SOLEUS SPASTICITY REDUCTION BY REPEATED BURST STIMULATION TO SUPERFICIAL PERONEAL NERVE

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ABSTRACT
The soleus spasticity reduction effect of the repeated burst stimulation to the superficial peroneal nerve has been evaluated through the pilot experiments with nine able-bodied subjects and the clinical experiment with a hemiplegic person. The soleus inhibitory effect was quantified at the repetition interval 0.25, 0.5, 1.4 and 3.3s. The constant depression effect (25 to 29 percent of the soleus activity was depressed after the stimulation for about 40ms) was observed. The SP stimulation at 10 bursts per second repetition rate showed the obvious depression of the clonus in a hemiplegic subject clinically.

INTRODUCTION
Spasticity reduction has been known as one of the effects of electrical stimulation. The spasticity in the soleus is often a serious obstacle for walking, and known to be reduced by an electrical stimulation to the common peroneal (CP) nerve. Capaday demonstrated the soleus inhibition which lasts several 10 ms by CP stimulation [1]. Zehr showed that the same inhibition is obtained by the superficial peroneal (SP) nerve stimulation during the stance phase, even in hemiplegic persons [2]. It can be hypothesized that the soleus activity can be depressed continuously by repeating the stimulation. The expected advantage of SP stimulation is a muscle-fatigue-free spasticity reduction because SP nerve is a branch that has almost no muscle activation effect.

This study was conducted to clarify the effect of the repeated burst stimulation to SP nerve for the soleus spasticity reduction through the experiments with able-bodied subjects and a hemiplegic person.

METHODS
The stimulus burst consists of five pulses with 1 ms duration and 4 ms interval was repeated at various repeating rates. The two electrodes were placed on the foot back along the SP nerve as shown in figure 1. The stimulus amplitude was set to the 2.5 times of the radiating threshold which is the same as the previous study [2].

(ABLE-BODIED SUBJECTS)
In order to depress the soleus activity continuously, the inhibitory effect induced by the burst stimulation must not be decreased while the stimulation is repeated at shorter repetition interval. The soleus activity inhibitory effect caused by the SP nerve stimulation was quantified in 9 able-bodied subjects aged from 19 to 24 years old. Burst pulse train was applied while the subject maintain the soleus activity at 30%MVC in upright posture. The ensemble average of 30 measurements was calculated. The repetition intervals were 0.25, 0.5, 1.4 and 3.3s.

(HEMIPLEGIC PERSON)
The electrical stimulation same as the stimulation used in the normal subjects was applied to a spastic, male, 47 years old, left hemiplegic person due to cerebral infarction, five months after the accident. The stimulus intensity was also set to 2.5 times of the radiating threshold by the same protocol as the able-bodied subjects because the sensation at the left leg was maintained.

The inhibitory effect was quantified at first, but at only 0.25, 1.4 s interval. The strength of the spasticity with/without SP stimulation was evaluated by three physical therapists independently. The therapists manually moved the ankle joint in sinusoidal pattern. The velocity threshold for the clonus was evaluated by increasing the velocity gradually.

RESULTS
(ABLE-BODIED SUBJECTS)
The rectified electromyogram of the soleus is shown in figure 2. The activity was normalized by the 30ms average activity before the stimulation. The inhibitory effect which last about 45 ms can be observed as already reported [1]. The average inhibitory effect was between 25 and 29 percent and was independent from the repetitive interval as shown in figure 3. The continuous inhibition of the soleus by repeating the bursts at higher rate can be expected.

(HEMIPLEGIC PERSON)
The same form of the inhibition was observed in the hemiplegic subject as shown in figure 4. The evaluations of the physical therapists were that the depression of the clonus was obvious.

CONCLUSIONS
It was clinically demonstrated the SP nerve stimulation with repeated burst pulse train reduce the soleus spasticity. The quantitative evaluation of the spasticity reduction effect and the evaluation of the phase dependency during walking are to be performed.

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REFERENCES
Figure 1. Electrodes placement.

Soleus EMG with SP stim (average of 30 trials, 100LPFed)

- Latency: 45.6 ms
- Duration: 44.4 ms
- Average: 80.9%
- Integral: 849% ms
Figure 2. Soleus inhibition by SP stimulation. (able-bodied)

Figure 3. Soleus activity inhibited by SP stimulation.
Figure 4  Soleus inhibition by SP stimulation. (hemiplegic).