Brief Technical Note

SIMULTANEOUS HOFFMANN REFLEX MEASUREMENTS IN MULTIPLE MUSCLES AROUND THE ANKLE

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Measurement of the Hoffmann reflex (H-reflex) provides an estimate of alpha motoneuron activity in the target motoneuron (MN) pool. The H-reflex has been assessed for a wide variety of reasons in neuroscience research. However, the majority of protocols have focused on the assessment of only one muscle and its corresponding motoneuron pool at any instant. Previously established protocols do not simultaneously assess reflex activity in multiple muscles elicited from a single stimulation. This new protocol allows for assessment of alpha motoneuron activity in three muscles around the ankle joint from a single stimulus to the sciatic nerve. To elicit the responses, the sciatic nerve was stimulated...
just prior to its bifurcation into the tibial and common peroneal nerves in the popliteal fossa. Electromyographic recording electrodes were placed on the tibialis anterior, peroneal longus, and soleus muscles. The 1-ms square wave pulse was delivered every 15 s during the recruitment curve mapping. The maximum H reflex and M waves were measured in each muscle and their ratios calculated. The measurement of these ratios simultaneously allows for assessment of the cumulative alpha motoneuron activity about the ankle at a given point in time.

**Keywords**  H-reflex, methodology, motoneuron pool

Hoffmann reflex (H-reflex) measurements serve as a reliable estimate of spinal level motoneuron (MN) pool activity (Ali & Sabbahi, 2001; Hoffman & Koceja, 2000; Hoffman & Koceja, 1995; Hopkins, 2002; Hopkins, Ingersoll, Cordova, & Edwards, 2000; McIlroy & Brooke, 1987; Morelli, Sullivan, & Seaborne, 1990; Palmieri, Hoffman, & Ingersoll, 2002; Williams, Sullivan, Seaborne, & Morelli, 1992). Commonly used methods for H-reflex assessment provide a “snapshot” of neural activity in the target motoneuron pool. Modifications have been derived from the basic H-reflex protocols allowing for the study of heteronymous connections between two motoneuron pools (Barbeau, Marchand-Pauvert, Meunier, Nicolas, & Pierrot-Deseilligny, 2000; Forget, Hultborn, Meunier, Pantieri, & Pierrot-Deseilligny, 1989; Hultborn, Meunier, Morin, & Pierrot-Deseilligny, 1987). However, these approaches still limit the assessment of activity in only one motoneuron pool at any given point in time. The below described protocol was developed to allow for simultaneous assessment of activity in multiple motoneuron pools from a single peripheral nerve stimulation. Specifically, to measure MN pool activity in three muscles of the leg from a single stimulation of the common peroneal and tibial nerves.

**MATERIALS AND METHODS**

**Electromyography Recording Equipment**

- Data collection system (MP100A data acquisition unit. Biopac Systems, Santa Barbara, CA, USA).
- UIM100A Universal interface amplifiers and associated cables for each test muscle.
• ACK100W AcqKnowledge 4.5.1 (Biopac Systems).
• EL503 general-purpose electrodes (Biopac Systems).

Peripheral Nerve Stimulation Equipment

• Grass S88 Dual channel stimulator (Grass, West Warwick, RI, USA).
• Grass SIU5 RF Transformer Isolation Grass, West Warwick, RI, USA).
• Grass CCU1 Constant Current Unit (Grass, West Warwick, RI, USA).

Equipment Preparation

The Biopac AcqKnowledge software running on a personal computer controlled the Grass S88 nerve stimulator and Biopac MP100 data collection hardware. All data from each subject were collected (2000 HZ) into a single file for postcollection analysis.

Patient Preparation

Skin locations of all electrodes were cleaned with alcohol, shaven, and slightly abraded with sandpaper. Placement of EMG electrode on the peroneal longus muscle was 2 to 3 cm distal to the head of the fibula. Tibialis anterior recording electrode was placed at the approximate midpoint of the muscle belly. The soleus-recording electrode was placed over the midsubstance of the soleus in the distal third of the leg. All surface electromyography-recording electrodes were placed on the muscle sites with an intra-electrode distance of 2 cm. A reference ground electrode was placed over the lateral malleolus.

Location of Optimal Stimulation Point

The basics of this multiple muscle technique are based on the methods set forth by Hugon (Hugon, 1973) on H-reflex testing. The exact pathways of the two sciatic nerve branches should be identified. The sciatic nerve forms from the sacral plexus and runs posterior to the femur the length of the thigh until it splits just above the popliteal
fossa. When it bifurcates, it branches into the common peroneal and tibial nerves. The common peroneal nerve passes laterally where it crosses the head of the fibula prior to splitting into the deep peroneal and superficial peroneal nerves. In general, the deep peroneal nerve innervates the muscles of the anterior compartment of the leg, including the tibialis anterior. Likewise, the superficial peroneal nerve innervates the muscles of the lateral compartment, which contains the peroneal longus muscle. The remaining branch of the sciatic nerve, the tibial nerve, passes through the popliteal fossa to innervate the muscles of the posterior aspect of the leg. The muscle in the posterior aspect of the leg that is of interest in this protocol is the soleus muscle.

Starting at the head of the fibula with stimulus intensity strong enough to elicit a motor response in either the peroneal longus or the tibialis anterior, the stimulating electrode is progressed in a superior medial direction toward the center of the knee in the popliteal fossa. This procedure is continued along the common peroneal nerve until a response is also seen in the soleus. At this point, it is determined that the location of sciatic nerve bifurcation had been identified.

**Collection of Test Reflexes**

Following the location of a stimulation point that elicits reflexes in all three of the target muscles, measurements are collected. The mapping of the H/M recruitment curves was conducted by increasing the intensity of the stimulus in very small increments until plateau of the M wave was obtained. The peak-to-peak amplitudes of the H-reflexes and M waves were measured and recorded for all of the test stimulations and the maximum values for each wave were used for the formation of a ratio.

**Time Required**

- Instruction to subject and obtaining Informed Consent, 15 min.
- Skin preparation and electrode placement, 15 min.
- Location of optimal stimulation point and establishment of baseline reflex values, 30 min.
• Mapping of recruitment curve for reflex profile of all muscles, 30 min.
• Data analysis of reflex profiles, 60 min.

RESULTS

A ratio between the maximum H-reflex and maximum M wave was calculated for each of the involved muscles. In the graphs below (Figures 1, 2, and 3) it can be seen that each muscle has a different H max/M max ratio. It should be noted that these recruitment curves were all collected simultaneously from stimulations to the tibial nerve. The ratios for the soleus, tibialis anterior and peroneal longs muscles were 0.62, 0.10, and 0.20, respectively.

DISCUSSION

The impetus for the development of this protocol was that a comprehensive understanding of the interactions among the ankle dorsiflexors, plantarflexors, and evertors does not exist, and the ability to

FIGURE 1. Recruitment curve of soleus muscle. The arrow indicates the test reflex that is depicted in the right side tracing.
measure all muscles simultaneously can be a useful assessment technique. The interactions of these motoneuron pools are complex and extensive. There likely exist numerous inhibitory, as well as facilitatory, connections between these entities. The use of this multiple muscle technique provides an avenue for assessing reflex ampli-

FIGURE 2. Recruitment curve of tibialis anterior muscle. The arrow indicates the test reflex that is depicted in the right side tracing.

FIGURE 3. Recruitment curve of peroneal longus muscle. The arrow indicates the test reflex that is depicted in the right side tracing.
tudes in the major muscle groups that control the multiplanar actions of the ankle joint.

A special technical note should be mentioned. Essential to the method is that unique reflexes be elicited in each muscle. It is critical to establish that the reflexes being measured originate from the targeted muscles. Due to the close proximity of the leg muscles, EMG cross talk between muscles is quite possible. To ensure the uniqueness of each reflex, voluntary contractions should be used to affirm electrode placement.

This model is not without limitations. The primary limitation is that all of the individual reflex measurements are influenced by the interconnectivity of the motoneuron pools via interneurons and complex circuitry. Due to the fact that the stimulation is delivered simultaneously to the common peroneal and tibial nerves, volleys in each inevitably influence the other. Therefore, reflexes obtained from this technique cannot be considered pure and cannot be compared to reflexes obtained by methods in which a single peripheral nerve is stimulated.

QUICK PROCEDURES

- Prepare skin locations of all electrodes.
- Place EMG electrode on the peroneal longus, tibialis anterior, and soleus muscles.
- Secure a reference ground electrode over the lateral malleolus.
- Identify the exact pathways of the two sciatic nerve branches.
- Map the H/M recruitment curves by increasing the intensity of the stimulus in very small increments until plateau of the M wave is obtained.
- Measure the peak-to-peak amplitudes of the H-reflexes and M waves and form a ratio for each test muscle.

REFERENCES


