The motor cortex contributes to contractions that persist after peripheral nerve stimulation and tendon vibration

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Background

Human motoneurons often continue to discharge after being activated by a brief excitatory synaptic input (self-sustained firing; SSF). SSF can be initiated by electrical stimulation over peripheral nerve, voluntary contractions or vibration on the muscle tendon. During SSF participants are unaware of the residual contraction of their muscle. SSF is thought to be driven by "turning-on" motoneurons in the spinal cord, through the activation of persistent inward currents. Whether signals from the motor cortex contribute has not been investigated adequately.

Subthreshold transcranial magnetic stimulation (TMS) is a technique that has been used to explore the contribution from the motor cortex to muscle contractions. Delivering 100 TMS pulses below active motor threshold (i.e. subthreshold TMS) suppressed ongoing voluntary electromyographic (EMG) activity (Davey et al., 1994). The suppression was due to reduction of the corticospinal output (Davey et al., 1994) by activating intracortical GABAergic interneurons (Classen & Benecke, 1995) via fast-conducting corticospinal axons (Butler et al., 2007). Presently, we used subthreshold TMS to explore the origins of SSF.

Purpose

Determine whether the motor cortex contributes to SSF of human motoneurons.

Hypotheses

Output from the motor cortex contributes to SSF of human motoneurons but less than during voluntary contractions.

Prediction

EMG will be suppressed during SSF at subthreshold AMT but less than during a voluntary contraction.

Methods

To induce SSF: Simultaneously applied neuromuscular electrical stimulation (NMES; 1ms pulse width; 10-100Hz) over right tibial nerve and vibration (50Hz) over right Achilles' tendon.

To measure cortical excitability: Subthreshold TMS (figure-eight coil; ~73% active motor threshold) for right soleus muscle.

Recordings:
Surface EMG from the right triceps surae muscles
Torque generated around the ankle joint was measured using a Biodex system

No feedback of SSF was provided to the participants during the experiment.

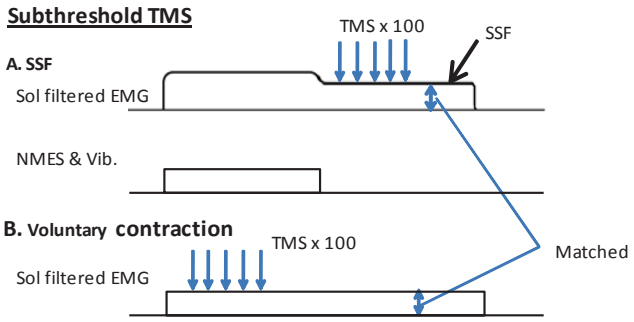

Figure 1. Experimental protocol.

Data Analysis

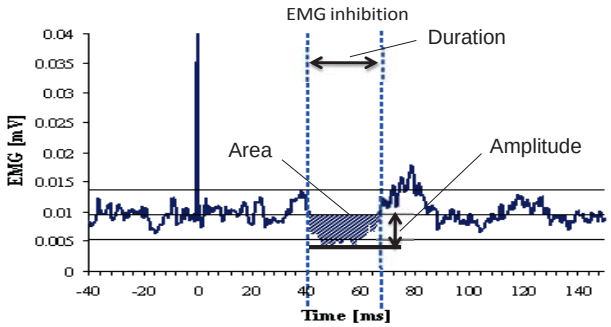

Figure 2. Data analysis method.

Results

The EMG activity during SSF and voluntary contraction were suppressed by subthreshold TMS.

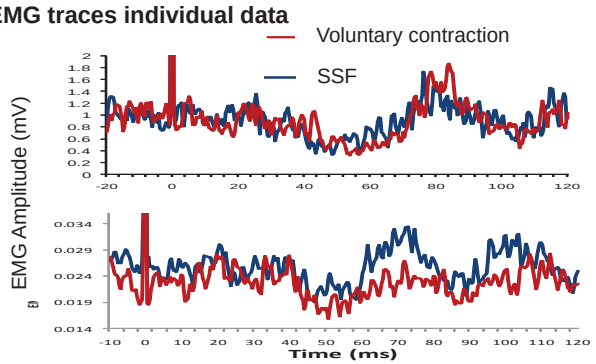

Figure 3. Individual EMG trace (n = 2) during SSF and voluntary contraction .

When background contraction was matched between SSF and voluntary contraction, amplitude and duration of suppression were not different; however, the area of suppression was larger during voluntary contraction.

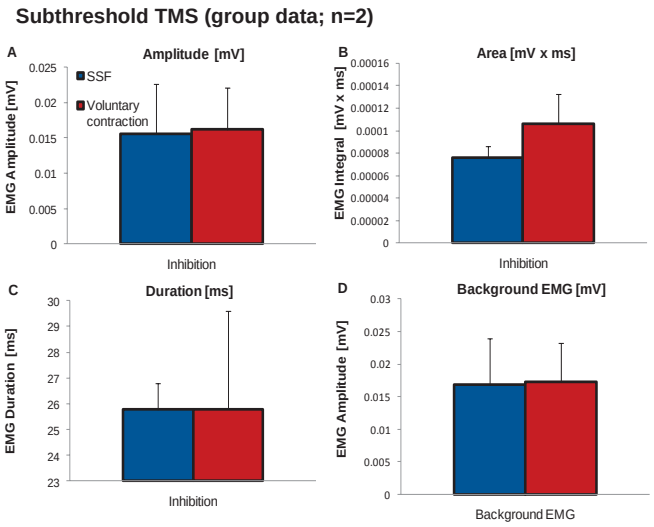

Figure 4. Group data (n=2) showing quantified inhibition caused by subthreshold TMS during SSF and voluntary contraction.

Conclusions

1. Inhibition was present in both SSF and voluntary contraction.
2. The area of the inhibition was larger during a voluntary contraction than SSF.

Previously, it was thought that SSF was due to mechanisms within the spinal cord such as the activation of persistent inward currents in motoneurons. Here we have shown that output from the motor cortex contributes to SSF, but less than during a voluntary contraction.

These results show that afferent inputs can turn on cells in the motor cortex and contribute to SSF. SSF probably arises from spinal and cortical mechanisms.

References

Butler et al. (2007).*J Physiol.,584.2;651-659*
Classen & Benecke*(1995).Electroencephalogr.Clin.Neurophysiol.,97: 264-274*
Davey et al. (1994).*J Physiol.,477:223-235.*