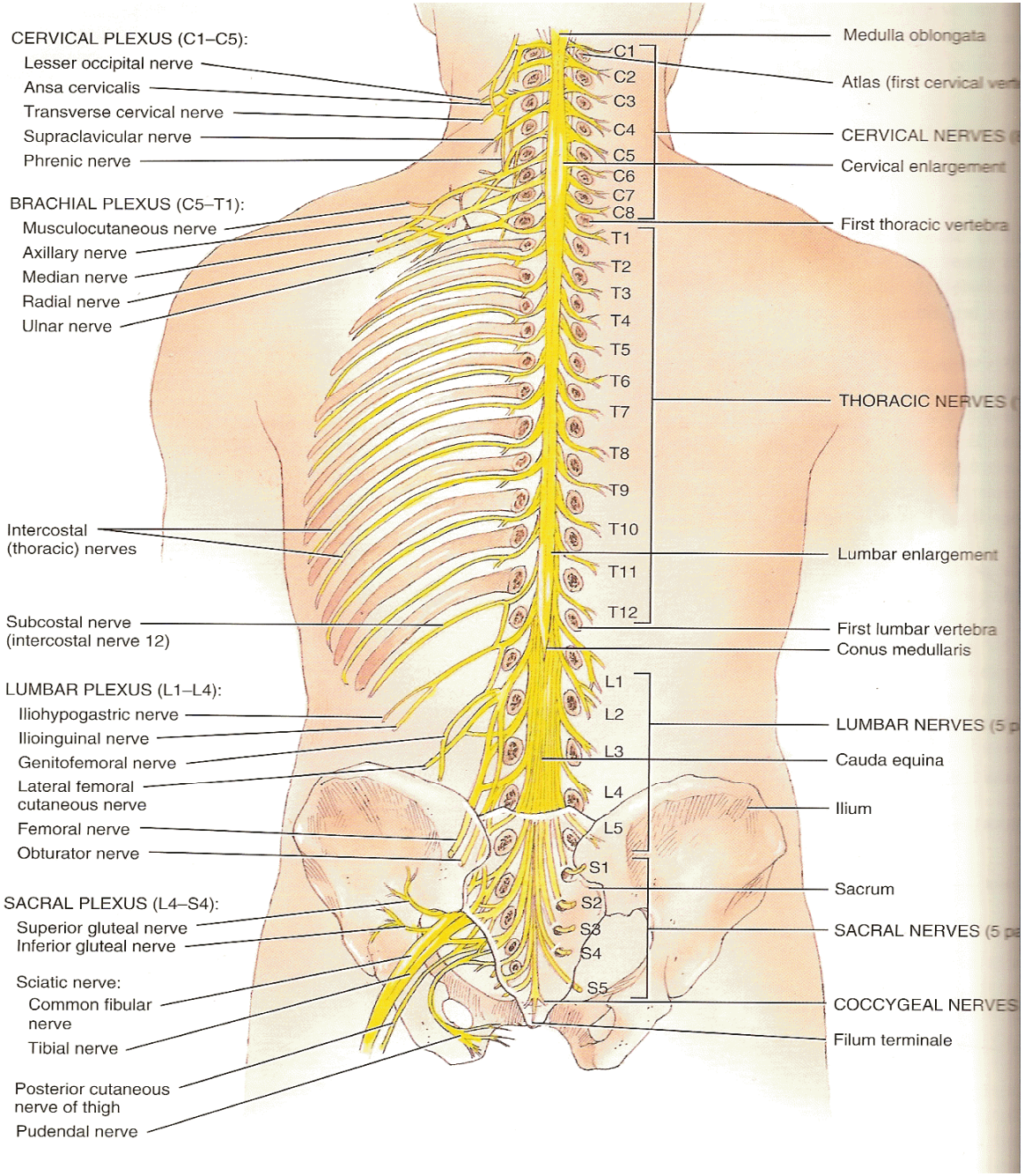
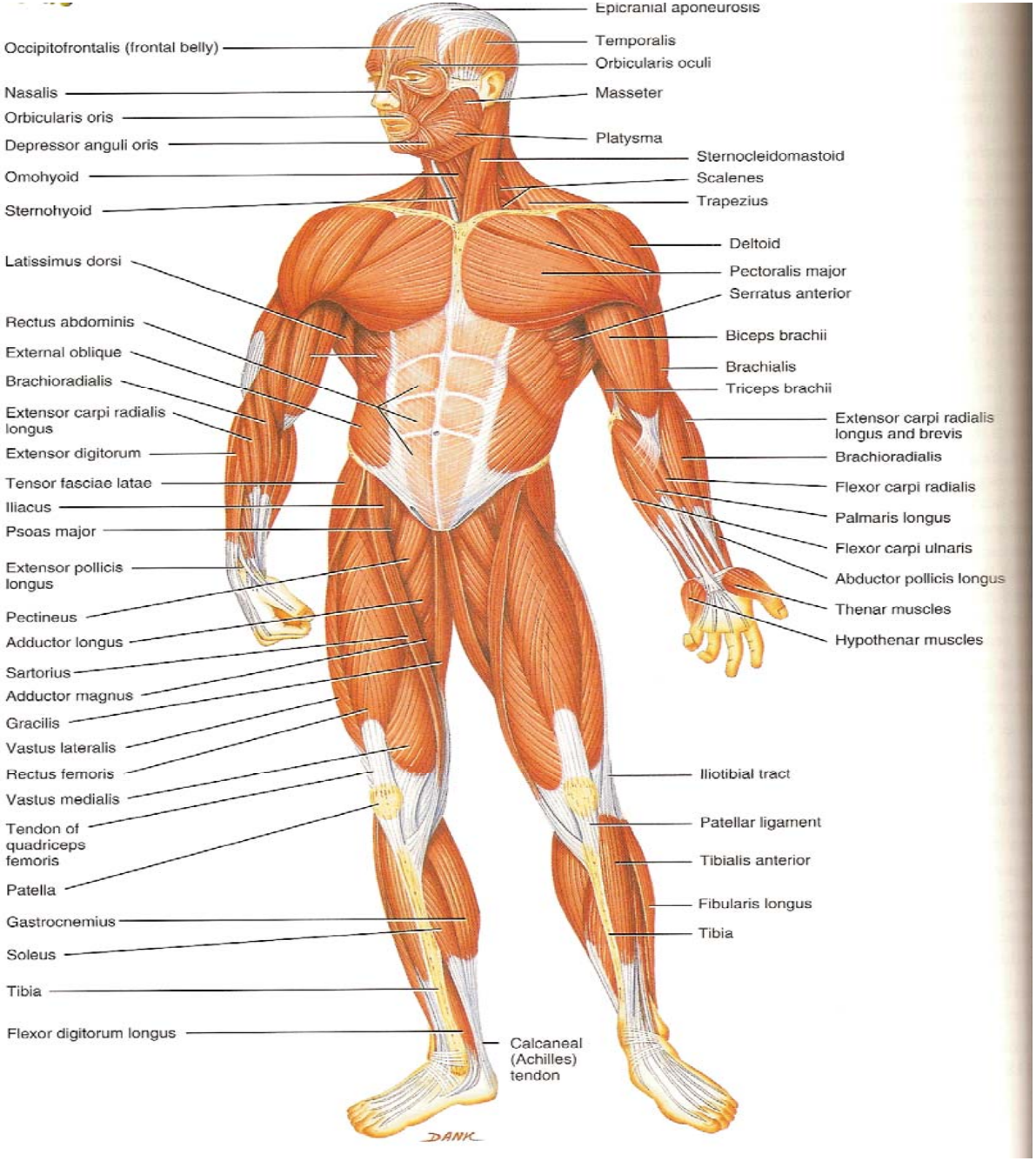
EE 795 Lecture 8

Electromyography

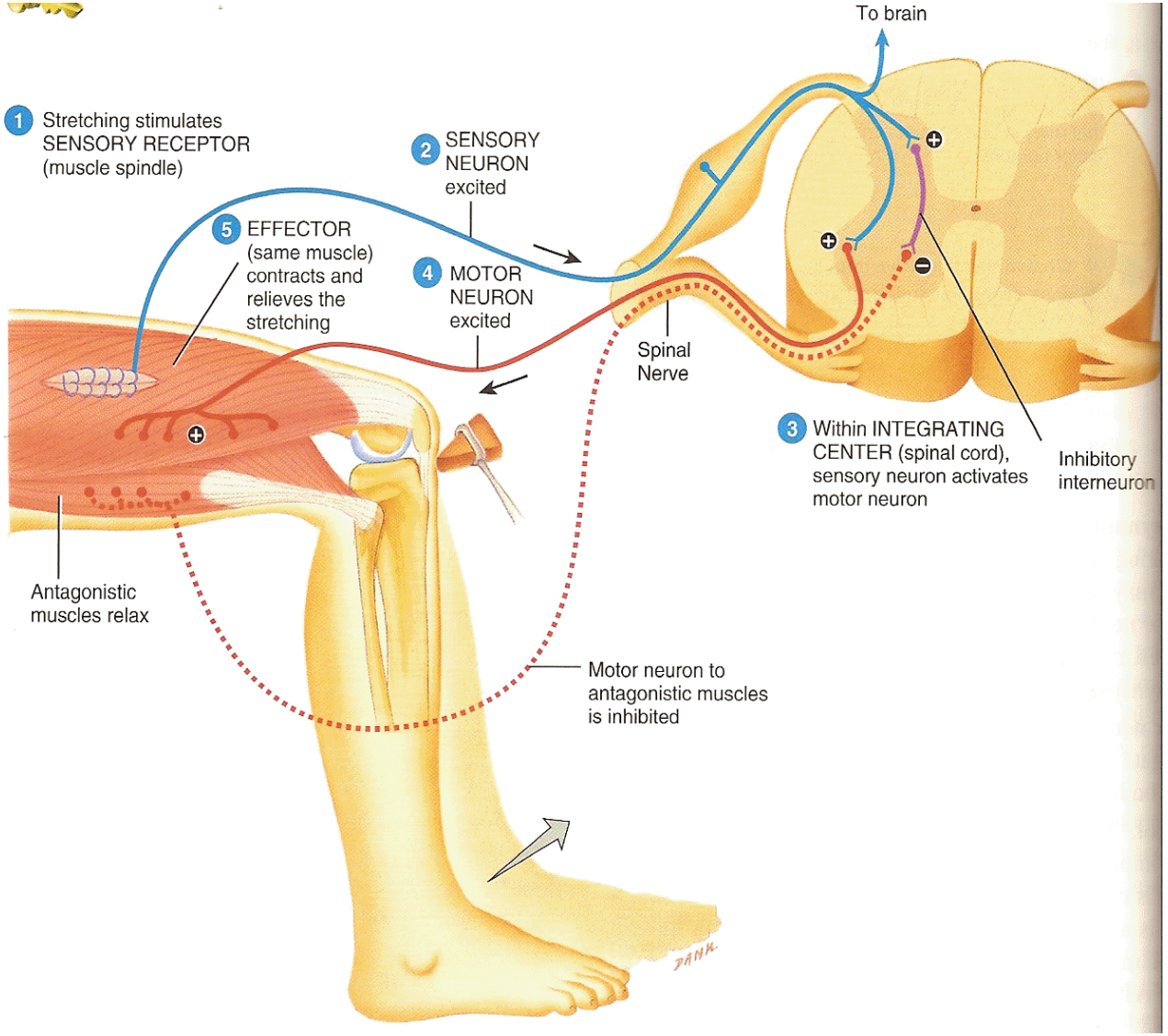
Peripheral Nerves



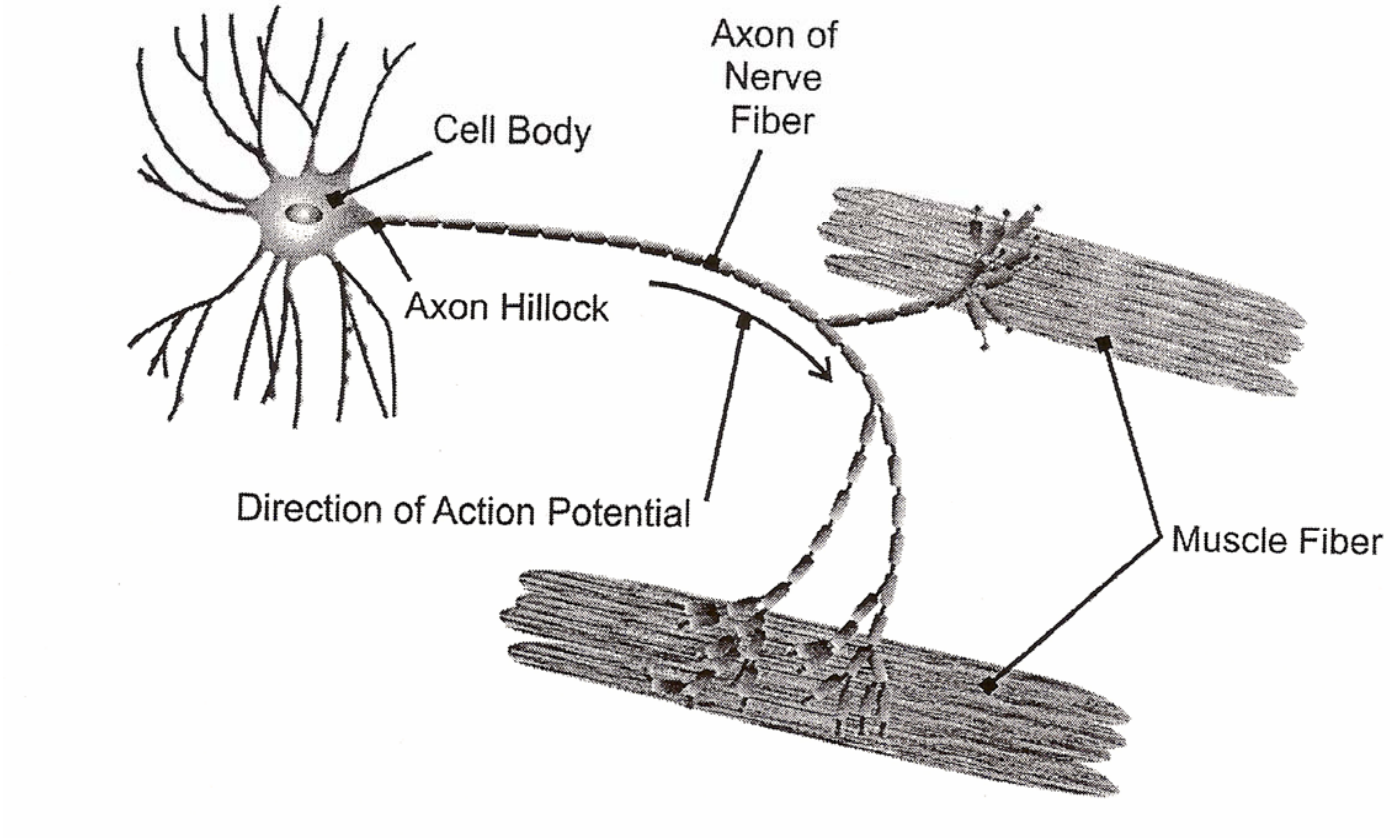
Skeletal Muscles



Spinal – Muscle Connections (Simple Reflex Arc)



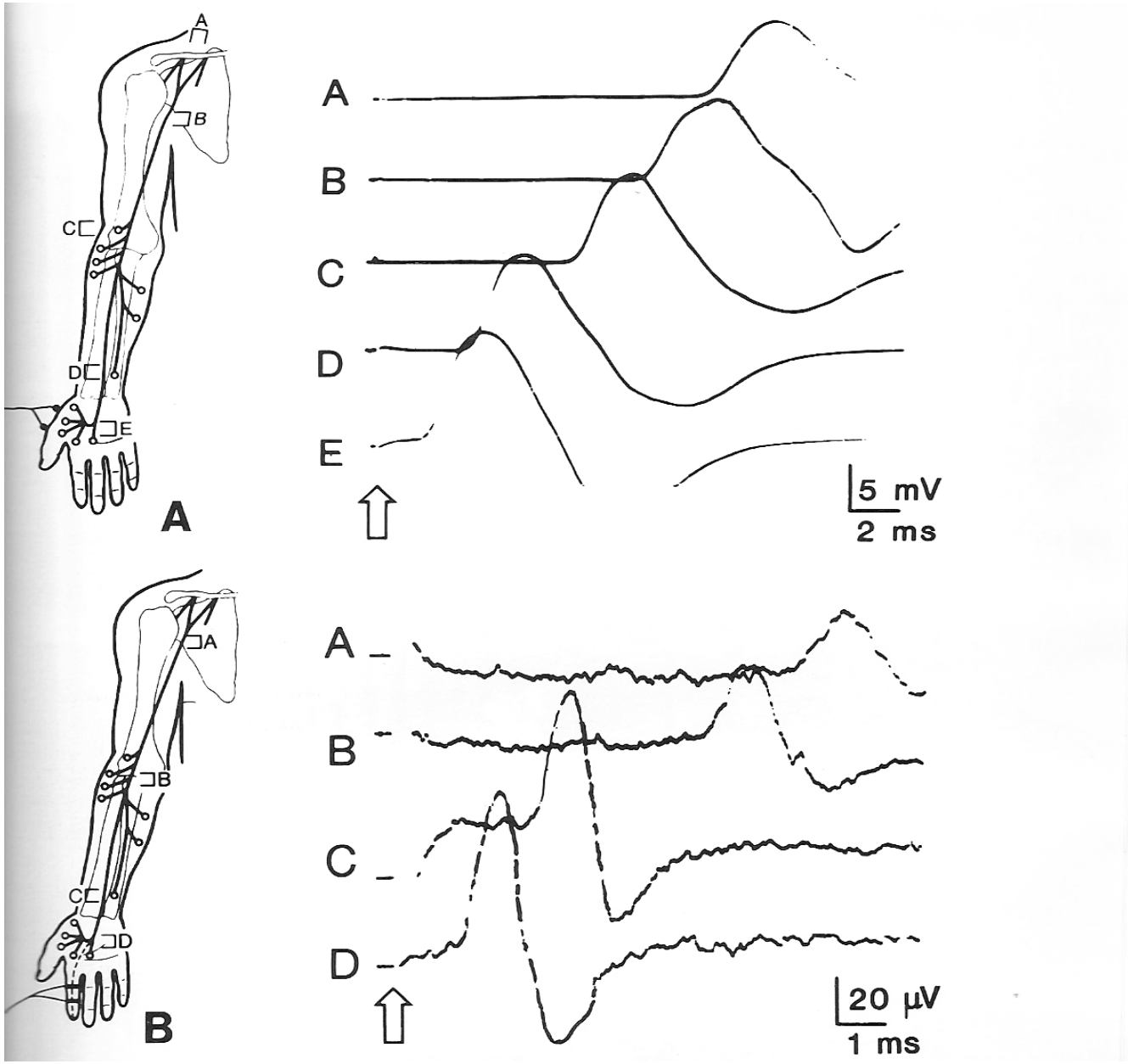
The Motor Unit



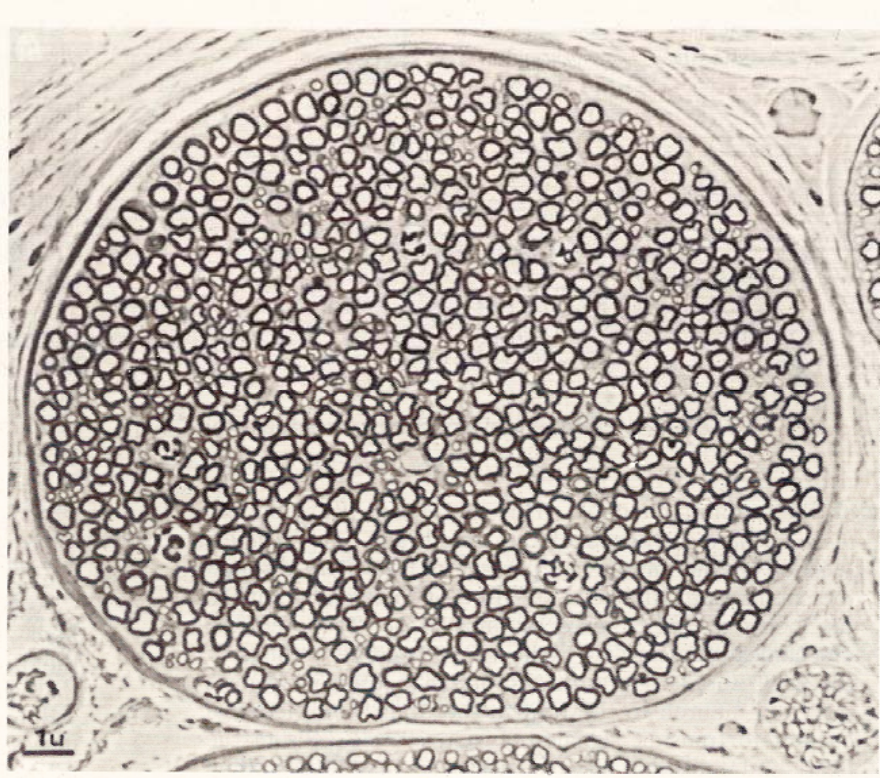
Goals of Electromyography

- **Diagnosis (Identify Neuromuscular Disease, e.g. ALS, muscular dystrophy)**
- **Determine extent of disease and monitor progress**
- **Measure dysfunction and propose solutions**
- **Study normal anatomy and physiology**

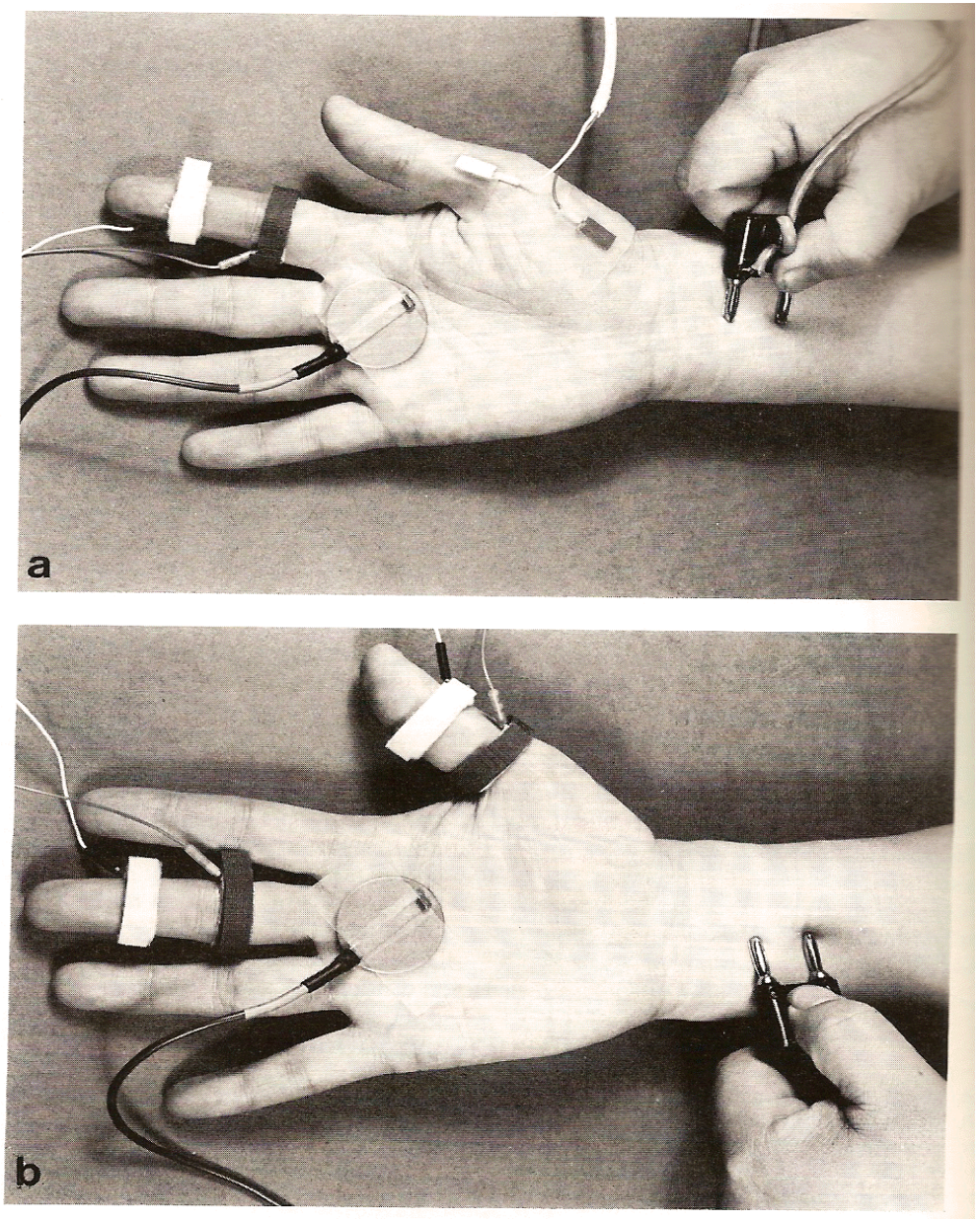
Surface Diagnostic Techniques (Motor and Sensory Conduction)



Peripheral Nerve



Patient Instrumentation
(Sensory and Motor Conduction Velocity)



Stimulation at Wrist

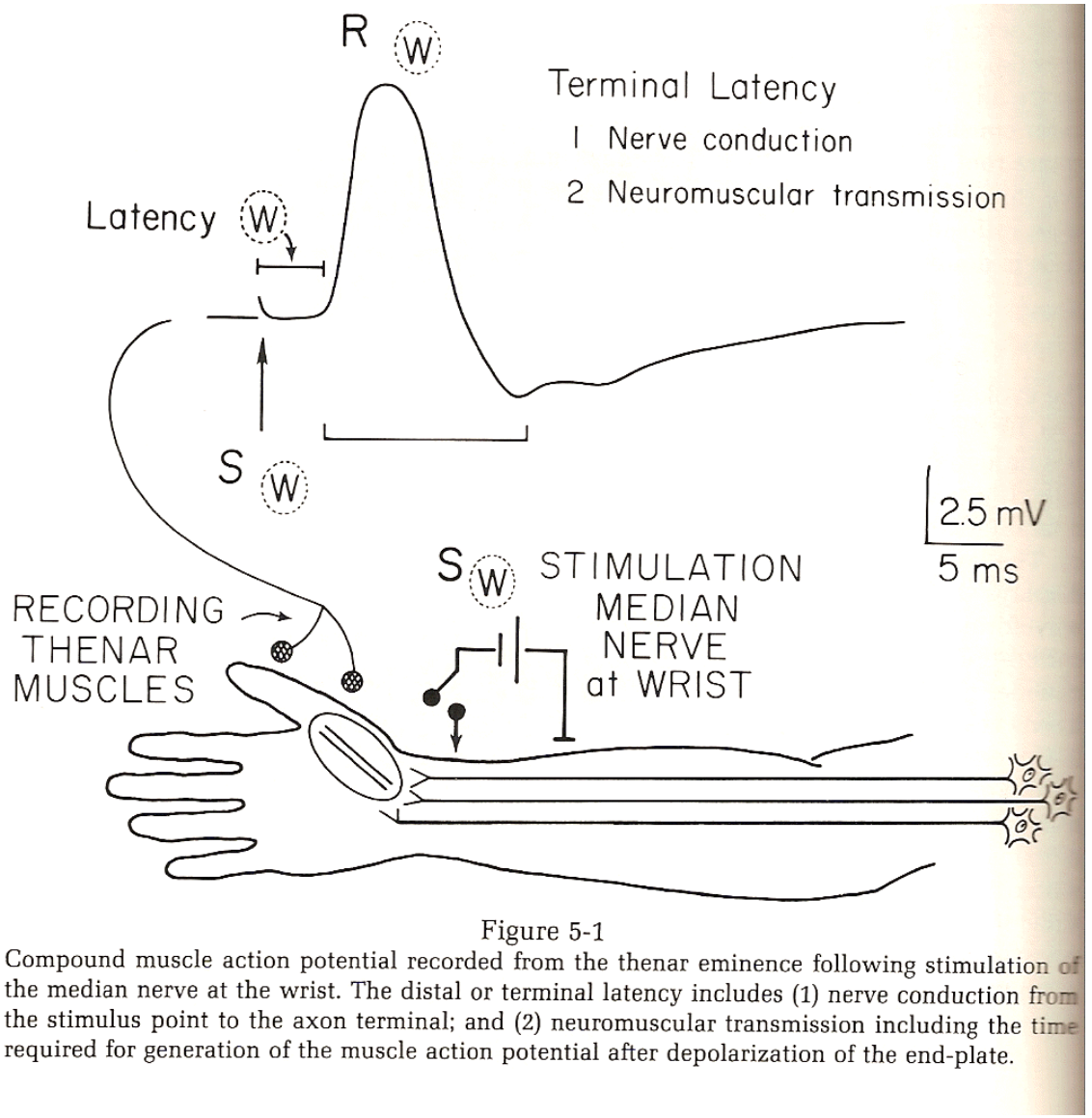


Figure 5-1

Compound muscle action potential recorded from the thenar eminence following stimulation of the median nerve at the wrist. The distal or terminal latency includes (1) nerve conduction from the stimulus point to the axon terminal; and (2) neuromuscular transmission including the time required for generation of the muscle action potential after depolarization of the end-plate.

Stimulation at the Elbow

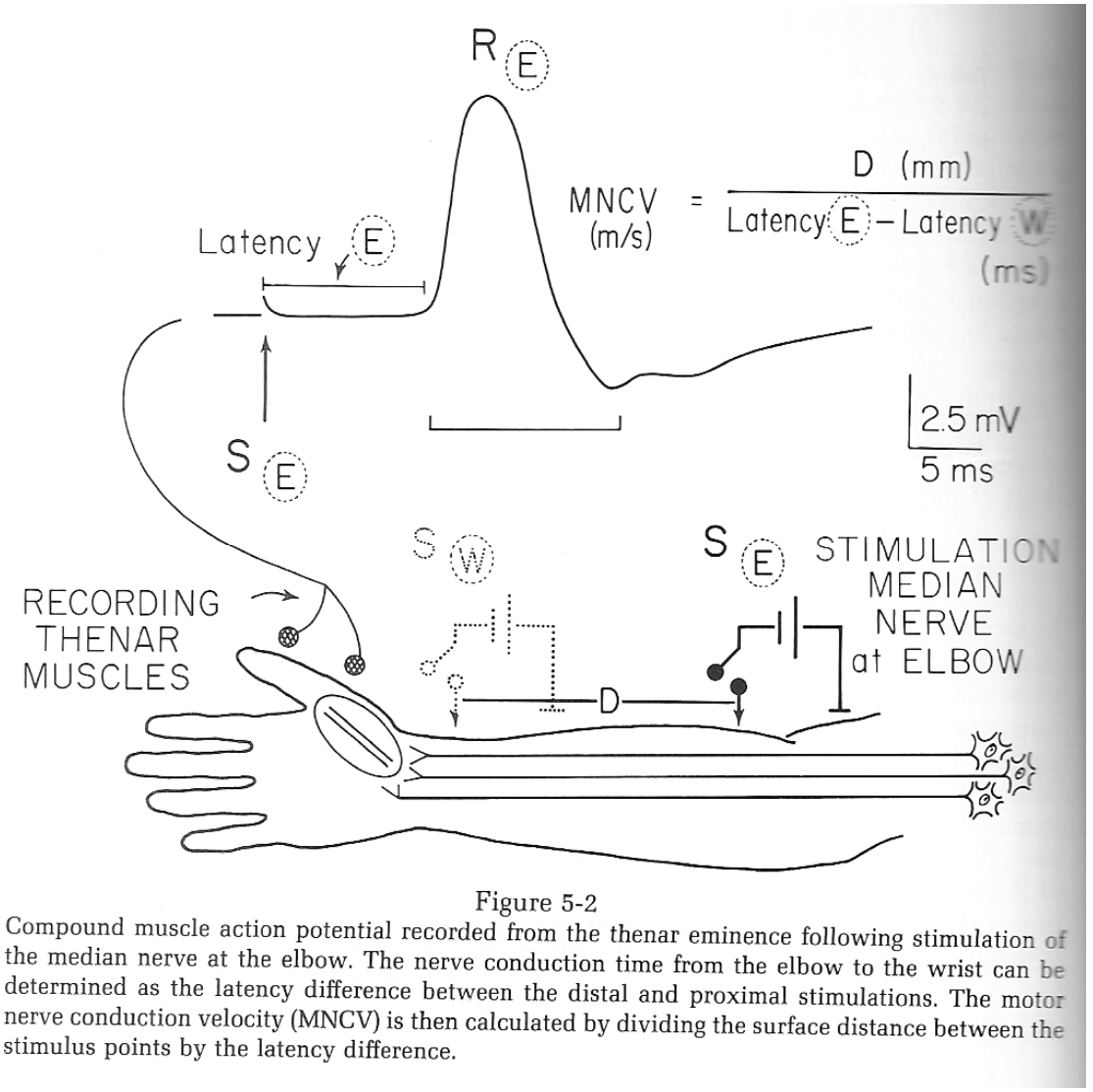
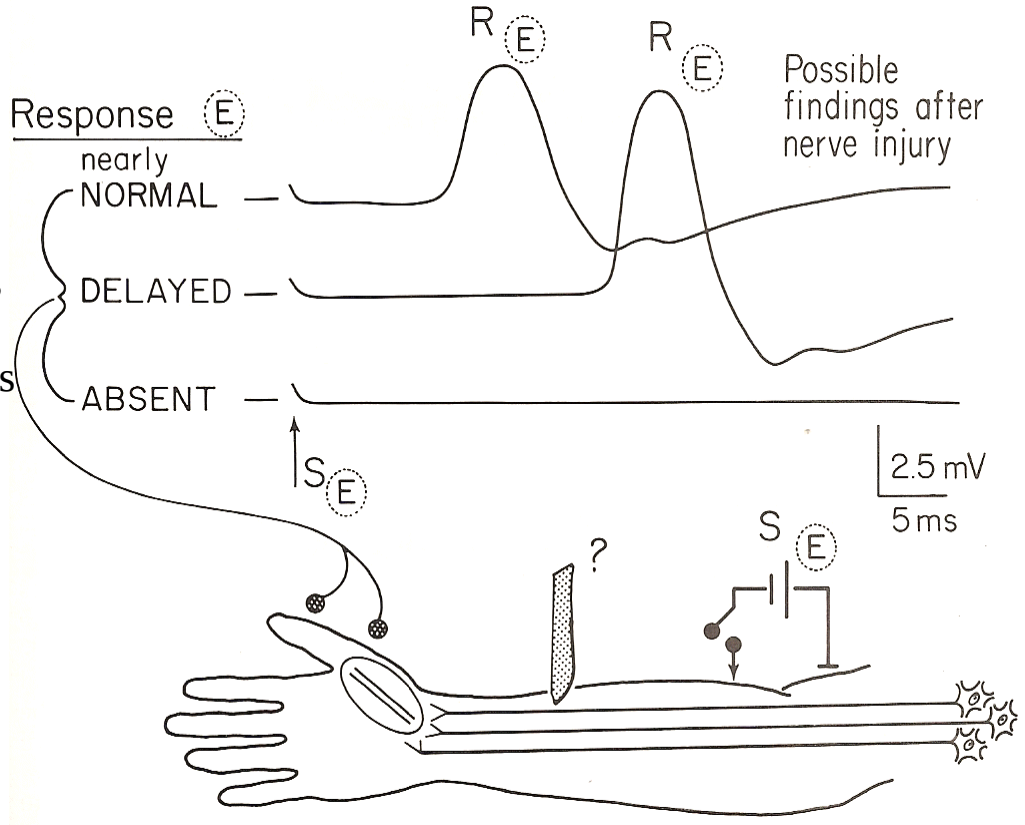


Figure 5-2
Compound muscle action potential recorded from the thenar eminence following stimulation of the median nerve at the elbow. The nerve conduction time from the elbow to the wrist can be determined as the latency difference between the distal and proximal stimulations. The motor nerve conduction velocity (MNCV) is then calculated by dividing the surface distance between the stimulus points by the latency difference.

Pathological Findings

Some Loss of Axons Demyelinating Condition

Complete Loss of Axons



Invasive Techniques

- **Measure motor unit action potentials (MUAPs)**
- **Recorded from voluntary contractions**
- **Information is in shape, duration and amplitude of MUAPs**
- **Considered “gold standard” by physicians**
- **Pattern recognition is subjective excep[t for fibrillation and fasiculation potentials**
- **MUAPs from low threshold units only**

Needle Recordings Instrumentation

Differential Amplifier and Filter

Monopolar, Coaxial Needles
.3 mm to 1 mm

Selectivity of Recording

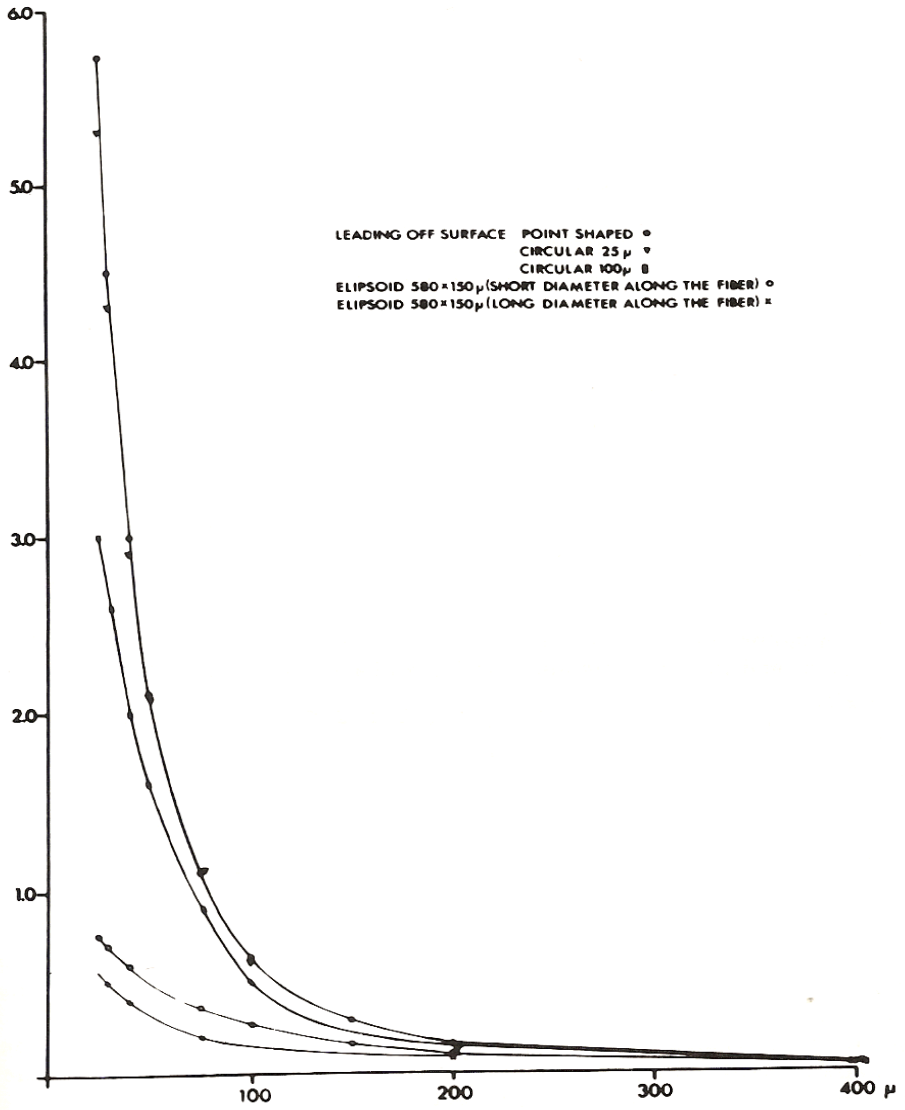


Figure 12-6

Reduction in amplitude of recorded response as the electrode is moved away from the source. With a large leading-off surface, the amplitude is low even near the spike generator and changes relatively little as the distance between the electrode and the source increases. Amplitude change per unit distance is much steeper with a smaller leading-off surface. See Figure 15-1 for further explanation. (From Ekstedt and Stålberg,[20] with permission.)

Typical Low Level Recordings

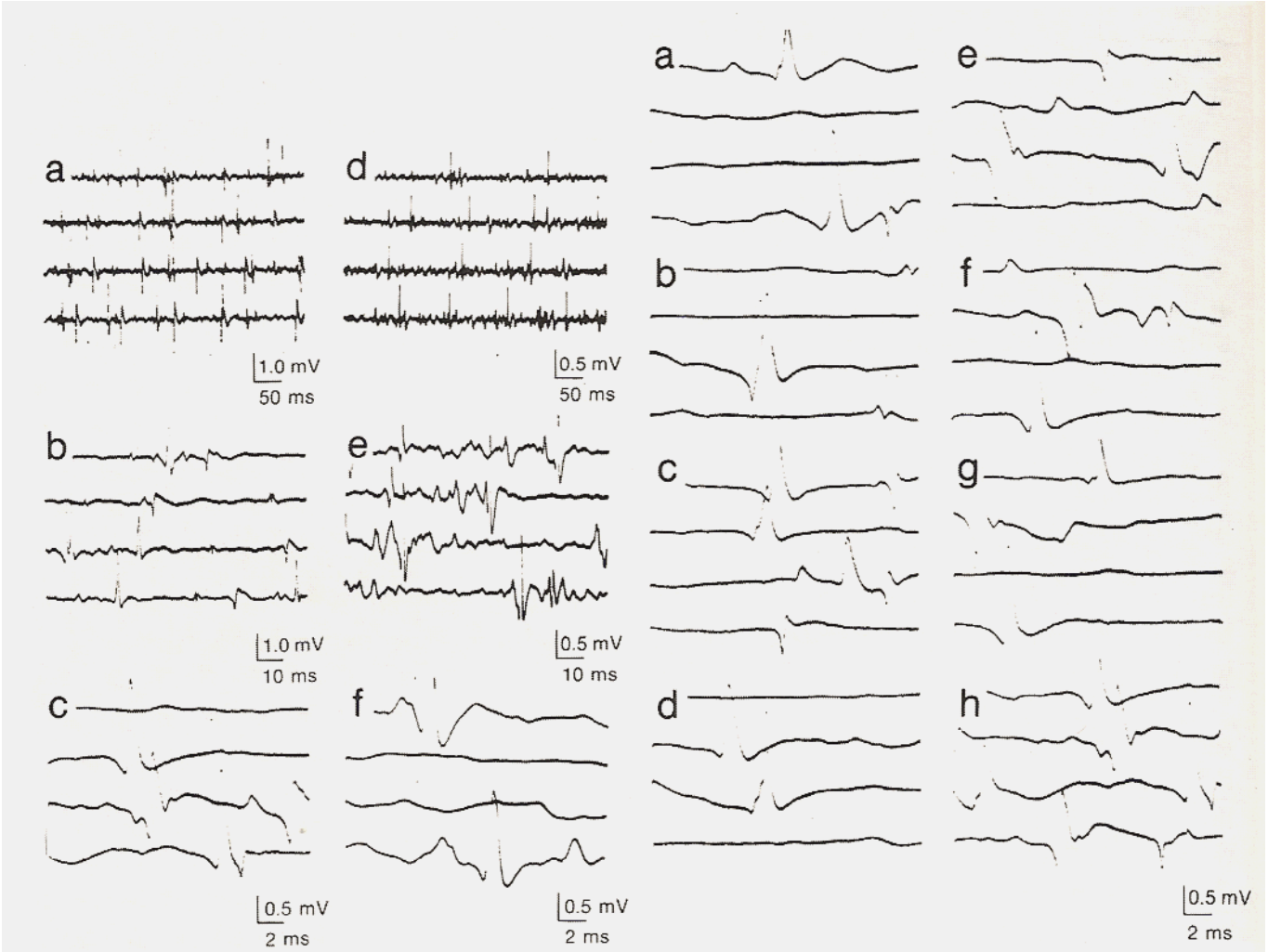


Figure 12-5

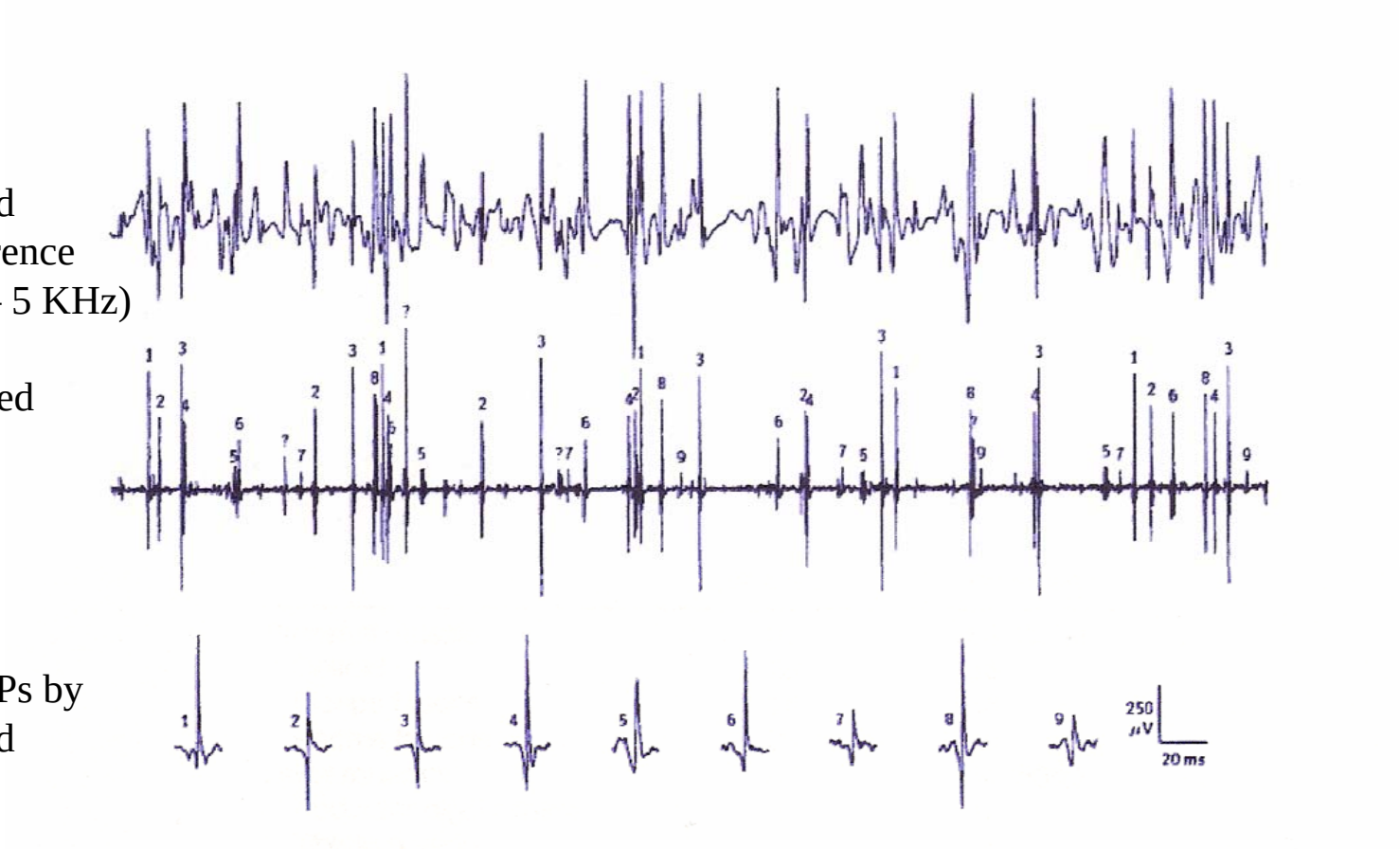
(Left) Normal motor unit potentials from minimally contracted biceps in a 40-year-old healthy man (a, b, c) and maximally contracted tibialis anterior in a 31-year-old woman with hysterical weakness (d, e, f). The amplitude, duration, and waveform are normal in both, but the firing frequency is inappropriately low for the presumed maximal effort in the latter. *(Right)* Normal variations of motor unit potentials from the biceps in the same healthy subject as shown at left. Tracings a through h represent eight different sites of recording.

Extracting Motor Unit Action Potentials from Higher Level Recordings

Needle Recorded Signal – Interference Pattern (20 Hz – 5 KHz)

High Pass Filtered 400 Hz – 5 KHz

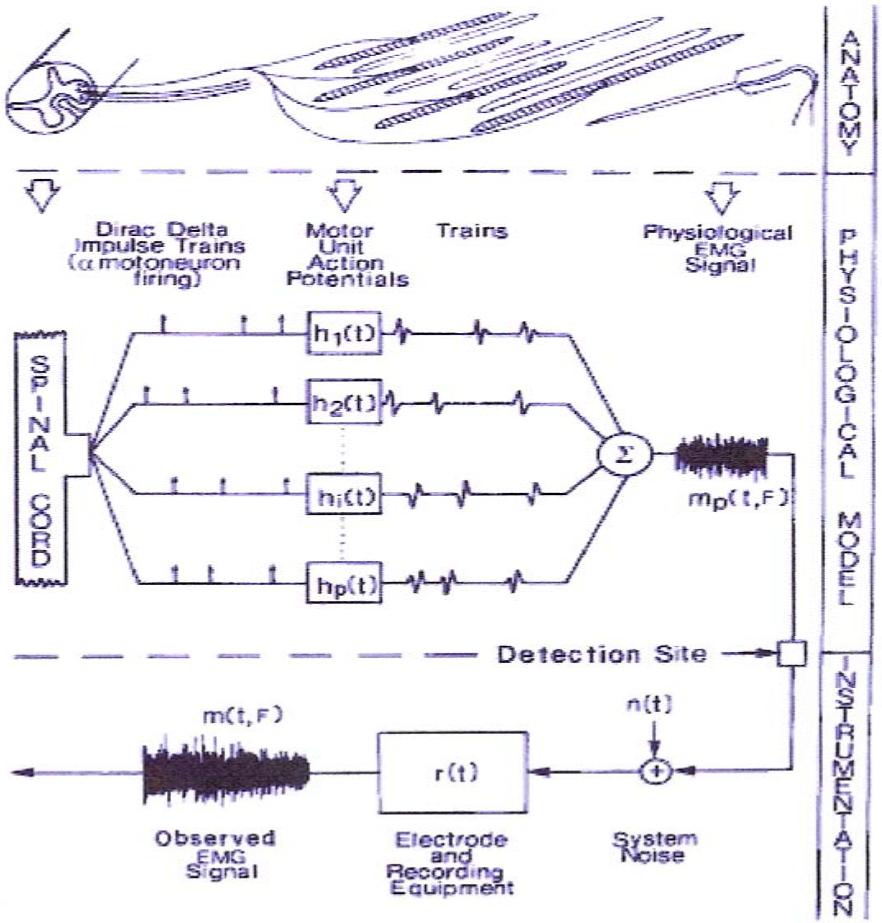
Extracted MUAPs by "Spike Triggered Averaging"



Central Nervous System Identification

- Diagnose and monitor diseases of the central nervous system (Parkinsonism)
- Assess dysfunction following trauma
- Assess effects of intervention (drugs, physiotherapy, surgery)
- Study normal muscle control

Modeling the Electromyographic Signal



Measuring Control of Individual Motor Units Recorded with Single Fibre 25 micron Needle

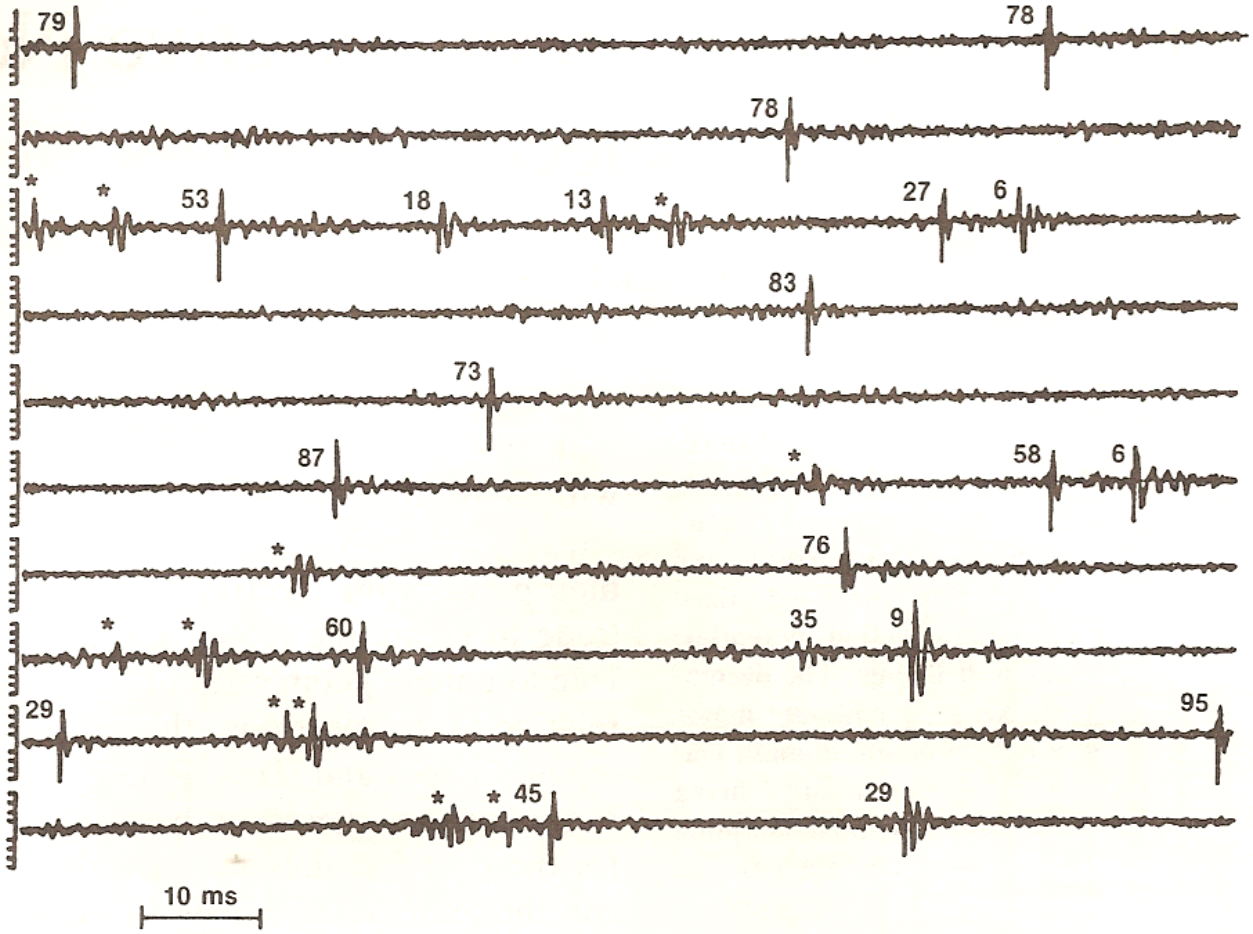


Fig. 1. Continuous ME signal detected from the first dorsal interosseous muscle using an SFEMG electrode, sampled at 10 kHz. Asterisks indicate MUAP's not compressed for Fig. 2.

Compressed Single Fibre MUAPs (one to several contributing fibres)

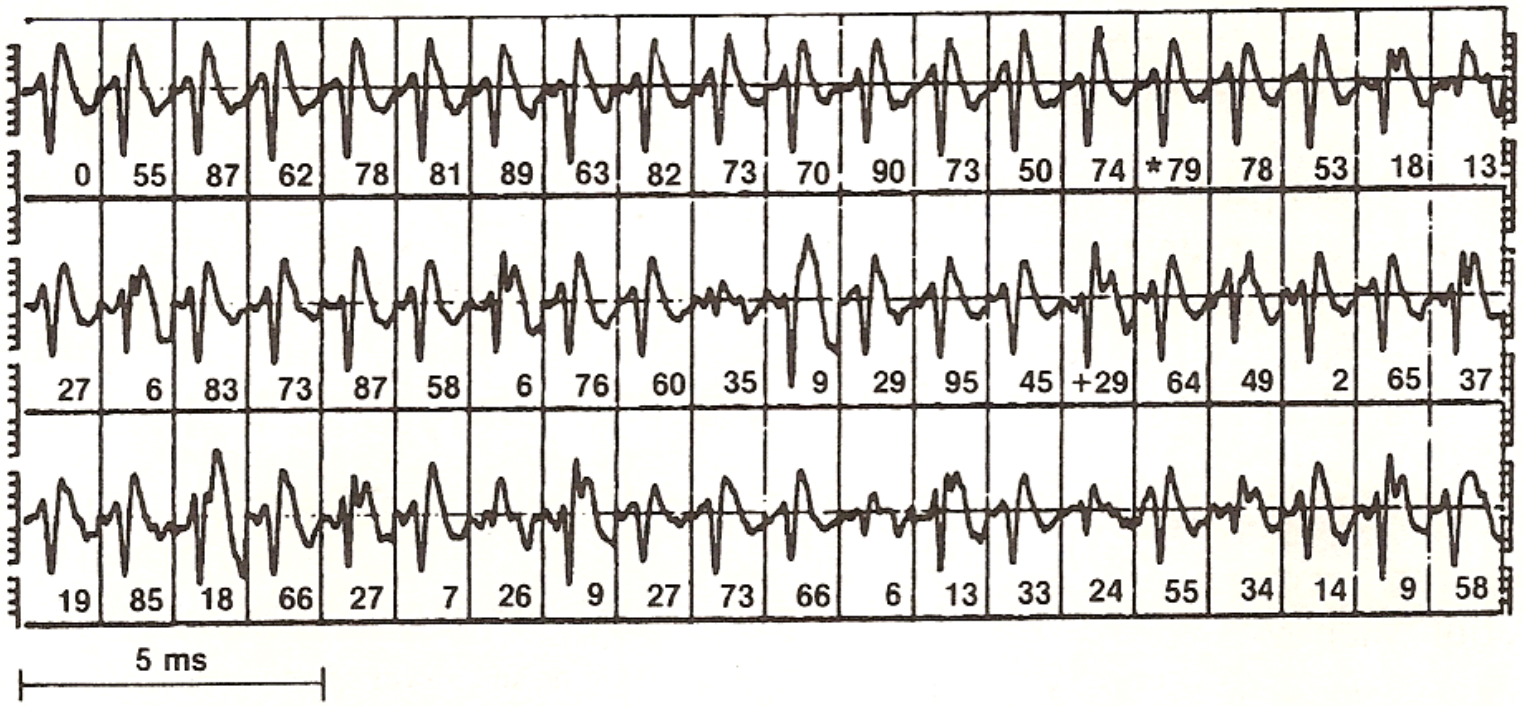


Fig. 2. Compressed ME signal from first dorsal interosseous muscle using an SFEMG electrode, sampled at 20 kHz with 25 samples stored per epoch. The sampling rate and number of samples stored were chosen to provide good visual resolution of the middle portion of the MUAP's. Asterisks indicate first and last MUAP's of Fig. 1.

Motor Unit Firing Rates

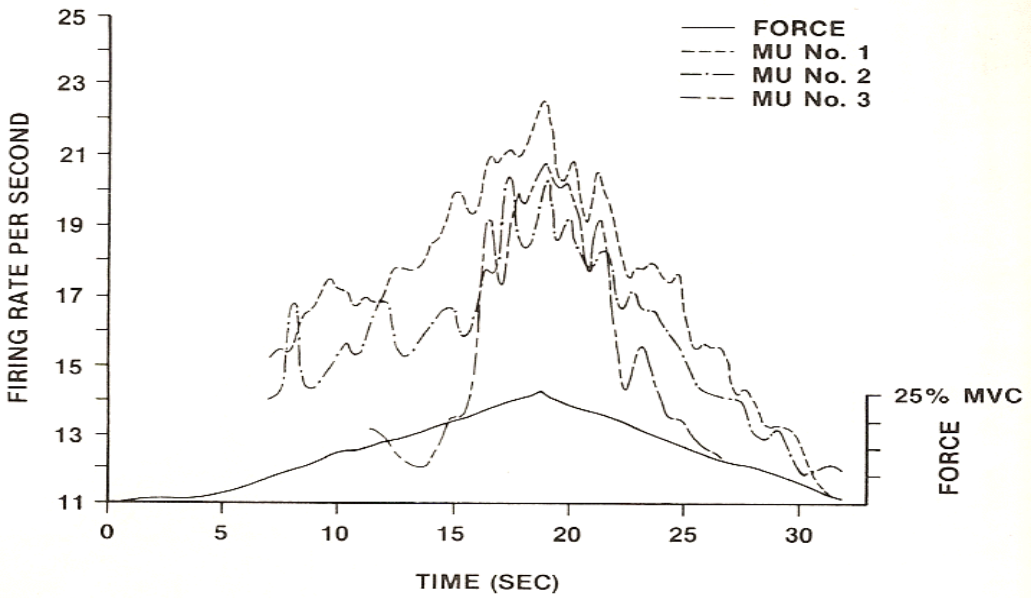


Fig. 7. Rate coding results for a ramped (to 25 percent MVC) contraction of the first dorsal interosseous muscle.

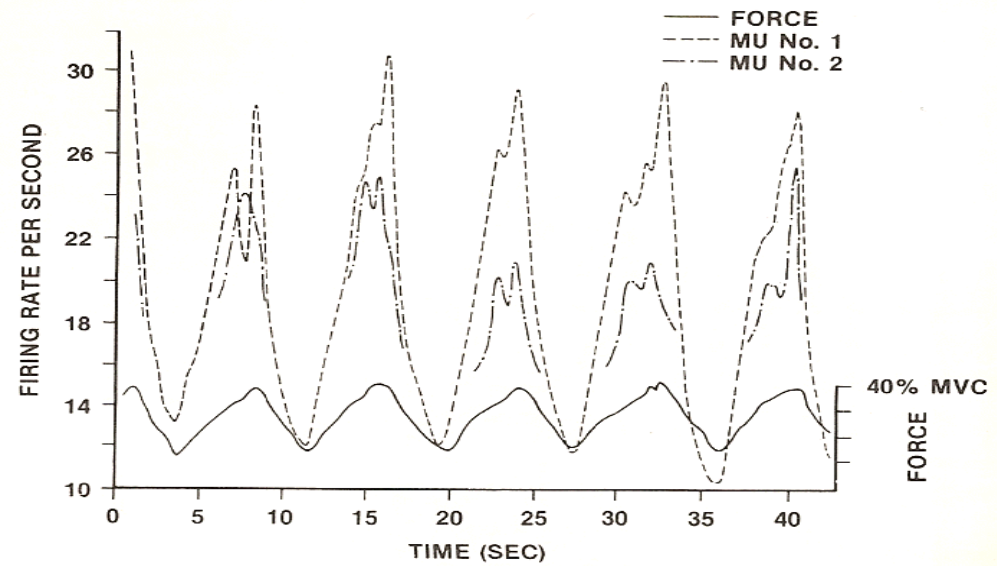
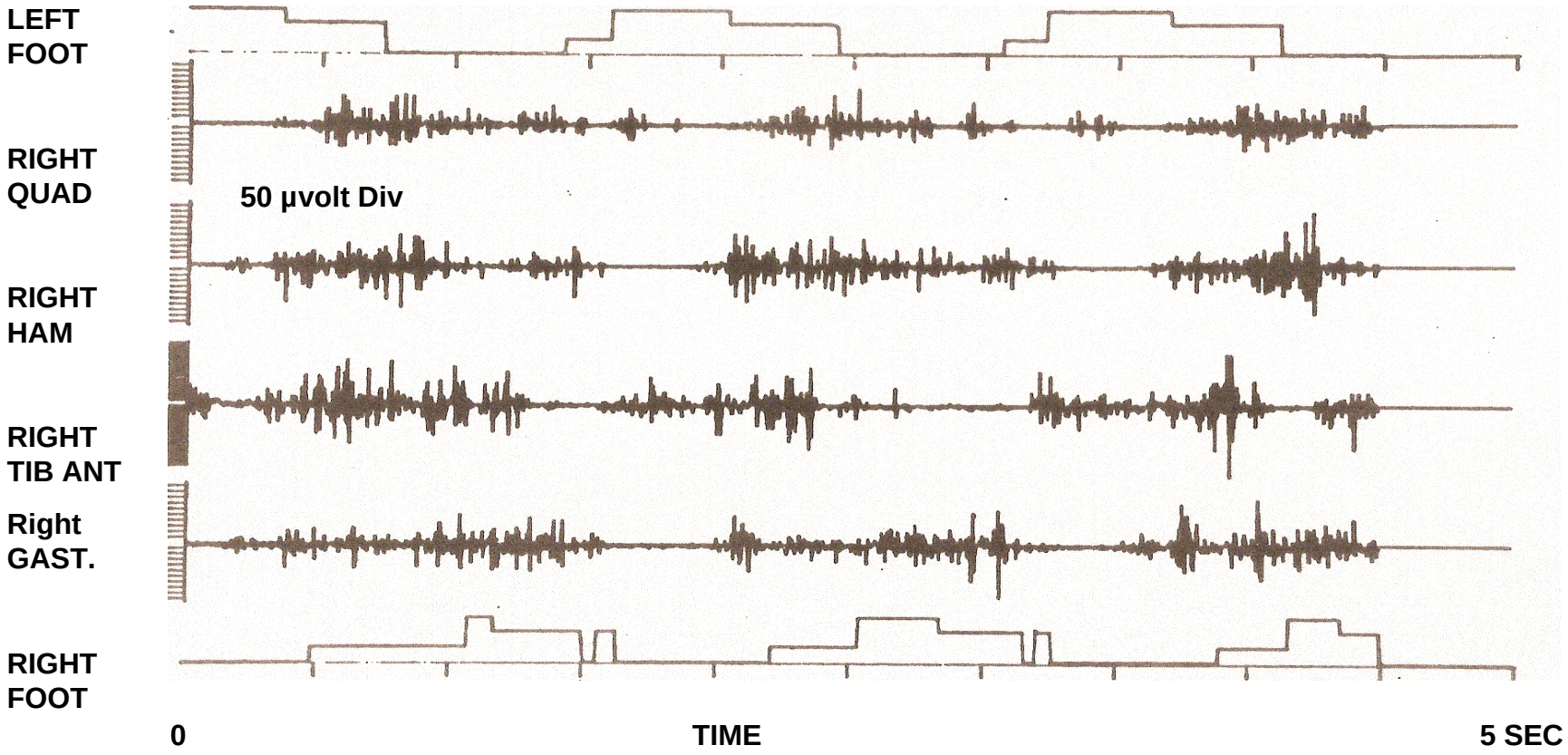


Fig. 8. Rate coding results for a contraction modulated about 25 percent MVC of the first dorsal interosseous muscle.

RAW EMG DURING GAIT

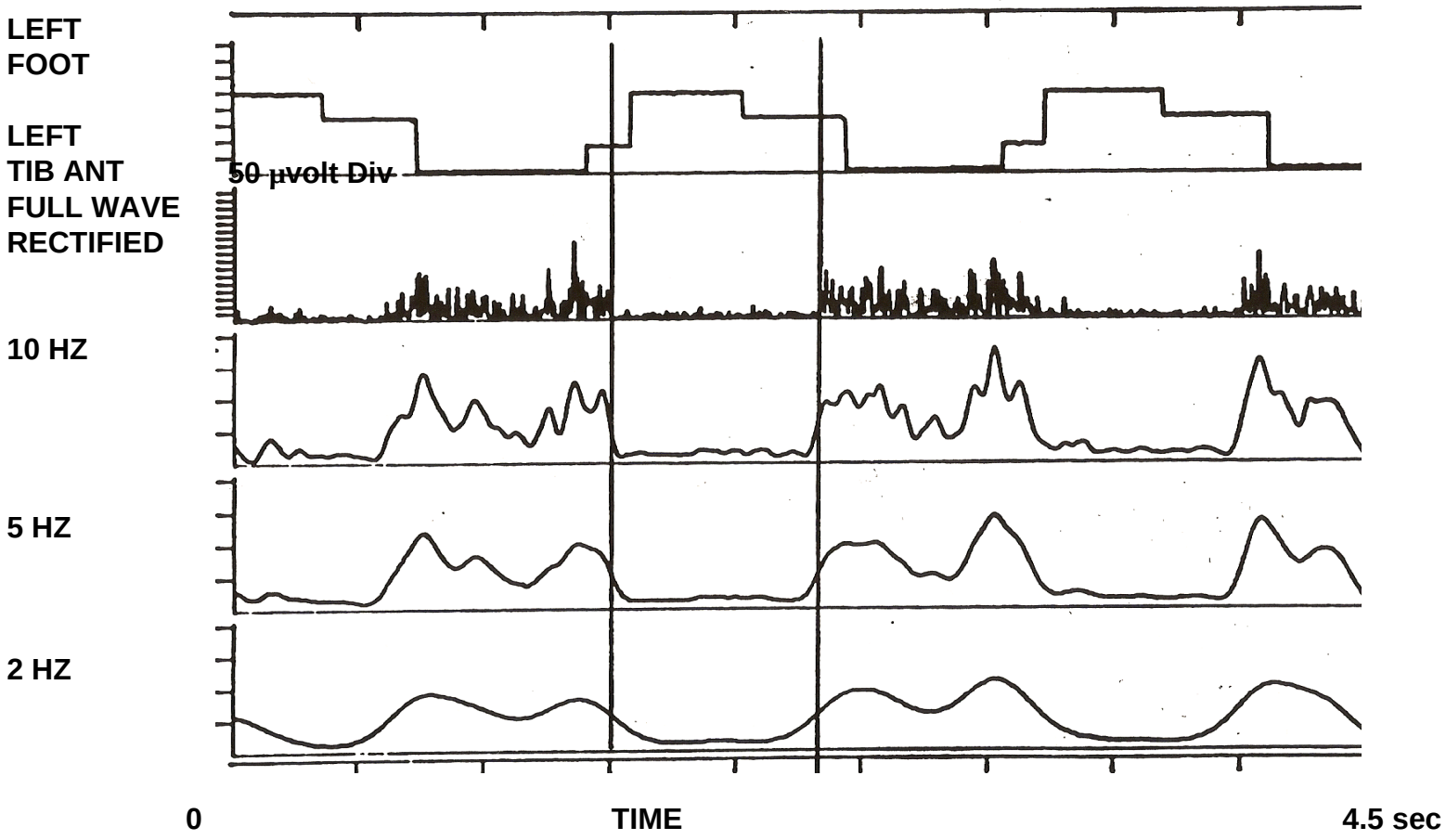
LEFT HEMIPLGIC GAIT NO AIDS **WALKING SPEED .87 m/sec**



EMG PROCESSING

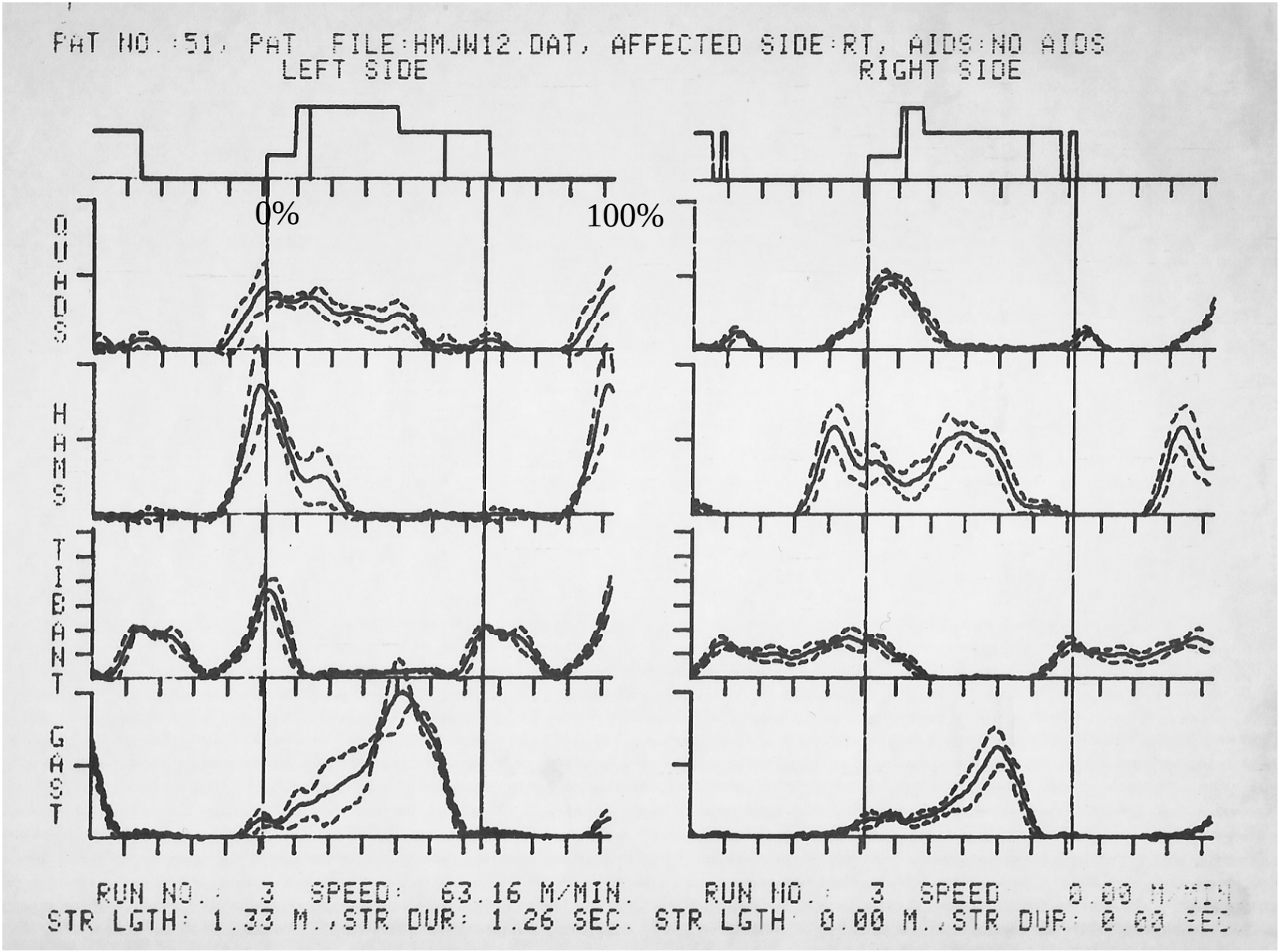
Full –Wave Rectification plus LPF

EFFECTS OF INCREASING SMOOTHING



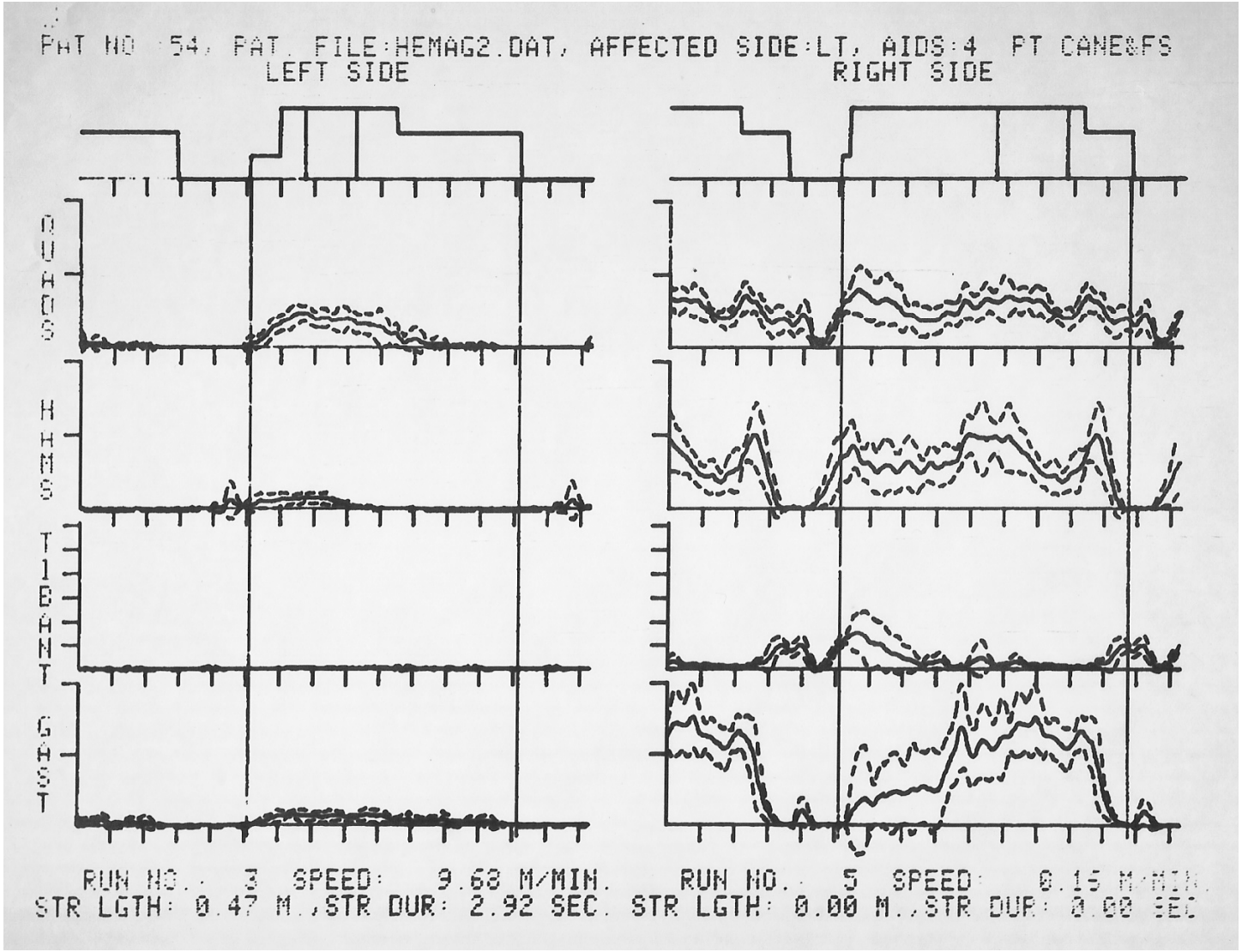
EMG Profiles for Light Hemiplegia

Mean Profile plus 1 Std Dev



EMG Profiles for Severe Hemiplegia

Mean Profile plus 1 Std Dev



EMG Profiles for Severe Hemiplegia

Mean Profile plus 1 Std Dev