Applications of the H Reflex and Transcranial Magnetic Stimulation

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CONTINUED PROGRESS IN research on athletic therapy is coupled with an improved understanding of the neurophysiological contributors to and the etiology and rehabilitation of athletic injuries. Two research techniques, the Hoffman (H) reflex and transcranial magnetic stimulation (TMS), are briefly introduced as two probes into neuromuscular function.

The H Reflex

Using a combination of percutaneous nerve stimulation and surface electromyography (EMG), a researcher can measure the H reflex in several muscles throughout the body, provided that the nerve is superficial at some point along its path. The magnitude of the H-reflex response is an estimate of motor-neuron excitability. In H-reflex research on walking, it has been suggested that the cyclical increase and decrease of soleus motor-neuron excitability reflects task-related modulation of the stretch reflex. The H-reflex technique has been applied to topics such as control, aging, postural stability, fatigue, and adaptations to exercise training. A simple search in PubMed will reveal over 2,000 articles published since 1960. Examples of H-reflex research related to athletic therapy include the effects of simulated joint effusion, reflex profiles and function after anterior cruciate ligament reconstruction, and the effects of disuse or immobilization.

The soleus muscle is very popular in H-reflex studies and will be used as an example here. In the H-reflex technique, electrical stimuli are applied to the skin over the tibial nerve, a mixed nerve that includes both efferent and afferent fibers (Figure 1). The electrical response of the nerve is transmitted bidirectionally. The impulse travels distally along efferent fibers toward the soleus muscle and proximally along afferents toward the spinal cord. These nerve fibers have dissimilar thresholds for activation. Precise tuning of the stimulus intensity allows somewhat selective activation of efferent or afferent fibers. At different stimulus intensities, the maximal H reflex and M wave are measured. The first response in the EMG (maximal at supermaximal stimulus intensities) is the direct response, muscle response, or M wave. M-wave latency is determined by the anatomical distance between the stimulus site at the superficial nerve and the muscle and by motor-nerve conduction velocity. On their own, the latency and amplitude of the M wave provide some information for the researcher. In H-reflex applications, the maximal M wave is often used to normalize the H response and minimize confounding influences of the placement of recording or simulating electrodes. The second response (maximal at submaximal stimulus intensities) is the H reflex. H-reflex latency is determined by anatomical distance along the reflex arc from the stimulus site to the spinal cord and back to the recording site on the muscle. Sensory- and motor-nerve conduction velocities and delay resulting from the single synapse also influence the latency. Whereas this reflex has been described simply here, careful consideration must be given to several neurophysiological factors that are reviewed by Misiaszek, such as neurotransmitter dynamics or contraction history. Furthermore, there are many technical considerations related to the application of this technique.
Figure 1  In the H-reflex technique an electrical stimulus is provided to the mixed nerve. In the electromyogram a stimulus artifact is followed by the direct response (M wave) and then the H reflex. Stimulus intensities are precisely tuned to measure maximal H and M responses, which are usually expressed as an H:M ratio.

Transcranial Magnetic Stimulation

Sometimes, the availability of new technology opens new frontiers for research. Unlike electrical stimulation, TMS allows comfortable stimulation of selected brain areas. Briefly, a wand that is held over the scalp creates an instantaneous magnetic field that results in neuron depolarization (Figure 2). With the correct wand configuration and placement, a researcher can elicit motor-evoked potentials from selected brain areas associated with specific muscle groups. Like the H reflex, the magnitude and timing of this response and a subsequent silent period are measured using surface EMG. A very nice summary of the technique can be found in a 2000 issue of *Nature*.\(^8\)

The utility of this technique is evidenced by the fact that PubMed identifies over 2,600 publications on it since 1988. To cite a few examples, TMS has been applied to the study of mental practice,\(^9\) motor-cortical dedication to trained musculature,\(^10\) central fatigue and caffeine,\(^11\) and motor learning.\(^12\) In relation to athletic therapy, TMS has been used to study moderate and minor head injuries,\(^13\) decreases in motor-cortical dedication to immobilized muscles,\(^14\) hyperthermia,\(^15\) and the lasting effects of transcutaneous electrical nerve stimulation (TENS) on the motor cortex.\(^16\) Indeed, one study indicated that chronic knee pain has an effect on motor-cortical output.\(^17\) When used together, TMS and H-reflex techniques are quite powerful. The complementary measurements enable some differentiation between the contributions of spinal and supraspinal neural networks. For example, while study participants maintained balance on an unstable platform, TMS indicated greater motor-cortical involvement while the H-reflex indicated decreased spinal-level excitability.\(^18\)

As with the H-reflex technique, both implementation and interpretation of TMS require careful consideration. A 2003 review\(^19\) provides a good overview of the principles and neurophysiology of TMS, including different protocols and applications.

Summary

Depending on your research setting, you might not have ready access to these techniques. Both, however,