Electrophysiological characteristics of H-reflexes elicited by percutaneous stimulation of the cauda equina.

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Introduction

Electrical stimulation of the tibial nerve in the popliteal fossa evokes a short-latency and/or a delayed activation of the motor units of the triceps surae muscle. The latter, reflex-elicited response is due to activation of group Ia fibers from spindles, and became called H-reflex.

The soleus H-reflex has commonly been used to assess stimulus-induced or task-related changes in the excitability of reflex pathways in humans, e.g. during locomotion (Capaday and Stein, 1986).

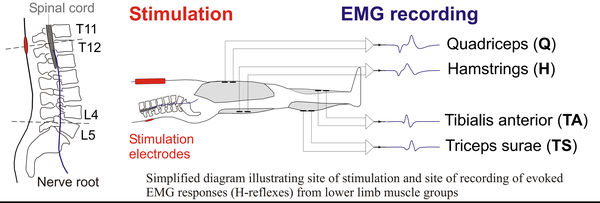
Recent studies have documented that the soleus H-reflex can also be elicited by percutaneous electrical stimulation of nerve roots at the cauda equina (Zhu et al. 1998). On the basis of our experience gained from lumbosacral posterior roots stimulation by epidural electrodes (Minassian et al. 2004), we tried to simultaneously elicit H-reflexes in lower limb muscle groups bilaterally by non-invasive percutaneous electrical stimulation. In the present poster we describe the electrophysiological properties of these H-reflexes.

Methods

Electrode set-up. The stimulating electrodes were two small self-adhesive disc electrodes (∅ = 3 cm) placed bilaterally on the subject's back between two spinous processes at vertebral levels between T11/T12 to L4/L5. Two large indifferent electrodes (8 x 13 cm) were placed on the abdomen.

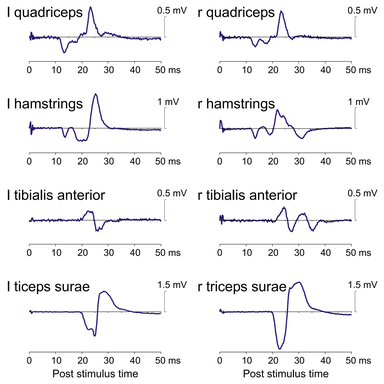
Stimulator. Two different stimulators were used. Stimulator 1 was delivering trains of stimuli at 0.5 Hz with amplitudes of 0–70 mA and monophasic pulses of 300 µs length. Stimulator 2 generated biphasic pulses of various widths with strength of 0–60 V. Single stimuli and pairs and trains of stimuli could be applied with different interstimulus intervals .

Recording set-up. Stimulus-evoked electromyograhic (EMG) responses were recorded with surface electrodes placed over quadriceps, hamstrings, tibialis anterior and triceps surae in *five adult, able-bodied subjects* in supine position.



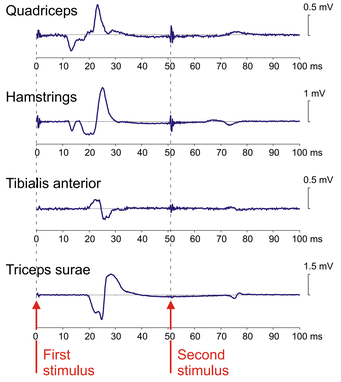
Simplified diagram illustrating site of stimulation and site of recording of evoked EMG responses (H-reflexes) from lower limb muscle groups

1 H-reflexes elicited simultaneously in several lower limb muscle groups



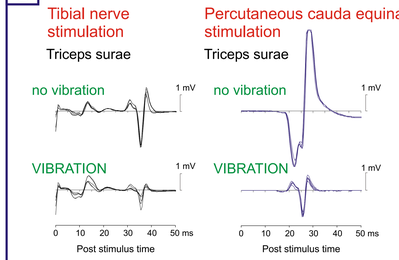
EMG recordings of H-reflexes of the left (l) and right (r) lower limb muscle groups elicited by percutaneous electrical stimulation of lumbosacral posterior roots. Stimulation site: T11/T12; stimulation amplitude: 50 V; pulse width: 1 ms; subject 2.

2 Responses to pairs of stimuli



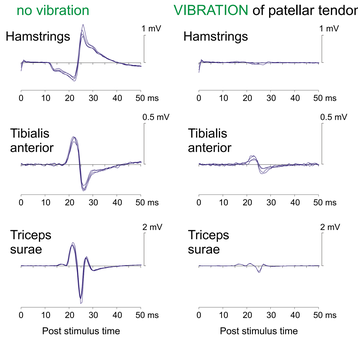
EMG responses of the left quadriceps, hamstrings, tibialis anterior and triceps surae muscles to pairs of stimuli. Same subject, stimulation site and amplitude as in Fig. 1. The long refractory period of 50 ms confirms that the responses are reflexes in origin.

3 Effect of vibration on H-reflexes



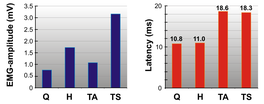
Triceps surae responses to tibial nerve stimulation at the popliteal fossa and to percutaneous nerve root stimulation (Stimulation site: T12/L1; amplitude: 40 mA; pulse width: 300 µs; subject 4) in the same subject. Direct motor responses (M-wave) and H-reflexes are differentiated by Achilles tendon vibration, which suppresses only the reflex response. Five stimulus-triggered individual responses are displayed in each case.

4 Vibration suppresses responses to cauda equina stimulation



EMG responses to percutaneous cauda equina stimulation (Stimulation site: L2/L3; stimulation amplitude: 40 mA; pulse width: 300 µs; subject 4) without and with patellar tendon vibration. Four stimulus-triggered individual responses are displayed in each case. Further evidence that responses to lumbosacral nerve roots stimulation are reflexes in origin.

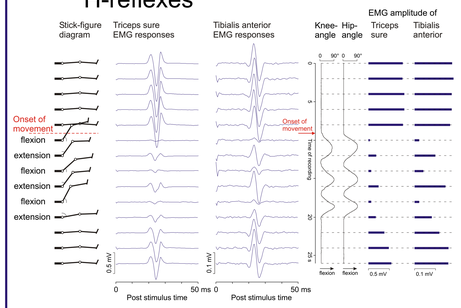
5 Mean EMG-amplitudes and latencies of H-reflexes to stimulation at T11/T12



Values derived from 5 subjects with average height of 178.4 cm. Stimulation amplitude was the highest which still elicited pure or predominant H-waves (mean: 36.25 V).

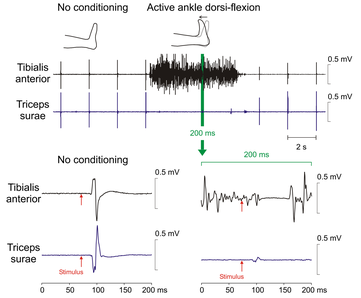
Q …quadriceps, H …hamstrings, TA …tibialis anterior, TS …triceps surae

6 Effect of passive movement on H-reflexes



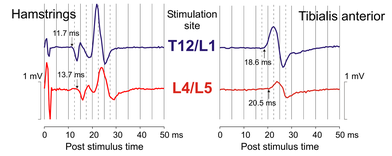
EMG responses of triceps surae and tibialis anterior to percutaneous electrical cauda equina stimulation conditioned by passive hip-knee flexion-extension movements of the ipsilateral lower limb. Stimulation site: T12/L1; stimulation amplitude: 70mA; stimulation frequency 0.5 Hz, pulse width: 300 µs; subject 1.

7 Effect of active movement on H-reflexes



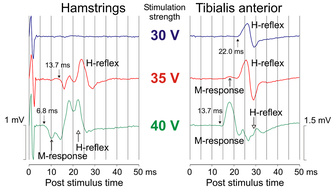
EMG responses of triceps surae to percutaneous electrical cauda equina stimulation conditioned by active ankle dorsi-flexion. Stimulation site: T12/L1; stimulation amplitude: 70 mA; stimulation frequency 0.5 Hz, pulse width: 300 µs; subject 4.

8 H-reflexes to stimulation at different vertebral levels



Longer reflex latencies in the case of the more distal stimulation site due to longer afferent path of the reflex arc. Stimulation amplitude: 35 V; pulse width: 2 ms; subject 4.

9 Responses to stimulation with different strengths



Stimulation applied at the same site L4/L5 but with different strengths. Low amplitude stimuli evoke H-reflexes with no or minimal M-responses. Higher amplitude stimuli excites both posterior and anterior roots, the antidromic activation of alpha-motoneurons reduces the H-reflex amplitude; subject 4.

Conclusions

1) H-reflexes can be elicited bilaterally in several lower limb muscle groups by percutaneous cauda equina stimulation due to the geometrical characteristics of the lumbosacral spinal roots anatomy

2) Relevance for physiological studies: to examine reflex mechanisms under suprasegmental control in able-bodied during different motor tasks and gait, and also in people with impaired suprasegmental control during externally controlled locomotion

3) clinical application: non-invasive method for assessing and localizing cauda equina lesions (posterior and anterior roots) electrophysiologically

4) non-invasive method to provide sustained tonic input to the lumbosacral cord via large posterior root fibers to enhance the central state of excitability of spinal neuronal circuits

References

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Minassian K, Jilge B, Rattay F, Pinter MM, Binder H, Gerstenbrand F, Dimitrijevic MR (2004). Stepping-like movements in humans with complete spinal cord injury induced by epidural stimulation of the lumbar cord: electromyographic study of compound muscle action potentials. Spinal Cord 42, 401-416.

Zhu Y, Starr A, Haldeman S, Chu JK, Sugerman RA (1998). Soleus H-reflex to S1 nerve root stimulation. Electroencephalogr Clin Neurophysiol. 109, 10-14.