Anatomy and Physiology
Exercise 9b

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.

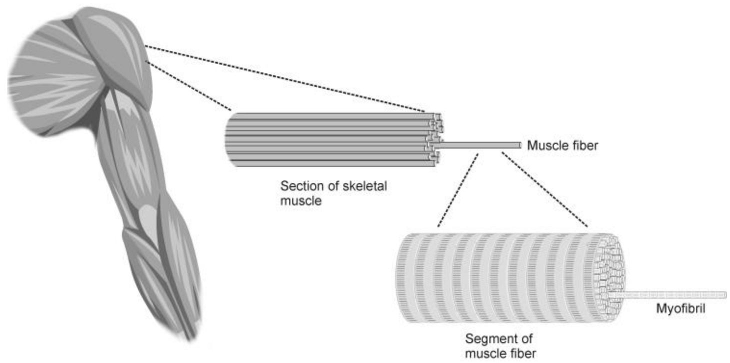


Figure 1

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

- Vernier Labquest2 interface with Logger Pro software
- Vernier Hand Dynamometer

PROCEDURE

Select one person from your lab group to be the subject.

Part I Muscle Strength with Continuous Grip

1. Connect the Hand Dynamometer to the Vernier Labquest2 interface Channel 1. Select  mode.
2. Zero the readings for the Hand Dynamometer: Tap on Ch1:Force and select "Zero".
   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.

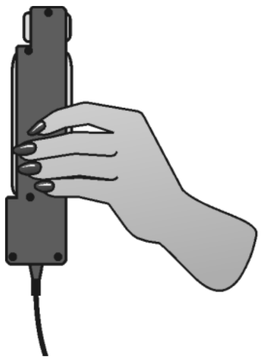


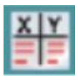
Figure 2

   b. Zero the readings for the Hand Dynamometer.
   c. Set duration of the recording to 100s.: tap 'Duration' and set proper value.
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).

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 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. Collect data for 100 s.
7. Determine the maximum force exerted during different time intervals.
   a. Tap with pen over your graph at 0s. and drag to highlight 0−10s. on the graph.
   b. Select Analyze->Statistics->Force.
   c. Record the maximum force during the interval in Table 1, rounding to the nearest 0.1 N.
   d. Move the range to highlight the 20−30s. period on the graph and record Statistics data in Table 1 rounding to the nearest 0.1 N.
   e. Repeat this process for the time intervals: 40−50s., 60−70s., and 80−90s.
8. Calculate the difference between each maximum value and the next and record these values in Table 1.
9. Tap with pen over your graph 0 s. and highlight 5−90s on the graph.
   Select Analyze->Curve Fit-> Force. Choose 'Linear' for Fit Equation and record the slope (round to the nearest 0.01) in Table 3.

Part II Muscle Strength with Repetitive Grip

10. Switch to Table tab  and clear all data (Table->Clear All Data).
11. 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 2).
12. Have the subject close his/her eyes, or avert them from the screen.
13. Zero the readings for the Hand Dynamometer: Tap on Ch1:Force and select "Zero".
    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. Zero the readings for the Hand Dynamometer.
14. Instruct the subject to rapidly grip and relax his/her grip on the sensor (approximately twice per second). Click to begin data collection. The subject should exert maximum effort throughout the duration of the experiment.
15. At 90 s, the lab partner(s) should encourage the subject to grip even harder. Data will be collected for 100 s.
16. Determine the maximum force exerted during different time intervals.
    a. Tap with pen over your graph at 0 s and drag to highlight 0−10s. on the graph.

b. Select Analyze->Statistics->Force and record the maximum force during that interval in Table 2, rounding to the nearest 0.1 N.
c. Move the range to highlight the 20–30s. period on the graph and find Statistics values.
d. Record the maximum force during this interval in Table 1, rounding to the nearest 0.1 N.
e. Repeat this process for the time intervals: 40–50s., 60–70s., and 80–90s.

17. Calculate the difference between each maximum value and the next and record these values in Table 2.
18. Tap with pen over your graph 0 s. and highlight 5−90s on the graph.
    Select Analyze->Curve Fit-> Force. Choose 'Linear' for Fit Equation and record the slope (round to the nearest 0.01) in Table 3.

DATA

Table 1

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

Table 2

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

Table 3

	Slope
Continuous grip	
Repetitive grip	

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 firing in the last 10 s compared with the first 10s.?

2. Is the change in number of muscle fibers that contract occurring at a constant rate?

3. Use your knowledge of fast, slow, and intermediate skeletal muscle fibers to hypothesize which fibers are contracting in the first, third, and final 10 s intervals.

4. How might you explain the subject’s response to coaching? This should be evident in the last 10s. of data for Parts I and II of the exercise. Discuss the possible involvement of the central nervous system, in addition to the muscle fibers.

5. Compare the slopes recorded in Table 3. Give a possible explanation for the difference, if any, in muscle fatigue rates seen in continuous versus repetitive gripping.