Common Biology Experiments Using the Latest Technology

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HANDS-ON ACTIVITIES

Limb Position and Grip Strength

- Go Direct Hand Dynamometer

Cell Respiration

- Go Direct CO_2 Gas

Monitoring EKG

- Go Direct EKG

Limb Position and Grip Strength

The importance of hand strength and function is evident in all aspects of our daily living, from eating and maintaining personal hygiene to typing at the computer, performing brain surgery, or playing tennis or the piano. People suffering from arthritis or hand injury quickly appreciate the difficulty of performing even simple tasks with reduced grip strength.

Testing of hand grip strength is used by orthopedic surgeons and physical therapists to evaluate the extent of an injury and the progress of recovery. Grip strength can also be used to diagnose neuromuscular problems such as stroke, herniated disks in the neck, carpal tunnel syndrome, and elbow tendonitis. Athletes are interested in grip strength because it relates to performance in many sports, such as tennis, golf, baseball, football, gymnastics, and rock climbing.

Pinch strength is a way for occupational therapists to measure loss of fine-motor strength in the thumb, fingers, and forearm. It is useful for analyzing the extent of an injury and the outcome from surgery or therapy.

In Part I of this experiment, you will measure and compare grip strength in your right and left hands. You will also correlate grip strength with arm position and handedness. In Part II you will analyze the pinch strength of each of your four fingers on your dominant hand.

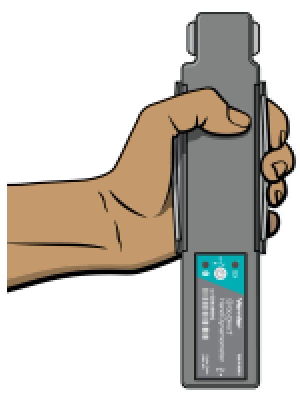

Figure 1

OBJECTIVES

- Measure and compare grip strength of your right and left hands in three different lower arm positions.
- Compare grip strength of dominant hand and nondominant hand.
- Compare the pinch strengths of the individual fingers of the dominant hand.

MATERIALS

LabQuest
LabQuest App
Go Direct Hand Dynamometer

PROCEDURE

Part I Hand grip strength

Each person in the group will have a chance to be the subject. **Important**: Do not attempt this exercise if you have arthritis, carpal tunnel syndrome, or any ailment that might be exacerbated by using the muscles of your arm and hand.

1. Connect the Go Direct Hand Dynamomenter to LabQuest and choose New from the File menu.

2. On the Meter screen, tap Duration. Change the data-collection length to 10 seconds. Select OK.

3. Zero the readings for the Go Direct Hand Dynamometer
   a. Hold the Hand Dynamometer along the sides, in an upright position (see Figure 2). Do not put any force on the pads of the Hand Dynamometer.
   b. When the readings stabilize, choose Zero from the Sensors menu. The readings for the sensor should be close to zero.

4. Have the subject sit with his or her back straight and feet flat on the floor. The Hand Dynamometer should be held in the left hand. The elbow should be at a 90° angle, with the arm unsupported and the hand in a neutral position (see Figure 1).

5. Have the subject close his or her eyes or avert them from the screen.

6. Click or tap Collect to start data collection. After collecting 2 seconds of baseline data, instruct the subject to grip the sensor with full strength for the next 8 seconds. Data will be collected for 10 seconds. Save your run.

7. Determine the maximum and mean force exerted by your hand during a portion of the data-collection period.
   a. Tap and drag across the data from 4 s to 8 s.
   b. Choose Statistics from the Analyze menu.
   c. Record the maximum and mean force in Table 1.

8. Repeat Steps 3−7 with the right hand. **Note**: Save your data after each run.

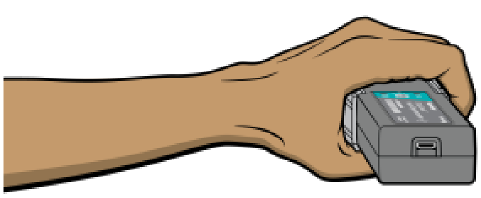

Figure 2

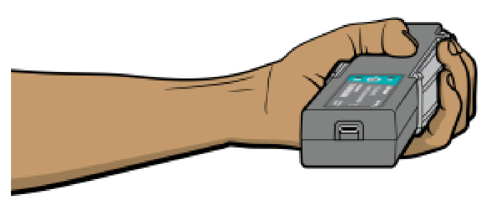

Figure 3

9. Repeat Steps 3−8 with the hand in a prone position (palm down) (see Figure 2).

10. Repeat Steps 3−8 with the hand in a supine position (palm up) (see Figure 3).

11. Repeat Steps 3–10 for each group member.

12. Work with your classmates to complete Table 2.

Part II Pinch strength

13. Tap the Meter tab. Tap Length and change the data-collection length to 30 seconds. Select OK.

14. Have the subject sit with his or her back straight and feet flat on the floor, holding the base of the Hand Dynamometer with the nondominant hand (see Figure 4). **Note**: No additional force should be placed on the sensor by this hand.

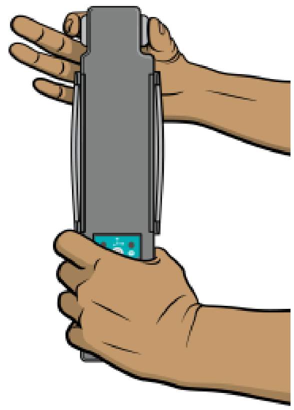

Figure 4

15. Have the subject close his or her eyes or avert them from the screen.

16. Zero the readings for the Hand Dynamometer.
    a. Hold the Hand Dynamometer along the sides, in an upright position. Do not put any force on the gray pads of the Hand Dynamometer.
    b. When the readings stabilize, select Zero from the Sensors menu. The readings for the sensor should be close to zero.

17. Click or tap Collect to start data collection. Instruct the subject to immediately pinch the end of the sensor between the pads of the thumb and forefinger of his or her dominant hand, and hold for 5 seconds.

18. Instruct the subject to switch to successive fingers every 5 seconds. Data collection will stop after 30 seconds. Save your run.

19. Determine the mean force applied during each pinch.
    a. Tap and drag across the first plateau on the graph, to select the data representing the pinch strength of the thumb and index finger (see Figure 4).
    b. Choose Statistics from the Analyze menu and record the mean pinch strength to the nearest 0.1 N in Table 5.
    c. Choose Statistics from the Analyze menu to turn off statistics.
    d. Select the data in the second plateau, representing the pinch strength of the thumb and middle finger. Choose Statistics from the Analyze menu.
    e. Record the mean pinch strength to the nearest 0.1 N in Table 5.
    f. Choose Statistics from the Analyze menu to turn off statistics.
    g. Repeat this process to obtain statistics for the remaining two pinch strengths.

20. Repeat Steps 16–19 for each person in the group.

DATA

Table 1: Individual Grip Strength Data		
	Maximum force (N)	Mean force (N)
Right hand grip strength: neutral		
Left hand grip strength: neutral		
Right hand grip strength: prone		
Left hand grip strength: prone		
Right hand grip strength: supine		
Left hand grip strength: supine		

Table 2: Class Grip Strength Data		
	Average mean force: neutral (N)	
	Right hand	Left hand
Right-handed individuals		
Left-handed individuals		

Table 3: Individual Pinch Strength Data	
	Mean force (N)
Dominant hand index finger	
Dominant hand middle finger	
Dominant hand ring finger	
Dominant hand little finger	

DATA ANALYSIS

1. Is there a difference in grip strength in your dominant and nondominant hands? Are you surprised by the result?
2. Does there appear to be a correlation between grip strength and arm position? If so, in which position was grip the strongest? Weakest?
3. Examining the data in Table 2, does there appear to be a correlation between “handedness” and grip strength? Are the results similar for right-handed and left-handed people?
4. Using the pinch strength data in Table 3, describe the difference in strength between fingers. Where is the difference the largest?
5. List at least two possible reasons for the differences you see between the pinch strength of the first two fingers and the second two fingers. In your answer consider actions of the hand and musculature. **Note**: You can use an anatomy book or atlas to view the muscles of the forearm and hand.

EXTENSIONS

1. Perform daily hand-strengthening exercises to increase your grip and/or pinch strength (such as squeezing a rubber ball). Measure your grip and/or pinch strength after two weeks and after four weeks. Compare the results with your original data.
2. Design an experiment to explore whether there is a correlation between grip strength and other physical characteristics such as height or arm circumference.

Cell Respiration

(CO$_2$ Gas Sensor)

Cell respiration refers to the process of converting the chemical energy of organic molecules into a form immediately usable by organisms. Glucose may be oxidized completely if sufficient oxygen is available by the following equation:

$$C_6H_{12}O_6 + 6\ O_2(g) \rightarrow 6\ H_2O + 6\ CO_2(g) + \text{energy}$$

All organisms, including plants and animals, oxidize glucose for energy. Often, this energy is used to convert ADP and phosphate into ATP. It is known that peas undergo cell respiration during germination. Do peas undergo cell respiration before germination? The results of this experiment will verify that germinating peas do respire. Using your collected data, you will be able to answer the question concerning respiration and non-germinating peas.

Using the CO_2 Gas Sensor, you will monitor the carbon dioxide produced by peas during cell respiration. Both germinating and non-germinating peas will be tested. Additionally, cell respiration of germinating peas at two different temperatures will be tested.

OBJECTIVES

- Use a CO_2 Gas Sensor to measure concentrations of carbon dioxide.
- Study the effect of temperature on cell respiration.
- Determine whether germinating and non-germinating peas respire.
- Compare the rates of cell respiration in germinating and non-germinating peas.

Figure 1

MATERIALS

Chromebook, computer, **or** mobile device
Graphical Analysis 4 app
Go Direct CO_2 Gas
250 mL respiration chamber
25 germinating peas
25 non-germinating peas
ice water
thermometer
100 mL beaker
paper towels
goggles

PROCEDURE

1. Launch Graphical Analysis. Connect the CO_2 Gas Sensor to your Chromebook, computer, or mobile device.
2. Set up the data-collection mode.
   a. Click or tap Mode to open Data Collection Settings.
   b. Change End Collection to 300 s. Click or tap Done.
3. Measure the room temperature using a thermometer and record the temperature in Table 1.
4. Obtain 25 germinating peas and blot them dry between two pieces of paper towel.
5. Place the germinating peas into the respiration chamber.
6. Place the shaft of the CO_2 Gas Sensor in the opening of the respiration chamber. Gently push the sensor down into the chamber until it stops. The sensor is designed to seal the chamber without the need for unnecessary force.
7. Wait one minute, then click or tap Collect to start data collection. Data will be collected for 5 minutes.
8. When data collection has finished, remove the CO_2 Gas Sensor and peas from the respiration chamber. Place the peas in a 100 mL beaker filled with cold water and an ice cube.
9. Use a notebook or notepad to fan air across the openings in the probe shaft of the CO_2 Gas Sensor for 1 minute.
10. Fill the respiration chamber with water and then completely empty it to remove residual gas from the peas. Thoroughly dry the inside of the respiration chamber with a paper towel.
11. Perform a linear regression to calculate the rate of respiration.
    a. Click or tap Graph Tools, , and choose Apply Curve Fit.
    b. Select Linear as the curve fit. Click or tap Apply.

c. Enter the slope, *m*, as the rate of respiration in Table 2.

d. Dismiss the Linear curve fit box.

12. Obtain 25 non-germinating peas and place them in the respiration chamber.

13. Repeat Steps 6–11 with non-germinating peas. In Step 8 place the non-germinating peas on a paper towel and not in the ice bath. **Note**: The previous data set is automatically saved.

Part II germinating peas, cool temperatures

14. Remove the peas from the cold water and blot them dry between two paper towels.

15. Use the thermometer to measure the temperature of the ice water. Record the temperature in Table 1.

16. Repeat Steps 5–11 using the cold peas. In Step 9 place the cold germinating peas on a paper towel and not back in the ice bath.

17. To display multiple data sets on a single graph, click or tap the y-axis label and select the data sets you want to display. Dismiss the box to view the graph. Continue to the Analysis Questions.

DATA

Table 1	
Condition	Temperature (°C)
Room	
Ice water	

Table 2	
Peas	Rate of respiration (ppm/s)
Germinating, room temperature	
Non-germinating, room temperature	
Germinating, cool temperature	

QUESTIONS

1. Do you have evidence that cell respiration occurred in peas? Explain.
2. What is the effect of germination on the rate of cell respiration in peas?
3. What is the effect of temperature on the rate of cell respiration in peas?
4. Why do germinating peas undergo cell respiration?

EXTENSIONS

1. Compare the respiration rate among various types of seeds.
2. Compare the respiration rate among seeds that have germinating for different time periods, such as 1, 3, and 5 days.
3. Compare the respiration rates of various small animal types, such as insects or earthworms.

Monitoring EKG

An electrocardiogram, or EKG, is a graphical recording of the electrical events occurring within the heart. A typical EKG tracing consists of five identifiable deflections. Each deflection is noted by one of the letters P, Q, R, S, or T. The P wave is the first waveform in a tracing and represents the depolarization of the heart's atria. The next waveform is a complex and consists of the Q, R, and S deflection. The QRS complex represents the depolarization of the heart's ventricles. The deflection that represents the repolarization of the atria is usually undetectable because of the intensity of the QRS waveform. The final waveform is the T wave and it represents the repolarization of the ventricles.

Because an EKG is a recording of the heart's electrical events, it is valuable in diagnosing diseases or ailments that damage the conductive abilities of the heart muscle. When cardiac muscle cells are damaged or destroyed, they are no longer able to conduct the electrical impulses that flow through them. This causes the electrical signal to terminate at the damaged tissue or directed away from the signal flow. The termination or redirection of the electrical signal will alter the manner in which the heart contracts. A cardiologist can look at a patient's electrocardiogram and determine the presence of damaged cardiac muscle based on the waveform as well as the time interval between electrical events.

In this activity, you will use the EKG sensor to make a five-second graphical recording of your heart's electrical events. From this recording, you will identify the previously mentioned waveform components and determine the time intervals associated with each.

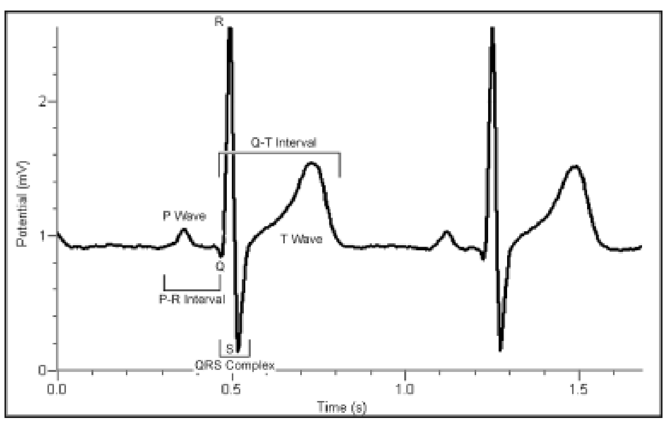

Figure 1

OBJECTIVES

- Use the EKG Sensor to graph your heart's electrical activity.
- Determine the time interval between EKG events.
- Calculate heart rate based on your EKG recording.

MATERIALS

Chromebook, computer, **or** mobile device
Graphical Analysis 4 app
Go Direct EKG
disposable electrode tabs

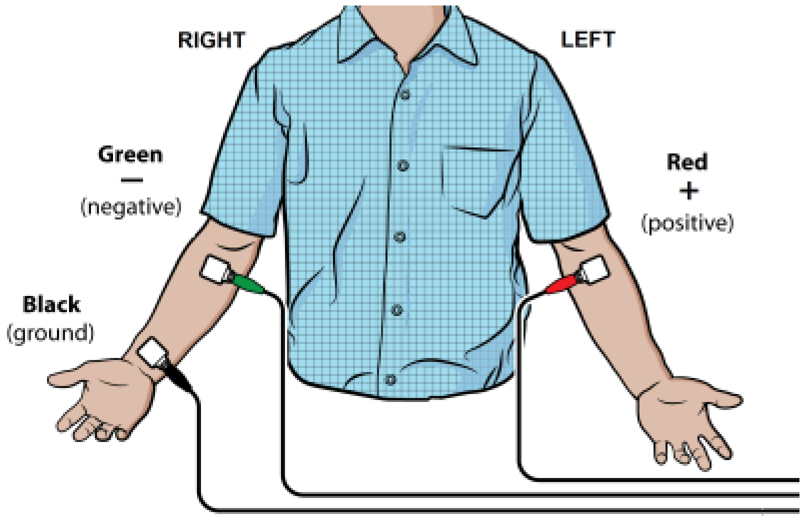

Figure 2

PROCEDURE

1. Launch Graphical Analysis. Connect the EKG Sensor to your Chromebook, computer, or mobile device.

2. Click or tap Mode to open Data Collection Settings. Change End Collection to 5 s. Click or tap Done.

3. Attach three electrode tabs to your arms, as shown in Figure 2. A single tab should be placed on the inside of the right wrist, on the inside of the right upper forearm (below elbow), and on the inside of the left upper forearm (below elbow).

4. Connect the three sensor leads to the electrode tabs as shown in Figure 2. Sit in a reclined position in a chair or lay flat on top of a lab table. Your arms should be hanging at the side unsupported.

5. Another member of the lab group should click or tap Collect to start data collection.

6. Once data have been collected, a graph with voltage and time values will be displayed. Click or tap the graph to examine the data. **Note**: You can also adjust the Examine line by dragging the line.

7. For at least two heartbeats, identify the various EKG waveforms using Figure 1 and determine the time intervals listed below.

8. Record the average for each set of time intervals in Table 2.

Table 1	
Waveform	Time interval
P-R interval	Time from the beginning of P wave to the start of the QRS complex
QRS complex	Time from Q deflection to S deflection
Q-T interval	Time from Q deflection to the end of the T

9. Calculate the heart rate in beats/min using the EKG data. Remember to include the time between the end of the T Wave and the beginning of the next P Wave. Use the total number of seconds for one full heart cycle in the equation. Record the heart rate in Table 2.

$$\frac{\#\ \text{beats}}{\text{minute}} = \frac{1\ \text{beat}}{\_\_\ \text{seconds}} \times \frac{60\ \text{seconds}}{1\ \text{minute}}$$

10. If your EKG was unsatisfactory, repeat Steps 4–6.

11. (optional) Print a copy of your EKG graph. Identify and label the various waveforms on the graph.

DATA

Table 2	
Interval	Time (s)
P - R	
QRS	
Q - T	
Heart rate: ___________ beats/min	

QUESTIONS

1. The electrocardiogram is a powerful tool used to diagnose certain types of heart disease. Why is it important to look at the time intervals of the different waveforms?

2. What property of heart muscle must be altered for an EKG to detect a problem? Explain.

3. Based on what you have learned regarding electrocardiograms, can they be used to diagnose all heart diseases or defects? Explain.

4. Describe a cardiovascular problem that could be diagnosed by a cardiologist using an electrocardiogram.

EXTENSION

Using data collected with the EKG Sensor, it is possible to determine a more accurate maximum heart rate value for a person. The commonly used formula for calculating maximum heart rate is:

220 bpm – Individual's Age = Max Heart Rate

While this formula is sufficient for general purposes, it fails to take into account physical differences such as size, and fitness level. For example, an individual that engages in regular exercise will likely have a heart that operates more efficiently due to the effects of athletic training.

To calculate your maximum heart rate, do the following:

a. Run in place or perform some type of exercise, such as jump-n-jacks, for 1-minute.
b. Repeat Steps 1–8 to collect and analyze your electrocardiogram. When analyzing the data in Step 8, only determine the average Q-T interval.
c. Divide 60 seconds by the Q-T interval to calculate your maximum heart rate.