise:

Students will exercise for 10 minutes by comfortably running. Following exercise, students will record the same parameters measured at rest and perform the same calculations. Cardiovascular and pulmonary measurements should be collected concurrently.

Cardiovascular measurements and calculations:

Systolic and diastolic blood pressure (SBP and DBP) can be measured through use of a sphygmomanometer. Heart rate should be measured concurrently. Once blood pressure and heart are recorded, you will calculate the MAP (Equation 1) and PP (Equation 2). Estimate stroke volume (Equation 3). Calculate cardiac output (Equation 4). TPR can be calculated using the value for CO and MAP (Equation 5).

Equation 1: $MAP = \frac{1}{3}(PP) + DBP$

Equation 2: $PP = SBP - DBP$

Equation 3 estimates stroke volume using SBP and DBP. Ideally, stroke volume would be measured directly, but this is impractical here. This equation is an empirical estimate based on a large sample of measurements taken by others. Measuring stroke volume is generally an invasive procedure or requires equipment that we do not have access to.

Equation 3: $SV = 101 + 0.5 * SBP - 1.09 * DBP - 0.61 * age$

- SBP and DBP: must be measured in mm Hg
- age: must be measured in years
- SV: the calculated stroke volume will be in ml/beat. This should be converted to L/beat before moving on.

Equations 4-5 use the estimated stroke volume to calculate total peripheral resistance and cardiac output.

Equation 4: $CO = SV * HR$

Equation 5: $CO = MAP/TPR$

Total peripheral resistance at rest should be around 20-24 mmHg/ml/min at rest.

Respiratory measurements and calculations:

Pulmonary measurements will focus on lung volumes and ventilation frequency (V_f). To measure lung volumes spirometry can be used. V_f should be measured prior to collecting lung volumes. For post-exercise measurements, ventilation frequency should be measured prior to recording lung volumes. This value should be measured as quickly as possible following exercise. Once ventilation frequency is recorded, lung volumes should be recorded.

Students should refer to the manufacturer's instructions for use of the spirometer.

Measurement of V_f:

1. Record the number of breaths during a 30 second period.
2. Multiply the number of breaths by two.

Measurement of TV:

1. Apply the nose clip to ensure air can only move through your mouth.
2. Inhale and exhale normally repeat five times.
3. Record the value on the spirometer.
4. Divide value by five.

Measurement of ERV:

1. Apply the nose clip to ensure air can only move through your mouth.
2. Breath normally.
3. Following the normal exhalation forcefully exhale until you cannot exhale any further.
4. Record value on spirometer following full exhalation.

Measurement of VC:

1. Apply the nose clip to ensure air can only move through your mouth.

2. Inhale as deep as possible.

3. Exhale fully.

4. Record the value on the spirometer.

Once initial pulmonary measurements are collected, calculate IRV (Equation 6), IC (Equation 7), FRC (Equation 8), and T_{vent} (Equation 9). RV can be estimated using the height and age of the subject (Equation 10).

Equation 6: $VC = TV + ERV + IRV$

Equation 7: $IC = TV + IRV$

Equation 8: $FRC = VC - ERV$

Equation 9: $T_{vent} = V_f * TV$

Equation 10 estimates residual volume based on characteristics from the participant. Like the stroke volume equation, this equation is an empirical estimate. In order to accurately measure RV, we would need to use a gas dilution technique.

Equation 10: $RV = \begin{cases} 1.31(H) + 0.022(age) - 1.23, & \text{if male} \\ 1.81(H) + 0.016(age) - 2.00, & \text{if female} \end{cases}$

- H: Height must be measured in meters
- age: must be measured in years
- RV: Residual lung volume will be in Liters

Record your values on the data collection sheet.