

# Neuromuscular Reflexes

## CONCEPTS

### Physiology

- Motor neuron
- Sensory neuron
- Efferent pathway
- Afferent pathway
- Receptors (e.g. stretch receptor)
- Spinal reflex
- EMG

### Engineering

- Feedback loop
- Accelerometer
- Synchronization
- Conduction velocity
- Delay / latency

## BACKGROUND

A reflex is essentially the physiological / medical terminology for a feedback loop. There are feedback loops from the muscles back to the spinal cord. So, when a stimulus is sent from the spinal cord to the muscles, receptors in the muscle will send information back to the spinal cord causing the muscle to automatically respond.

One spinal reflex from which the effect is commonly observed is the patellar reflex. Tapping on the tendon below the knee (a.k.a. patella) causes stretch receptors in the knee to send sensory feedback via sensory nerves to the spinal cord. The incoming nerve impulses signals to the spinal cord that the leg needs to be extended and activate motor neurons. The resulting impulses from the motor neurons then travel back to the muscle and cause the quadriceps muscle to contract. This reflex arc is primarily a spinal reflex, but is influenced by other pathways to and from the brain (Figure 1).

In this experiment, you will measure electrical activity from the muscle (EMG) 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.

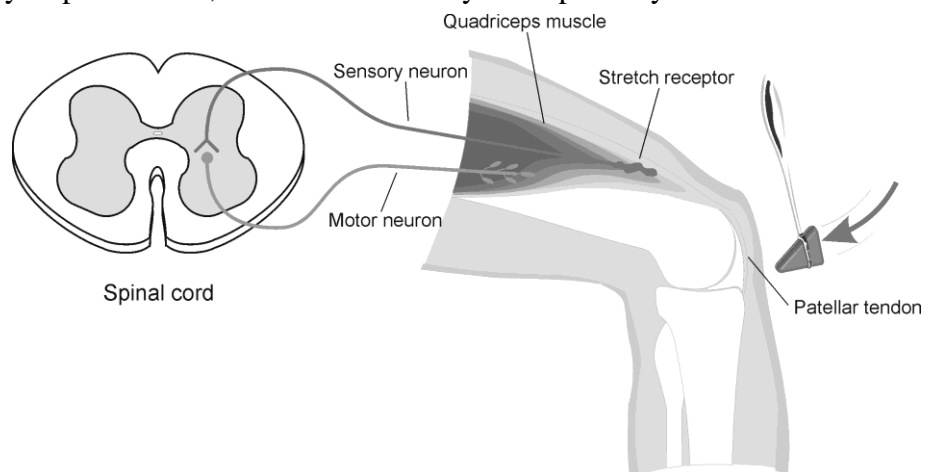


Figure 1

## Experiment 14A

You will make a rough calculation of nerve iIn this experiment, you will measure electrical activity from the muscle (EMG) 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 ECG 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

The objectives of this experiment are to:

- practice measuring EMG and identifying placement of electrodes;
- understand issues of synchronization in biomedical instrumentation;
- observe an example of calibration; and
- compare EMG activation time scales during voluntary and involuntary muscle contraction..

## MATERIALS

LabQuest  
LabQuest App  
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 ECG Sensor and accelerometer to LabQuest. Choose New from the File menu. If you have older sensors that do not auto-ID, manually set up the sensors.
2. On the Meter screen, tap Rate. Change the data-collection rate to 100 samples/second and the data-collection length to 30 seconds. Select OK.
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.

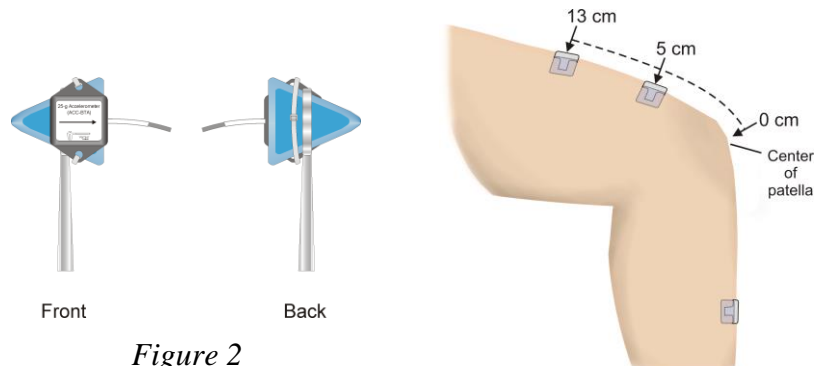
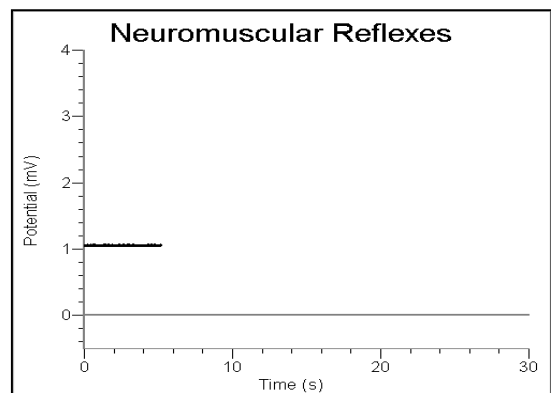


Figure 2

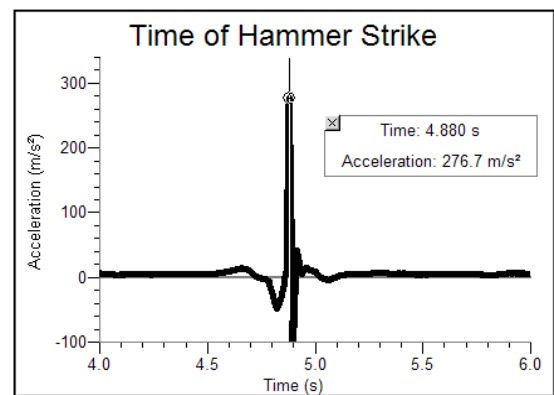
4. Have the subject sit comfortably in a chair that is high enough to allow his/her legs to dangle freely above the floor.
5. Attach two electrode tabs above one knee along the line of the quadriceps muscle between the knee and the hip. The tabs should be 5 cm and 13 cm from the middle of the patella (see Figure 3). Place a third electrode tab on the lower leg.
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. Start data collection. If the graph has a stable baseline as shown in Figure 4, stop data collection continue to Step 8. If your graph has an unstable baseline, stop data collection and collect a new set of data by starting data collection 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 become familiar with the procedure.

- a. Have the subject close his/her eyes, or avert them from the screen.
- b. Start data collection.
- 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.



*Figure 4*

9. Determine the time elapsed between striking the table surface with the reflex hammer and the contraction of the quadriceps muscle.
  - a. To analyze the data, tap and drag across the EKG data to highlight the area from just before the table was struck to just after the muscle contraction.
  - b. Choose Zoom In from the Graph menu.
  - c. To examine the data pairs on the acceleration graph, tap any data point. As you tap each data point, the acceleration and time values are displayed to the right of the graph.
  - d. Tap the first high peak (which corresponds to the first kick) on the acceleration graph (Figure 5). This peak indicates the time at which the table surface was struck. Record this time in a table (i.e., the table you created).
  - e. Tap the first high peak (Kick 1) on the EMG graph. This peak indicates the time at which the quadriceps muscle contracted. Record this time in a table.
  - f. Choose Autoscale Once from the Graph menu.



*Figure 5*

**Repeat this process of zooming in and determining the time of Part II Patellar Reflex**

## Experiment 14A

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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. Start data collection. If your graph has a stable baseline as shown in Figure 4, stop data collection and continue to Step 12. If your graph has an unstable baseline, stop and collection 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. Start data collection.
  - 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. To analyze the data, tap and drag across the EKG data to highlight the area from just before the tendon was struck to just after the muscle contraction.
  - b. Choose Zoom In from the Graph menu.
  - c. Tap 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 a table.
  - d. Tap the first high peak (Kick 1) in the EMG graph. This peak indicates the time at which the quadriceps muscle contracted. Record this time in a table.
  - e. Choose Autoscale Once from the Graph menu.
  - f. Repeat this process of zooming in and determining the time of the hammer strike and reflex for a total of five stimulus-kick pairs.
  - g. 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 a table.

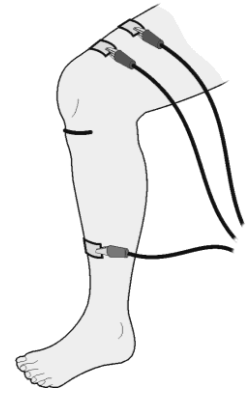


Figure 6

## DATA ANALYSIS

1. Estimate the average conduction velocity around the spinal reflex arc (from the patellar tendon to the spinal cord and back to the quadriceps muscle). Create a table of the data needed to calculate this estimate, and show your calculation.
  2. What was the average latency of your / your subject's reflex? What was the standard deviation of this latency? Again, create a table of the data needed to calculate this estimate, and show your calculation.
- (What two pieces of information could you use to calculate the latency? Correspondingly, what two measurements do you need to make, and how do you need to set up the experiment?)

## **DISCUSSION**

Present your results in an organized fashion. Some discussion points to include are:

1. Compare the reaction times for voluntary vs. involuntary activation of the quadriceps muscle. What might account for the observed differences in reaction times?
2. How does the conduction velocity you computed for the spinal reflex circuit compare to the speed of electricity in a copper wire (approx.  $3.00 \times 10^8$  m/s)?
3. What information could we gain by measuring the latency a patient's EMG response after the patellar tap?