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Short communication

# Between-day reliability of upper extremity H-reflexes

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**Abstract**

H-reflexes are useful for evaluating the group Ia monosynaptic reflex excitability in the lower and upper extremities (UEs). However, there is no established between-day protocol for measuring H-reflex excitability in the UE extensor carpi radialis longus (ECRL). The purpose of this study was to develop a reliable protocol to measure the H-reflex excitability between-days for the ECRL, and the antagonist muscle, the flexor carpi radialis (FCR). H-reflex recruitment curves were recorded from eight healthy young subjects over 3 consecutive days in both muscles. Variables associated with the H-reflex excitability were measured: (a) maximum amplitude (Hmax); (b) gain (HGN); (c) threshold (HTH, visHTH, and sdHTH). All variables were normalized with respect to the M-wave. Within individual muscles, there were no statistically significant differences between-days for the group ($p > 0.05$) and variables showed fair to good reliability (ICC = 0.57–0.99). This method of reliably measuring H-reflex excitability within UE muscles will be useful for investigating the effects of pathology and rehabilitation on monosynaptic reflexes.
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*Keywords:* H-reflex; Healthy adults; Between-day reliability; Upper extremity

## 1. Introduction

Impaired upper extremity (UE) function severely impacts the quality of life for individuals with hemiparesis following stroke (Dromerick et al., 2006). Currently, few therapeutic interventions are completely effective for restoring hand function in this population, although recent evidence suggests that neuromuscular electrical stimulation (NMES) may enhance paretic hand and wrist movement (Santos et al., 2006; Sullivan and Hedman, 2004). While the mechanisms underlying NMES-induced improvement remain unclear, monosynaptic reflex excitability in the forearm muscles may be altered following treatment. Potentially, NMES applied to the wrist extensors may facilitate wrist and finger extension by increasing homonymous monosynaptic reflex excitability and simultaneously decreasing reflex excitability of the wrist flexors via reciprocal inhibition. However, prior to investigating these mechanisms, a reliable method for measuring reflexes from the wrist extensors must be established, which is the primary focus of this study.

The H-reflex method is commonly used to probe monosynaptic reflex excitability in health and disease (Schindler-Ivens and Shields, 2000), and techniques for assessing H-reflex excitability in the soleus and tibialis anterior are well-established (Palmieri et al., 2002, 2004; Schindler-Ivens and Shields, 2004b). However, fewer studies have used H-reflexes to assess reflex excitability within the UE (Lewis et al., 2004; Marchand-Pauvert et al., 2000; Miller et al., 1995; Nafati et al., 2004). We are aware of only one study that has examined the between-day reliability of the flexor carpi radialis (FCR) H-reflex (Jaberzadeh et al., 2004), while no study has examined between-day repeatability of the extensor carpi radialis longus (ECRL) H-reflex. The purpose of this study was to develop a reliable between-day method for measuring H-reflex excitability in the FCR and ECRL muscles, which may then be used to examine the neurophysiological effects of NMES post-stroke.

## 2. Materials and methods

### 2.1. Subjects

Eight healthy subjects ages 29–42 years of age (three male; five female; 36 ± 6 years) participated in this study. All subjects

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were right-hand dominant, were free from any UE pathology and possessed normal UE range of motion and strength. The Human Subjects Institutional Review Board for the University of Kansas Medical Center approved the experimental design, and all participants gave their informed consent prior to testing.

### 2.2. Experimental design

Each subject underwent H-reflex testing of the FCR and ECRL muscles of the right UE over 3 consecutive days. The order of muscle testing (i.e., FCR or ECRL) was counterbalanced between-days and across subjects to avoid an ordering effect. Tests were scheduled at approximately the same time each day, and subjects refrained from ingesting caffeine 2 h prior to testing. Daily test sessions lasted approximately 1.5 h.

### 2.3. Instrumentation

H-reflexes and M-waves were elicited using a constant current stimulator and isolation unit (Digitimer DS7A, Hertfordshire, England) with current range of 50 μA to 200 mA and total output capability of 400 V. Stimulation was delivered via bipolar surface electrodes (Ambu, Ballerup, Denmark) placed over the radial or median nerve to elicit ECRL or FCR H-reflexes, respectively. The cathode was proximal to the anode. EMG signals were recorded using a commercially available unit (DelSys Inc.). Double differential silver surface electrodes (10-mm length, 1-mm width, 1-cm inter-electrode distance; Delsys; Boston, MA, USA) were used to reduce cross-talk between muscles, as well as decrease the contribution of electrical activity recording from motor units distant to the target muscle. Signals were amplified 10× at the electrode site before remote differential amplification (common mode rejection ratio 92 dB, gain range 100–10,000 times). Data were sampled online to a personal computer at a rate of 1000 Hz using a 16-bit analog-to-digital converter (National Instruments, Austin, TX) and a custom-designed data acquisition program (Labview, National Instruments, Austin, TX).

### 2.4. Experimental procedures

Subjects were seated comfortably in a chair with their right UE resting on a pillow. The elbow and shoulder were flexed 90° and 15°, respectively. During ECRL recordings, the forearm was fully pronated and the wrist was extended approximately 15°; whereas, during FCR recordings, the forearm was supinated and the wrist was flexed approximately 15°. Effort was made to position the arm the same way across subjects and over sequential test days.

A previous report suggested difficulties in obtaining H-reflexes from the ECRL and FCR muscles without facilitation during testing (Miller et al., 1995). Therefore, during each test session, subjects held a 0.50-lb weight which assisted in facilitating the H-reflexes for the individual muscles. Prior to this study, we calculated the effects of this weight on the motor neuron excitability measured from the EMG activity. In three healthy subjects (one male, two female; 39–53 years old), the 0.50-lb weight produced an EMG signal that was approximately 4.5–6.0% of that which was recorded during the maximum voluntary contraction (MVC) for the individual forearm muscles.

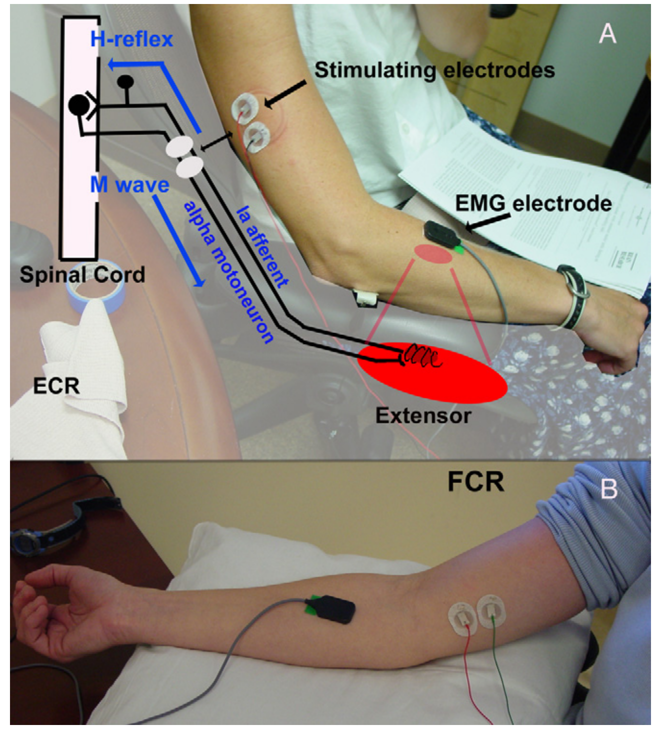


Fig. 1. Experimental set-up and spinal circuitry in the UE muscles. (A) Subject shows electrode placement for eliciting and recording the ECRL H-reflex. Superimposed below the subjects arm is an illustration of the monosynaptic reflex pathway. The two white ovals over the nerves show the sight of electrical stimulation. The path of the H-reflex and the M-wave are depicted using grey arrows as they arise from the sight of stimulation. (B) Electrode placement and arm position for H-reflex measurements in the FCR.

Effort was made to place the stimulation and recording electrodes at sites in which the H-reflex was obtained without an M-wave at low stimulation intensities, but yet the M-wave appeared at the higher intensities. The ECRL and FCR muscle bellies were identified by palpation during manually resisted wrist extension and flexion, respectively. In preparation for placement of EMG electrodes the skin over both muscles was abraded with a pumice stone and wiped with an alcohol swab. As shown in Fig. 1, ECRL recording electrodes were placed dorsally on the proximal one-third of the forearm, approximately, 2–3-cm medial and 4–5-cm distal of the lateral epicondyle. The FCR electrodes were positioned on the anterior aspect of forearm approximately one-third the distance from the medial epicondyle to the radial styloid (Jaberzadeh et al., 2004). The ground was placed on the olecranon process of the ulna. Radial nerve activation was achieved by placing the stimulating electrodes over the lateral aspect of the humeral region proximal to the elbow (Nafati et al., 2004; see Fig. 1A). For median nerve stimulation, electrodes were placed proximal to the anticubital fossa approximately one-third of the distance from the lateral epicondyle to the biceps tendon (Christie et al., 2005; Jaberzadeh et al., 2004; see Fig. 1). After the appropriate stimulating and recording sites were determined, we photographed the subject's