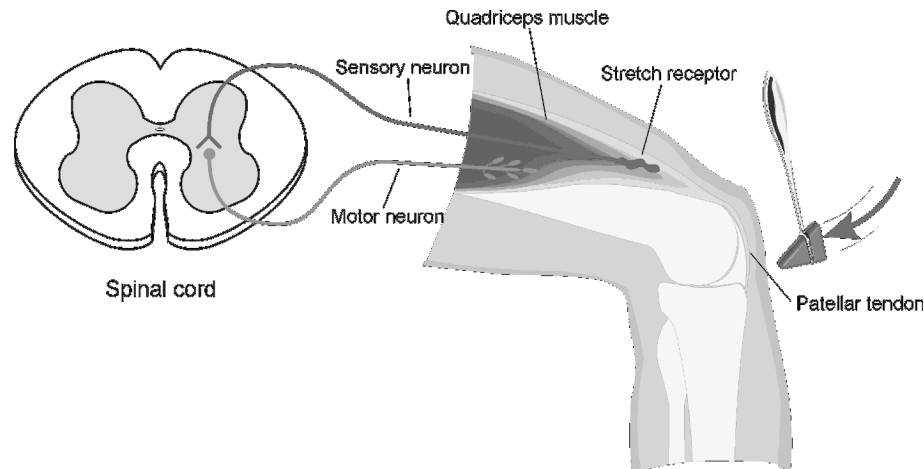


# Neuromuscular Reflexes

The automatic response of a muscle to a stimulus is called a reflex. The patellar reflex results from tapping the patellar tendon below the knee with a reflex hammer. This causes contraction of the quadriceps muscle and extension of the leg. Stretching of the muscle activates nerve impulses which travel to the spinal cord. Here the incoming impulses activate motor neurons, which travel back to the muscle and result in muscle contraction. This reflex arc is primarily a spinal reflex, but is influenced by other pathways to and from the brain (Figure 1).



*Figure 1*

A reflex may be *reinforced* (a term used by neurologists) by slight voluntary contraction of muscles other than the one being tested. For example, voluntary activation of arm muscles by motor neurons in the central nervous system “spills over” to cause a slight activation of the leg muscles as well. This results in the enhancement of the patellar reflex. There are other examples of central nervous system influences on reflexes. Health care professionals use knowledge of these influences to aid in diagnosis of conditions such as acute stroke and herniated lumbar disk, where reflexes may be absent; and spinal cord injury and multiple sclerosis, which may result in exuberant reflexes.

In this experiment, you will use an EKG Sensor to compare the speed of a voluntary *vs.* a reflex muscle action and to measure the relative strength (amplitude) of the impulse generated by a stimulus with and without reinforcement. You will make a rough calculation of nerve impulse speed using data generated by an Accelerometer used in conjunction with the EKG sensor.

**Important:** Do not attempt this experiment if you have pain in or around the knee. Inform your instructor of any possible health problems that might be exacerbated if you participate in this exercise.

## OBJECTIVES

In this experiment, you will

- Graph the electrical activity of a muscle activated by a reflex arc through nerves to and from the spinal cord.
- Compare the relative speeds of voluntary and reflex muscle activation.
- Associate muscle activity with involuntary activation.
- Observe the effect of central nervous system influence on reflex amplitude.
- Calculate the approximate speed of a nerve impulse.
- Compare reflex response and electrical amplitude in different subjects.

## MATERIALS

computer  
Vernier computer interface  
Logger Pro  
Vernier EKG Sensor  
Vernier 25-g Accelerometer

electrode tabs  
reflex hammer  
cable tie, 10 cm long  
cloth tape measure  
pen

## PROCEDURE

Each person in the group will take turns being subject and tester.

### Part I Voluntary Activation of the Quadriceps Muscle

1. Connect the EKG Sensor and the Accelerometer to the Vernier computer interface.
2. Open the file “14A Reflexes with ACC” from the *Human Physiology with Vernier* folder.
3. Connect the Accelerometer to the reflex hammer using the cable tie, as shown in Figure 2. Place the Accelerometer cable toward the back of the hammer so it does not get in the way.

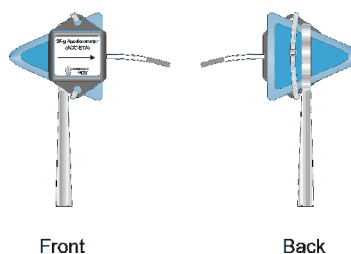


Figure 2

4. Have the subject sit comfortably in a chair that is high enough to allow his/her legs to dangle freely above the floor.
5. Attach two electrode tabs above one knee along the line of the quadriceps muscle between the knee and the hip. The tabs should be 5 cm and 13 cm from the middle of the patella (see Figure 3). Place a third electrode tab on the lower leg.

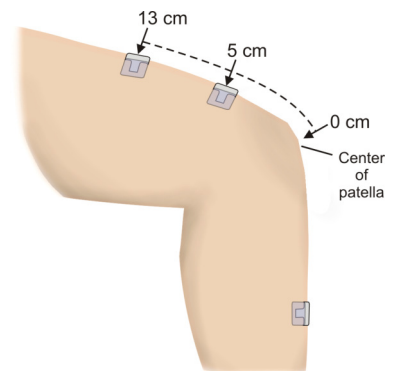


Figure 3

6. Attach the red and green leads to the electrode tabs above the knee with the red electrode closest to the knee. Attach the black lead (ground) to the electrode tab on the lower leg.
7. Click **▶ Collect** to begin data collection. If the graph has a stable baseline as shown in Figure 4, click **■ Stop** and continue to Step 8. If your graph has an unstable baseline, click **■ Stop** and collect a new set of data by clicking **▶ Collect** again. Repeat data collection until you have obtained a stable baseline for 5 s.
8. Collect voluntary activation data. **Note:** Read the entire step before collecting data to familiarize yourself with the procedure.
  - a. Have the subject close his/her eyes, or avert them from the screen.
  - b. Click **▶ Collect**.
  - c. After recording 5 s of stable baseline, swing the reflex hammer briskly to contact the table or other surface that generates a sound.
  - d. The subject should kick his/her leg out immediately upon hearing the sound.
  - e. Continue obtaining reflexes (repeat parts c and d of this step) so that you record 5–10 kicks during the data-collection period.
9. Determine the time elapsed between striking the table surface with the reflex hammer and the contraction of the quadriceps muscle.

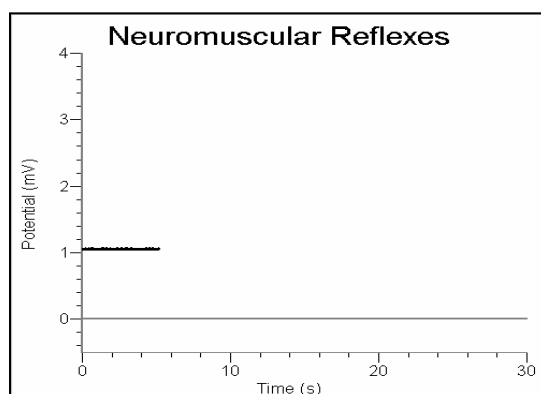



Figure 4

- a. Click the Examine button, , and place your cursor somewhere on the Acceleration graph.
- b. Align the Examine line with the first high peak (which corresponds to the first kick) in the Accelerometer graph (Figure 5). This peak indicates the time at which the table surface was struck. Record this time in Table 1.
- c. Move the cursor to the EMG graph and align the Examine line with the first high peak (Kick 1) in the graph. This peak indicates the time at which the quadriceps muscle contracted. Record this time in Table 1.
- d. Repeat this process of determining the time of the hammer strike and reflex for a total of five stimulus-kick pairs.
- e. Close the Examine box by clicking the × in the corner of the box.
- f. Calculate the change in time between the hammer strike and reflex for the five stimulus-kick pairs and then calculate the average change in time for all five pairs. Record the values in Table 1.

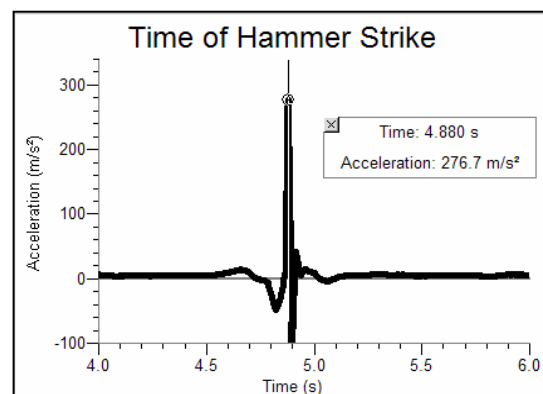


Figure 5

## Part II Patellar Reflex

10. Locate the subject's patellar tendon by feeling for the narrow band of tissue that connects the lower aspect of the patella to the tibia. Place a pen mark in the center of the tendon, which can be identified by its softness compared with the bones above and below (see Figure 6).
11. Click  to begin data collection. If your graph has a stable baseline as shown in Figure 4, click  and continue to Step 12. If your graph has an unstable baseline, click  and repeat data collection until you have obtained a stable baseline for 5 s.
12. Collect patellar reflex data. **Note:** Read the entire step before collecting data to familiarize yourself with the procedure.
  - a. Have the subject close his/her eyes, or avert them from the screen.
  - b. Click .
  - c. After recording 5 s of stable baseline, swing the reflex hammer briskly to contact the mark on the subject's tendon. If this does not result in a visible reflex, aim toward other areas of the tendon until the reflex is obtained.
  - d. Continue obtaining reflexes so that you record 5–10 reflexes during the collection period.
13. Determine the time elapsed between striking the patellar tendon with the reflex hammer and the contraction of the quadriceps muscle.
  - a. Click the Examine button,  and place your cursor somewhere on the Acceleration graph.
  - b. Align the Examine line with the first high peak (which corresponds to the first kick) in the Accelerometer graph (Figure 5). This peak indicates the time at which the tendon was struck. Record this time in Table 2.
  - c. Move the cursor to the EMG graph and align the Examine line with the first high peak (Kick 1) in the graph. This peak indicates the time at which the quadriceps muscle contracted. Record this time in Table 2.
  - d. Repeat this process of determining the time of the hammer strike and reflex for a total of five stimulus-kick pairs.
  - e. Close the Examine box by clicking the X in the corner of the box.
  - f. Calculate the change in time between the hammer strike and reflex for the five stimulus-kick pairs and then calculate the average change in time for all five pairs. Record the values in Table 2.

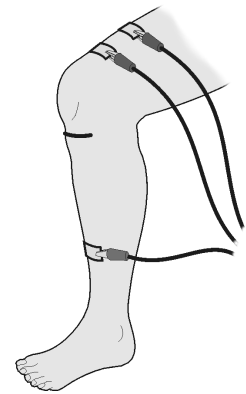
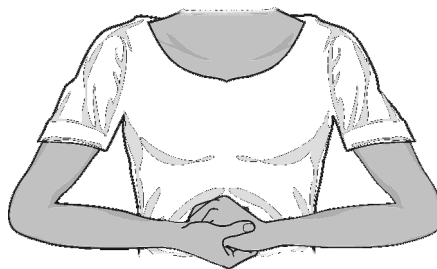


Figure 6


## Part III Reflex Reinforcement

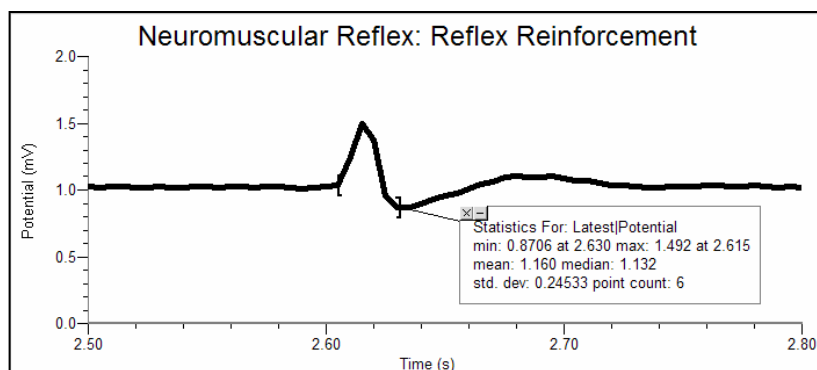
14. With the subject sitting comfortably in a chair, click  to begin data collection. If your graph has a stable baseline, click  and continue to Step 15. If your graph has an unstable baseline, click  and repeat data collection until you have obtained a stable baseline for 5 s.
15. Collect patellar reflex data without and with reinforcement. **Note:** Read the entire step before collecting data to familiarize yourself with the procedure.
  - a. Have the subject close his/her eyes, or avert them from the screen.
  - b. Click .
  - c. After recording a stable baseline for 5 s, swing the reflex hammer briskly to contact the mark on the subject's tendon. If this does not result in a visible reflex, aim toward other areas of the tendon until the reflex is obtained.

- d. After 5 or 6 successful reflexes have been obtained, have the subject *reinforce* the reflex by hooking together his/her flexed fingers and pulling apart at chest level, with elbows extending outward (see Figure 7).
- e. Continue obtaining reflexes until data collection is completed at 30 s. A total of 10–15 reflexes should appear on the graph.



*Figure 7*

16. Click the Statistics button, . Move the brackets to frame the first area of increased amplitude (depolarization) in this run (see Figure 8). Record the minimum, maximum and  $\Delta y$  value (amplitude) for this depolarization in Table 3, rounding to the nearest 0.01 mV.
17. Repeat this process for each of five *unreinforced* and five *reinforced* depolarization events, using the Accelerometer to identify each primary reflex. Ignore rebound responses. Record the appropriate values in Table 3.
18. Determine the average amplitude of the *reinforced* and *unreinforced* depolarization events examined. Record these values in Table 3.



*Figure 8*

**DATA**

Table 1						
	Kick 1	Kick 2	Kick 3	Kick 4	Kick 5	Average
Time of muscle contraction (s)						
Time of stimulus (s)						
$\Delta t$ (s)						

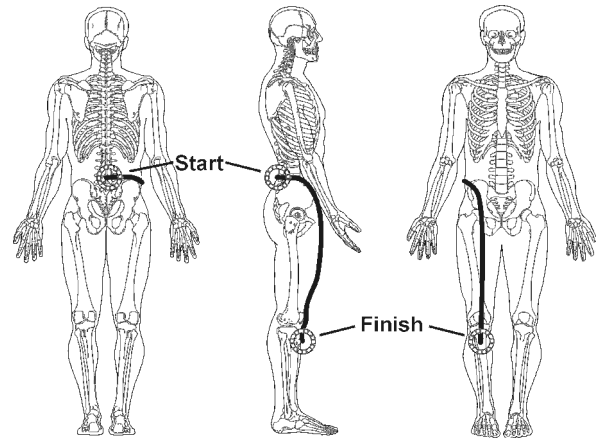
Table 2						
	Reflex 1	Reflex 2	Reflex 3	Reflex 4	Reflex 5	Average
Time of muscle contraction (s)						
Time of stimulus (s)						
$\Delta t$ (s)						

Table 3						
	Reflex without reinforcement			Reflex with reinforcement		
Reflex response	Max (mV)	Min (mV)	$\Delta mV$	Max (mV)	Min (mV)	$\Delta mV$
1						
2						
3						
4						
5						
Average values						

**DATA ANALYSIS**

1. Compare the reaction times for voluntary vs. involuntary activation of the quadriceps muscle. What might account for the observed differences in reaction times?

- Using data from Table 2, calculate speed at which a stimulus traveled from the patellar tendon to the spinal cord and back to the quadriceps muscle (a complete reflex arc). To do this, you must estimate the distance traveled. Using a cloth tape measure, measure the distance in cm from the mark on the patellar tendon to the spinal cord at waist level (straight across from the anterior-superior iliac spine—see Figure 9). Multiply the distance by two to obtain the total distance traveled in the reflex arc. Once this value has been obtained, divide by the average  $\Delta t$  from Table 2 and divide by 100 to obtain the speed, in m/s, at which the stimulus traveled.

*Figure 9*

- Nerve impulses have been found to travel as fast as 100 m/s. What could account for the difference between your answer to Question 2 and this value obtained by researchers?
- Assume the speed of a nerve impulse is 100 m/s. How does this compare to the speed of electricity in a copper wire (approx.  $3.00 \times 10^8$  m/s)?
- Compare the data you obtained in this experiment with other members of your group/class. Can individual differences be attributed to any physical differences (body shape/size, muscle mass, physical fitness level)?

## EXTENSION

- Explore the ankle and elbow reflexes.
- Perform the experiment with the subject watching the reflex hammer as it hits the patellar tendon. Compare this data to data gathered while the subject is focusing on an object elsewhere in the room.