

EFFECTS OF DIRECT CURRENT ON MOTONEURON REFLEX EXCITABILITY (ASSESSED BY H-REFLEX AMPLITUDE) IN HEALTHY SUBJECTS

G. Olyaei., M. Akbari and F. Esfandiarpour

Post Graduate Department, Rehabilitation Faculty, Tehran University of Medical Sciences, Tehran, Iran

Abstract - The purpose of this study was to investigate the effect of direct current on motoneuron reflex excitability. Thirty six subjects (18 males, 18 females) 19-36 years of age ($x = 24.06$, $SD = 3.63$) participated in this study. The reflex excitability of soleus motoneurons was assessed by measuring the amount of change in the peak to peak amplitude of the H-reflex before and after direct current was applied to the skin over the sural nerve. Reflex recordings were taken before and after direct current was applied. Direct current was administered for 5 minutes at an intensity no greater than 4 mA. A complete randomized block with one sample in each block was used. Paired t-test with Scheffe correction for multiple comparisons were used.

A significant increase in H-reflex amplitude was demonstrated for all post baseline measurements when compared to baseline. These results suggest that direct current has a facilitatory effect on motoneuron reflex excitability. In addition, motoneuron reflex excitability remained increased for 10 minutes after stimulus had been turned off.

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INTRODUCTION

Electrical current that flows in one direction for about 1 second or longer can be defined as direct current (DC). Physiological effects and therapeutic uses of DC includes: sensory stimulation, hyperaemia, relief of pain, acceleration of healing, tissue destruction and electrophoresis (1).

Electrical stimulation with DC is one of the oldest therapeutic modalities available to physical therapists. In two recent studies Agostinucci (1992) and Agostinucci, (1992) report that DC can increase H-reflexes amplitudes (2,3).

The H-reflex has been generally considered to be a reliable measure of the excitability of the α motoneuron (4).

The purpose of the present study was to clarify the effects of DC on the soleus H-reflex amplitude in healthy subjects. Based on previous studies it was

postulated that electrical stimulation by DC would exert a facilitatory effect on the amplitude of the soleus H-reflex.

MATERIALS AND METHODS

Subjects

Thirty six healthy subjects (18 male, 18 female) with a mean age of 24.06 years ($SD=3.63$) participated in this study. Participants were recruited from students of the school of Rehabilitation Sciences, Iran university of Medical Sciences. All subjects were asked to refrain from ingestion of caffeine and alcohol for 12 hours prior to the study because these substances could alter motoneuron excitability. The subjects gave their informed consent before participating in the investigation. Four healthy subjects (1 male and 3 females) took part in the sham experiment.

Instrumentation

A Medelec 92a electromyograph was used for all nerve stimulation and reflex recording. The recording electrodes were two EMG silver-plated ep electrode (9 mm) coated with a conductive gel. The stimulating electrodes were two rubber electrodes (3.5×4.5 cm) specialized for the TENS unit.

The skin temperature over the soleus muscle was monitored throughout each experimental session using a skin feedback thermometer (Barvo model). An electrical stimulation unit (Dynatron 438 Enraf) was used as DC source. Stimulating electrodes to CD application were two rubber electrodes (4×6 cm).

Electrical stimulation

DC was applied to the skin over the sural nerve. DC was administered for 5 minutes at an intensity no longer than 4 mA. The anode was placed on the skin of the lateral ankle just inferior to the lateral malleolus. The cathode was placed over the posterior middle calf proximal to the recording electrode.

Reflex testing

Subjects were positioned prone on the table with knee at

20-30° flexion and ankle joint was in plantar flexion (10-15).

The skin overlying the soleus muscle and the popliteal fossa were cleaned with isopropyl alcohol in preparation for placement of electrodes. The H reflex and M response of the soleus muscle were elicited according to the classic protocol of Hugon (5-11). The recording electrodes were placed 3cm apart on the skin overlying the soleus muscle inferior to the belly of gastrocnemius muscle in alignment with the Achilles tendon. The ground electrode which consisted of a silver plate cup electrode (9 mm) was placed on the lateral edge of the leg between the stimulation point and the recording site to minimize the stimulus artifact.

In order to stimulate the tibial nerve, the anode electrode was placed on the quadriceps muscle above the patella. In the popliteal fossa a 0.5 millisecond stimulation was applied to the skin over the tibial nerve and proper cathode positioning was determined when (1) the direct motor response (M Wave) and H-reflex displayed similar wave configurations (2). The H-reflex was evoked before the M Wave (5).

The stimulating intensity was increased until respectively a maximal H-reflex and M response were observed and average of 3 H-reflex and M responses were recorded. Then the intensity was decreased until 50% of the maximal H-reflex ($H_{max}/2$) was obtained. At this stimulating intensity ten H-reflexes with 10 seconds interval recorded and averaged for each subject before application of DC to obtain a baseline value (T0). H-reflexes were also recorded at 1 (T1) and 10 (T10) minutes after DC application. During the experiment if the M-wave amplitude or shape changed, the data were not used in the analysis. At the end of experimental session, the maximal M response and H-reflexes were recorded.

Data analysis

Paired t-tests were used for comparison of mean skin temperature, H_{max} and M_{max} amplitude before and after use of DC in subjects. A complete randomized block with one sample in each block was used to analyze the H-reflex baseline (T0)

measurements and the measurements after electrical stimulation (T1, T10). Paired t-test with Scheffe correction for multiple comparisons were used when significant P value obtained.

RESULTS

A significant increase in H-reflex amplitude was demonstrated for all post baseline measurement (T1 and T10) when compared to baseline ($P < 0.0001$) and the difference of mean H-reflexes in the two post baseline measurement were not significant ($P > 0.05$) (Figure 1 and 2, Table 1).

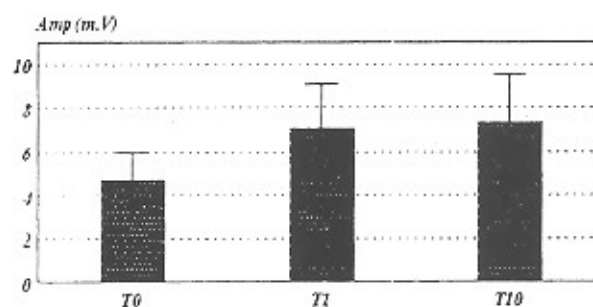


Fig. 1. Comparison between the mean amplitudes of H-Reflex at three different times (T0,T1,T10).

The differences between mean of H_{max} and M_{max} amplitudes and skin temperature at the beginning and end of experimental session was not significant ($P > 0.05$).

The sham group demonstrated no significant differences between measurements recorded after 5 minutes compared to baseline ($P > 0.05$).

Table 1. The results of skin temperature, soleus H_{max} amplitude, M_{max} amplitude, $1/2 H_{max}$ amplitude and H_{max}/M_{max} ratio before and after application of DC

Variable	Before DC		After DC		P value
	Mean	SD	Mean	SD	
Skin temp	33.07	0.67	33.07	0.73	0.94
H_{max} ampl	8.99	2.29	9.15	2.33	0.06
M_{max} ampl	15.89	3.91	15.98	3.88	0.16
$1/2 H_{max}$	4.70	1.30	7.10	1.95	0.0001
H_{max}/M_{max}	0.58	0.15	0.59	0.15	0.17

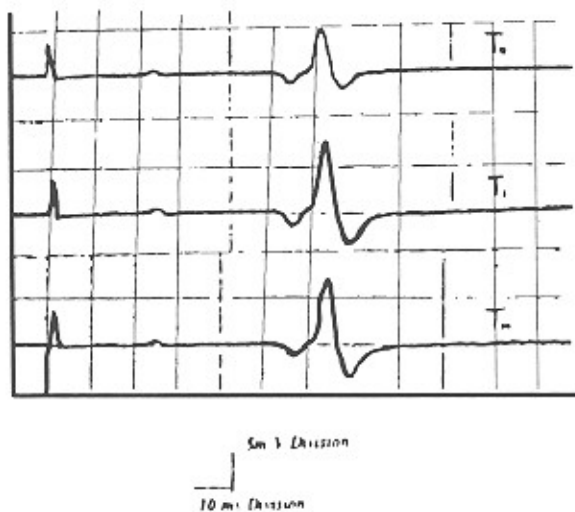


Fig. 2. Soleus H-Reflexes before application of DC (T0) after 1 min (T1) and 10 min (T10) application of DC

DISCUSSION

The principal finding of this study was significant increase in H-reflex amplitudes after application of DC on the skin over the sural nerve. This finding confirms earlier reports (2,3). The increase in H-reflex amplitudes was clearly observed in all subjects. It may be interpreted as an increase in alpha motoneurons excitability of the soleus muscle motoneurons pool.

Animal studies have shown that α motoneurons (Hagbarth 1952) and the γ motoneurons (Eldred and Hagbarth 1954) are affected by skin stimulation (4-6). These results are also demonstrated in man using noxious stimuli to the skin (Hagbarth and Finer, 1963) (2-6). Hugon (1973) described that spinal reflexes such as the H-reflex may be facilitated by low threshold shocks delivered to the human cutaneous nerves which supply the skin overlying the muscle group (4). Modulation of the motoneuron pool excitability by cutaneous receptors, may not be homogenous to a particular group of receptors (4).

Continuous DC by itself will not elicit contractions from normally innervated or denervated musculature (7). Continuous or noninterrupted wave forms are generally transmitted by means of the small, unmyelinated C fibers (7). These fibers transmit noxious stimuli. According to Hagbarth's findings noxious stimulation of the skin over a particular muscle, facilitated the motoneurons of that muscle. In this study DC was applied on the skin overlying the sural nerve which overlies the soleus muscle as well. This resulted in facilitation of the soleus extensor muscle.

The basis of the facilitation and re-education treatment programs, in healthy individuals as well as in orthopedically or neurologically involved patients, is the

bombardment of the CNS with sensory information. It is hypothesized that sensory stimulation increases awareness of the involved extremity and may promote improved function (8, 9).

Although neurophysiologic mechanisms that control alpha motoneuron excitability are not well understood, alpha cell excitability is thought to be an integrated summation of all impinging stimuli. Suprasegmental as well as segmental input mechanisms are probably involved in this modulation. Skin stimulation is presumably brought about by way of the descending pyramidal system and descending tonic reflex pathways originating within the brainstem (10). In animals, it has been shown that pyramidal tract systems exert an inhibitory effect on polysynaptic flexion reflexes and an excitatory effect on polysynaptic extension reflexes (Clark 1966). In these animal studies, it was postulated that increased pyramidal discharge was brought about by an increase in the level of activation somewhere in the reticular formation (2-10).

The results of this study demonstrated that electrical stimulation with direct current can increase H-reflex amplitude. This increase was interpreted as increase in motoneuron excitability.

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