Grip Strength and Muscle Fatigue

Important: Do not attempt this experiment if you have arthritis, or other conditions of the hand, wrist, forearm, or elbow. Inform your instructor of any possible health problems that might be exacerbated if you participate in this exercise.

OBJECTIVES

In this experiment, you will

- Obtain graphical representation of the force exerted by your hand while gripping.
- Observe, discuss, and analyze the change in hand strength during a continuous grip over time.
- Observe, discuss, and analyze the change in hand strength during rapid, repetitive gripping.

MATERIALS

Computer (Google Drive)
Vernier computer interface
Logger *Pro*
Vernier Hand Dynamometer

PROCEDURE

1. Open up your browser and log on to Google Classroom. Open the Chapter 7- Lab- Grip Strength Lab Report Template. Follow the instructions at the top of the template. Be sure to title your lab report correctly.
2. Each of you will be submitting a copy of the lab report. **Google Master will need to set up the group lab and share it with the other members.**

Part 1- Muscle Strength with Continuous Grip

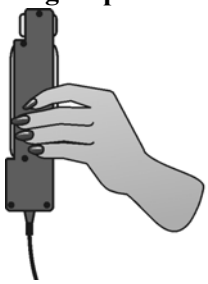

Figure 2

1. Connect the Hand Dynamometer to the Vernier computer interface. Click the LoggerPro icon on the desktop. Go to File, Open the *Human Physiology with Vernier* folder, and click on "17a Grip Strength Fatigue."
2. Zero the readings for the 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. Click the Zero button, Zero.
3. Have the subject sit with his/her back straight and feet flat on the floor. The Hand Dynamometer should be held in the dominant hand. The elbow should be at a 90° angle, with the arm unsupported (see Figure 3).
4. Have the subject close his/her eyes, or avert them from the screen.
5. Instruct the subject to grip the sensor with full strength and click Collect to begin data collection. The subject should exert maximum effort with each grip throughout the duration of the experiment.
6. At 90 s, the lab partner(s) should encourage the subject to grip even harder. Data will be collected for 100 s.

Figure 3

7. Determine the maximum force exerted during different time intervals.
   a. Position the cursor at 0 s and click and drag to highlight 0−10 s on the graph.
   b. Click the Statistics button, , to see the Statistics box.
   c. Record the maximum force during the interval in Table 1, middle column, rounding to the nearest 0.1 N.
   d. Move the brackets to highlight the 20−30 s period on the graph. As you move the brackets, the statistics in the Statistics box will be updated based on the data between the brackets.
   e. Record the maximum force during this interval in Table 1, rounding to the nearest 0.1 N.
   f. Repeat this process for the time intervals: 40−50 s, 60−70 s, and 80−90 s.

8. Calculate the difference between each maximum value and the next and record these values in Table 1, right column.
9. Position the cursor at 0 s. Click and drag to highlight **0−90 s** on the graph. Click the Linear fit button, , and record the slope (round to the nearest 0.01) in Table 3.
10. Add your graph to your lab report. To do this, right click the mouse on the graph and select "COPY." Next, open your group's Google Doc lab report and paste (Control V) it in the appropriate area.

Part 2- Muscle Strength with Repetitive Grip

1. Open the file "17b Grip Strength Fatigue" from the *Human Physiology with Vernier* folder.
2. Follow the same procedure as in Part 1.
3. Add your graph to your lab report.
4. Record your data on the Grip Strength Data Form located in the class website.
5. Take a picture of your completed data table, upload it to Google Drive, and insert the picture into your lab report.

DATA

Table 1–Continuous Grip		
Time interval	Maximum force (N)	Δ Maximum force (N)
0–10 s		
20–30 s		
40–50 s		
60–70 s		
80–90 s		

Table 2–Repetitive Grip		
Time interval	Maximum force (N)	Δ Maximum force (N)
0–10 s		
20–30 s		
40–50 s		
60–70 s		
80–90 s		

Table 3	
	Slope
Part I–Continuous gripping	
Part II–Repetitive gripping	

Analysis

Background

Skeletal muscle is composed of bundles of individual muscle fibers (see Figure 1) and has unique properties which allow it to respond to stimuli by contracting. Individual muscle fibers respond to an action potential with an all or none response, meaning the muscle fiber contracts to its maximum potential or not at all. Once a muscle has contracted, relaxation must occur before it can contract again. There are two basic types of muscle fibers: *slow-twitch fibers and fast-twitch fibers*. Fast-twitch fibers contract quickly creating short explosive movements and a high force of contraction. Because anaerobic metabolism provides the energy to fast-twitch fibers, fast-twitch fibers fatigue quickly. On the other hand, slow-twitch fibers contract slowly creating contractions that last longer over time and generate a low force of contraction. Because aerobic metabolism provides the energy to slow-twitch fibers and because the fibers are efficient at using oxygen to produce ATP, slow-twitch fibers fatigue slowly. The force of contraction of a muscle can be increased by increasing the frequency of stimulation to the muscle fibers (summation) or increasing the number of muscle fibers contracting by stimulating more motor units (recruitment).

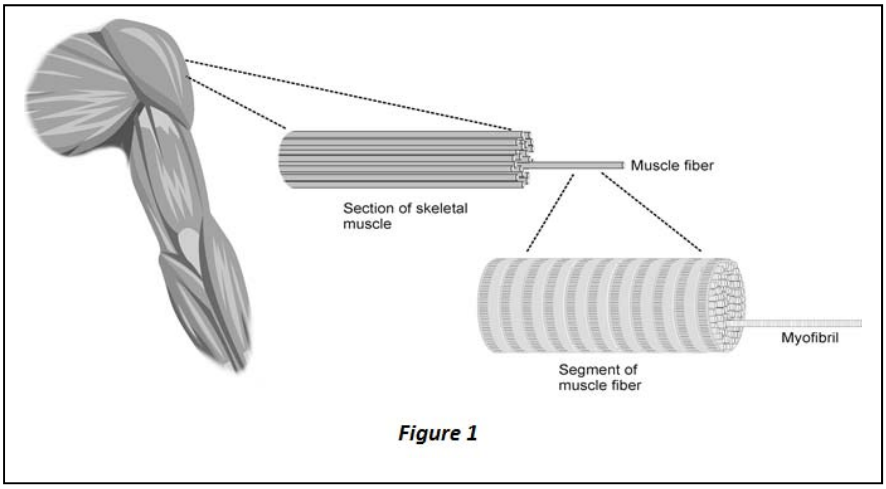

Figure 1

Muscle fatigue occurs with prolonged or repetitive use of a muscle group. With fatigue, there is a sense of weakness and even discomfort, which eventually leads one to discontinue the activity that is causing it. The mechanism of fatigue is multifactorial and not fully understood, but is felt to involve the central nervous system, peripheral nervous system, muscle units and individual muscle fibers. At the level of the muscle fiber, depletion of ATP plays a role in fatigue.

Regular exercise improves muscular function and delays the onset of fatigue, thus increasing the amount and duration of work that can be performed. Exercise is important for optimal athletic performance, prevention of injury in athletes and non-athletes, and the maintenance of good general health.

Questions

Prior to answering the Analysis Questions, read the background information.

The graphic organizers for Questions 2-5 are on the lab report template provided for you through Google Classroom.

1. What 2 ways can increase the force of a muscle contraction?

2. Examine your graph and the data in Table 1. Overall, **what is happening to the number of muscle fibers during the continuous grip activity?** Create a claim. Next, provide evidence by circling the part of your graph that supports your claim. Finally, provide the reason that links your evidence to your claim from the given background text.

   Claim:

   Evidence: (Insert copy of graph with circled evidence below)

   Reason: (Copy the reason and insert below)

3. Examine your graph and/or data in Table 1. **During the continuous grip, which type of muscle fibers are contracting in the first 10 second interval?**

   Create a claim. Next, provide 2 pieces of evidence 1) by circling the part(s) of your graph that supports your claim and 2) by writing the evidence from your data table. Finally, provide the reason that links your evidence to your claim from the given background text.

   Claim:

   Evidence #1: (Insert copy of graph with circled evidence below)

   Evidence #2: (Insert from Data Table)

   Reason: (Copy the reason and insert below)

4. Examine your graph and/or data in Table 1. **During the continuous grip, which type of muscle fibers are contracting during the 50-70 second interval?** Create a claim. Next, provide 2 pieces of evidence 1) by circling the part of your graph that supports your claim and 2) by writing the evidence from your data table. Finally, provide the reason that links your evidence to your claim from the given background text.

   a. Claim:

   b. Evidence #1: (Insert copy of graph with circled evidence below)

   c. Evidence #2: (Insert from Data Table)

   d. Reason: (Copy the reason and insert below)

5. Examine your graph and the data in Table 2. **Which type of muscle fibers are contracting during the repetitive grip exercise of this lab?** Create a claim. Next, provide evidence by circling the part or area of your graph that supports your claim. Finally, provide the reason that links your evidence to your claim from the given background text.

   Claim:

   Evidence: (Insert copy of graph with circled evidence below)

   Reason: (Copy the reason and insert below)

6. The slopes in Table 3 should both have negative slopes. What does a negative slope represent?

7. Compare the 2 slopes from Table 3. What difference do you notice between the slopes? Explain why there is a difference between the slopes.

8. Based on your graphs, explain what happened when the subject was "encouraged" to grip even harder? In your explanation, be sure to include what happened to the number of muscle fibers contracting and what was the cause.