Effects of different forearm positions on the motor evoked potentials in the arm and hand muscles

Kosei Mitsuhashi , Kazunori Seki, Tohru Fujii,Yasunobu Handa

Department of Restorative Neuromuscular Surgery and Rehabilitation Tohoku University Graduate School of Medicine, Sendai, Japan

E-mail:kosei@mail.tains.tohoku.ac.jp

Abstract

Motor evoked potentials (MEPs) from the biceps brachii, triceps brachii, abductor pollicis brevis (AbPB), and abductor digiti minimi (ADM) muscles induced by transcranial magnetic stimulation (TMS) were investigated in eight healthy subjects. MEP amplitudes were evaluated sequentially in three forearm positions from supination, neutral position and pronation.

MEPs in the biceps brachii and triceps brachii showed a parallel increase in amplitude in any forearm positions. In ADM, MEP amplitudes were specifically increased as changing the forearm positions sequentially. In AbPB, MEPs were also increased sequentially though none of significant difference was found.

An increase in MEP amplitude obtained from the biceps brachii might be explained by an increase in muscle length according to the sequential changes of the forearm positions. However MEP amplitudes in the other muscles were also changed though muscle length did not change in any forearm positions. This result indicates that MEPs might be influenced not only by monosynaptic stretch reflex but also by afferent inputs to the spinal cord and motor cortex from sensory receptors in the forearm.

1. INTRODUCTION

Recently, Ohyama reported that MEPs of the extensor carpi radialis longus were influenced by forearm positions, i.e., supination and pronation[1]. Sugawara also reported that MEP responses of the flexor carpi radialis and extensor carpi radialis were changed by supination and pronation of the forearm[2].

They mentioned that MEPs were influenced not only by monosynaptic stretch reflex but also by afferent inputs to the spinal cord from sensory receptors in the forearm. However, it seems likely that MEPs might be influenced also by the sensory inputs to the motor cortex.

The purpose of this study is to investigate amplitude changes in MEPs obtained from arm and hand muscles in different forearm positions.

2. METHODS

2.1. Subjects and General experimental procedure

Eight healthy subjects (one man, seven women) participated in this study. Their age ranged from 24 to 47 years old. All subjects made the right hand its dominant hand. They were seated comfortably on the chair with both forearms placed on the table. The joint positions of the upper limb were 0 degree of shoulder flexion, 90 degrees of elbow flexion, and 0 degree of wrist flexion. Joint angles of the wrist and fingers were fixed at 0 degree with plates for remaining these joint angles constant in any forearm positions. They were asked to perform positioning of their forearm in pronation of 90 degrees, neutral position (0 degree), and supination of 90 degrees.

2.2. TMS

For TMS, a Magstim200 (Magstim Company LTD, GB) and a circular coil were used. The coil was placed on the scalp. Center of the coil was held over the Cz position as defined by the International 10-20 system for electroencephalograph. The direction of current within the coil was anticlockwise to elicit motor responses of right side muscles. Stimulus output was set at 60% of the maximal power of this device.

2.3. Recording

Surface EMG was used for recording of MEP. Surface bipolar electrodes made of silver-silver chloride (NF-50K, NEC Medical) were placed over the biceps brachii, triceps brachii, abductor pollicis brevis (AbPB), and abductor digiti minimi (ADM). An indifferent electrode was placed on the olecranon. Diameter of the electrode was 10mm and Distance between bipolar electrodes was 10mm. The bipolar electrodes were placed according to define of the International Society of Electrophysiology and Kinesiology. Before TMS, we confirmed that none of background EMG activity was found.

2.4. Measurements and statistical Analysis

The EMG signals were amplified with an EMG amplifier system (DPA-10A, Diagram medical system; BIOTOP6R12, NEC Sanei) with a bandpass filter from 20Hz to 3000 Hz. Then the signals were digitized at 2kHz with a digitizer (AD12-16U (98) EH, Contec) and stored on a personal computer. The EMG signals were analyzed using BIMUTASII (Kissei Comtec Matsumoto). Peak-to-Peak amplitudes of the MEP were measured in each of muscles. Averaged EMG Amplitude in each of muscles was obtained from 6 MEP responses in each forearm position. The Wilcoxon signed-rank test was used to compare the amplitude in each forearm positions. 5% of significance was used for this test.

An informed consent for this study, which was approved by the Ethics Committee of Tohoku University, was obtained from all subjects.

3. RESULTS

Typical MEPs evoked by TMS in one subject were shown in Figure 1. Amplitudes of MEP obtained in each muscle in three forearm positions.

In AbPB, MEP values in supination, neutral position and pronation were 276.3μV, 359.5μV and 823.7μV, respectively. Thus, the MEP value was the highest in pronation.

In ADM, MEP values in supination neutral position and pronation were 340.2μV, 412.9μV, 142.8μV, respectively. Thus, the MEP value was the lowest in pronation

In the Biceps Brachii, MEP values in supination, neutral position and pronation were 272.4μV, 228.7μV, 146.5μV, respectively. The MEP value was the highest in supination.

In the Triceps Brachii, MEP values in supination, neutral position and pronation were 194.2μV, 154.9μV, 133.9μV, respectively. The MEP value was the highest in supination.

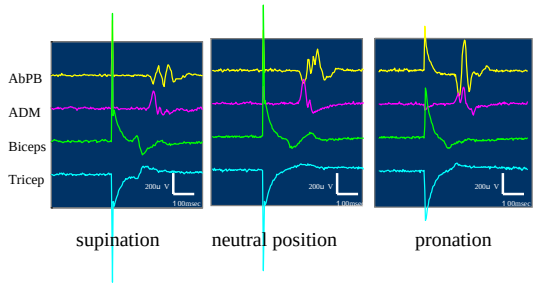

Figure 1 Typical MEP responses evoked by TMS in one subject

Averaged MEP responses of the biceps brachii and triceps brachii in 8 subjects were shown as box plots in Figure 2. Box plots show median (horizontal line), range from 25th to 75th percentile (box), and total range (bars).

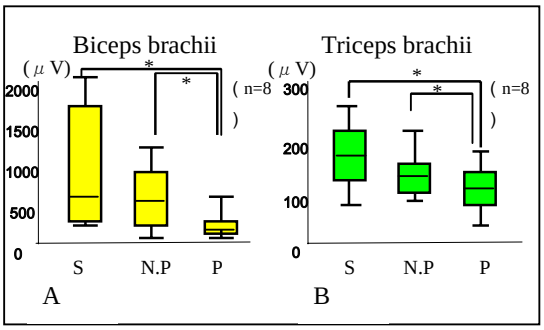

Figure 2 Averaged MEP responses of the biceps brachii (A) and triceps brachii (B) in 8 subjects. S:supination, N.P:neutral positon, P:pronation

In the Biceps Brachii, averaged MEPs in supination were ranged from 43.0μV to 2475.0μV as shown in figure 2A. Median value was 611.0μV. In neutral position, averaged MEPs were ranged from 47.0μV to 1304.0μV. Median of MEPs was 457.5μV. Averaged MEPs in pronation were ranged from 45.0μV to 914.0μV. Median of MEPs was 156.5μV. Significant differences in MEP

amplitudes were found between supination and pronation ($p<0.05$), and between neutral position and pronation ($p<0.05$).

In the Triceps Brachii, averaged MEPs in supination were ranged from 89.0μV to 241.0μV as shown in figure 2B. Median of MEP responses was 170.5μV. In neutral position, averaged MEPs were ranged from 102.0μV to 238.0μV. Median of MEPs was 145.0μV. Averaged MEPs in pronation were ranged from 62.0μV to 220.0μV. Median of MEPs was 134.5μV. Significant differences in MEP amplitudes were noted between supination and pronation ($p<0.05$), and between neutral position and pronation ($p<0.05$).

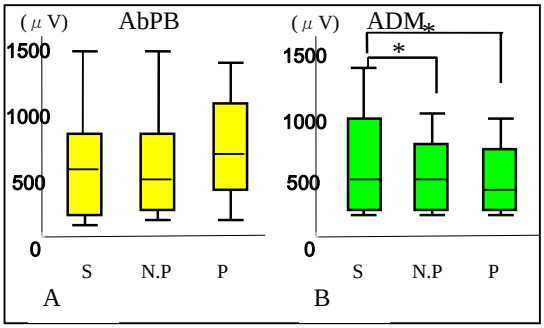

Figure 3 Averaged MEP responses of AbPB (A) and ADM (B) in 8 subjects. S:supination, N.P:neutral positon,P:pronation

In AbPB, averaged MEPs in supination were ranged from 68.0μV to 1605.0μV as shown in Figure 3A. Median of MEPs was 519.5μV. In neutral position, averaged MEPs were ranged from 121.0μV to 1555.0μV. Median of MEP responses was 466.0μV. Averaged MEPs in pronation were ranged from 104.0μV to 1423.0μV. Median of MEPs was 641.0μV. No significant difference was found among three positions.

In ADM, averaged MEPs in supination were ranged from 80.0μV to 1564.0μV as shown in Figure 3B. Median of MEPs was 451.5μV. In neutral position, averaged MEPs were ranged from 112.0μV to 1261.0μV. Median of MEP responses was 445.0μV. Averaged MEPs in pronation were ranged from 95.0μV to 1070.0μV. Median of MEPs was 385.5μV. Significant differences were found between supination and pronation ($p< 0.05$), and between supination and neutral position ($p< 0.05$).

4. DISCUSSION AND CONCLUSIONS

MEP amplitudes of the biceps brachii were changed sequentially in three forearm positions, supination, neutral position and pronation. An increase in MEP amplitude obtained from the biceps brachii might be explained by an increase in muscle length according to the sequential changes of the forearm positions. This amplitude increase in MEPs might be explained from both an increase in muscle length according to sequential changes of the forearm positions and facilitation of α -motoneurons due to excitatory inputs from group Ia fibers originated from the biceps brachii.

MEP amplitudes of the triceps brachii showed a parallel increase concomitant with an increase in MEP amplitudes of the biceps brachii. This implies that MEP amplitudes of the triceps brachii were not influenced by reciprocal inhibition from the biceps brachii. Therefore, these MEPs were not possibly explained by spinal reflex mechanisms.

MEP amplitudes obtained from AbPB and ADM muscles were changed though muscle length of these muscles was thought to be almost constant in any forearm positions.

This result indicates that MEPs might be influenced not only by monosynaptic stretch reflex but also by afferent inputs to the spinal cord and also to the motor cortex from sensory receptors in the forearm.

References

[1] Mineo Oyama. Effects of different forearm and wrist positions on the muscle activities in extensor muscles of the forearm (in Japanese). *The journal of Japanese association of occupational therapist*, 23(suppl):622, 2004.

[2] Kenichi Sugawara, Takamasa Tsurumi, Tatsuya Kasai. Effects of Forearm Position Changes and Teeth Clenching on Motor Evoked Potentials (MEPs) in Forearm Muscles. *Journal of the Japanese physical therapy Association*, 27:48-56, 2000.