

Grip Strength and Muscle Fatigue

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 a stimulus (e.g., nerve impulse) 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 three basic types of muscle fibers: *slow fibers*, *fast fibers*, and *intermediate fibers*. Fast fibers contract quickly but for a relatively short duration. Slow fibers respond less rapidly, but are capable of a more sustained contraction. The strength of contraction of a whole muscle is dependent on the number of muscle fibers involved.

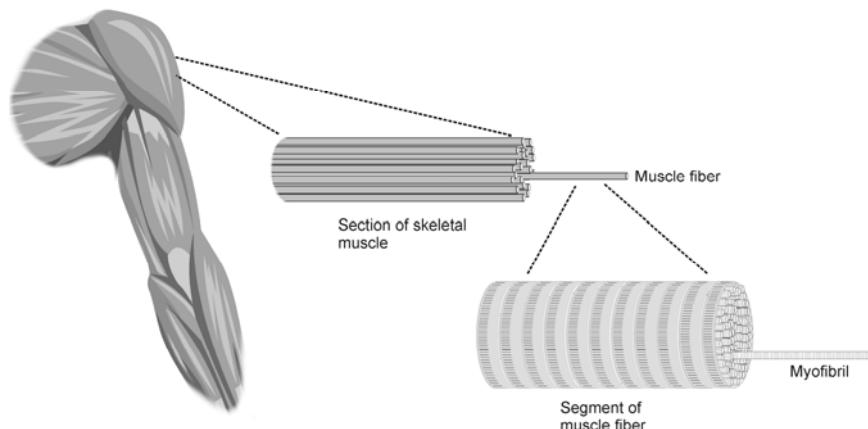


Figure 1

Muscle fatigue occurs with prolonged or repetitive use of a muscle group, and is familiar to anyone who has ever carried a heavy suitcase or walked up a long flight of stairs. 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 muscle cells, depletion of energy stores may be important.

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.

In this experiment, you will examine the effect of fatigue on muscle action by performing sustained and repetitive isometric contractions of muscles of the arm and hand using a Vernier Hand Dynamometer.

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 the change in hand strength during a continuous grip over time.
- Observe the change in hand strength during rapid, repetitive gripping.

MATERIALS

computer
Vernier computer interface

Logger Pro
Vernier Hand Dynamometer

PREDICTIONS

1. What type of relationship will exist between the circumference of the dominant hand's forearm and grip strength?
2. Predict the difference in grip strength between males and females.
3. Predict the difference in grip strength between athletes and non-athletes.

PROCEDURE

1. Open up your browser and log on to your Google Drive. Open the Chapter 7- Lab- Grip Strength document. Follow the instructions at the top of the document. Be sure to title your lab report correctly.
2. Using the tape measure, measure the circumference of your dominant hand's forearm. Record your measurement in the Data Table section. Record your measurement in centimeters to the nearest tenth.

Part I Muscle Strength with Continuous Grip

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, 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, **Ø Zero**.

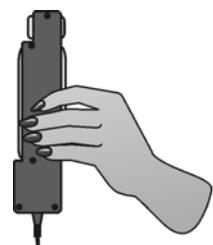


Figure 2

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.
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,  Σ_{STAT} , to see the Statistics box.
 - c. Record the maximum force during the interval in Table 1, 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.
 - g. Close the Statistics box by clicking the \times in the corner of the box.
8. Calculate the difference between each maximum value and the next and record these values in Table 1.
9. Position the cursor at 0 s. Click and drag to highlight 0–90 s on the graph. Click the Linear fit button,  \checkmark_{Re} , and record the slope (round to the nearest 0.01) in Table 3.
10. Add your graph to your lab report. To do this, push the print screen button on the keyboard. Next, open your group's Google Doc lab report and paste it in the appropriate area.
11. Record your data on the Grip Strength Data Form located in the class website.



Figure 3

Part II 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. Measure the circumference of your dominant hand’s forearm after completing Part 2.

Experiment 17

DATA

Circumference of Dominant Hand's Forearm	
	Circumference (cm)
Before Performing the Lab	
After Performing Both Parts of the Lab	

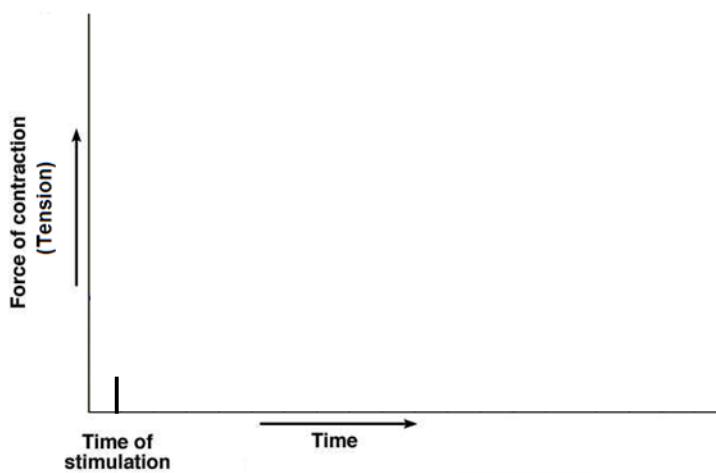
Table 1—Continuous Grip		
Time interval	Maximum force (N)	Δ Maximum force (N)
0–10 s		
20–30 s		
40–50 s		
60–70 s		
80–90 s		

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	

DATA ANALYSIS

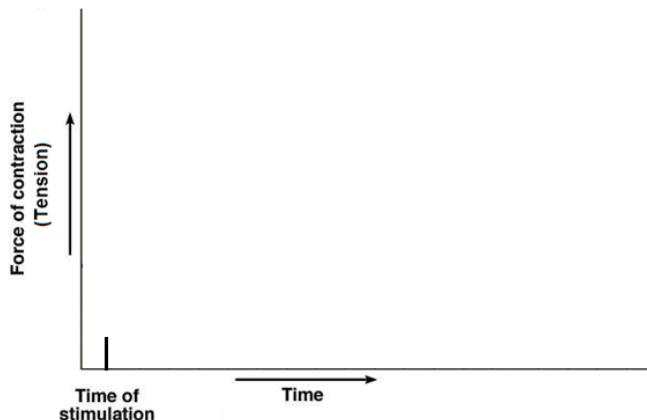
1. Examine your graph and the data in Table 1. What conclusion can you draw about the number of individual muscle fibers that are contracting in the last 10 s compared with the first 10 s?
 2. Based on your data from Table 1, which muscle fibers, fast-twitch and/or slow-twitch, are contracting in the first, third, and final 10 s intervals?
 3. Draw a graph and explain what would happen to the muscle if the subject was told to continue squeezing the hand dynamometer and they could no longer do it.



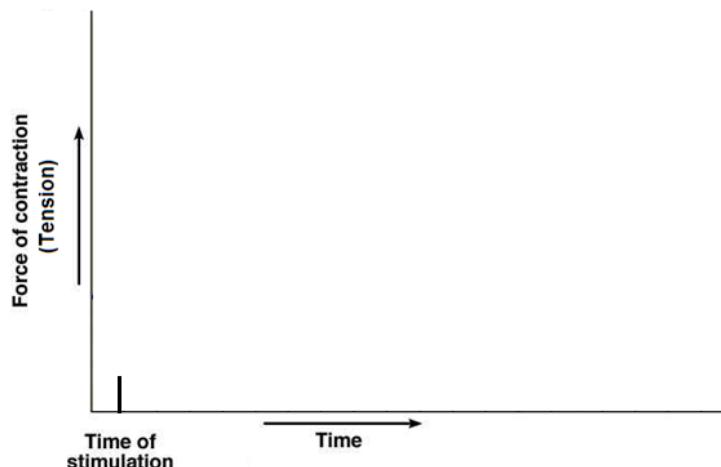
Experiment 17

6. If you were to perform the continuous grip section of this lab for both hands, what would the graph of your dominant hand look like in comparison to your non-dominant hand? To answer the question, draw what these two graphs would look like.

Dominant Hand



Non-Dominant Hand



7. Explain why the graphs of your dominant hand and non-dominant hand would look different.