SJSU SAN JOSÉ STATE UNIVERSITY

SJSU Undergraduate Research Grants

Development of an Optogenetic Method to Stimulate Gamma Motor Neurons

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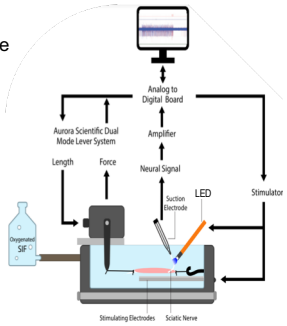
Abstract

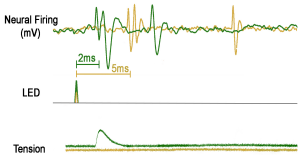
- Muscle spindles are proprioceptors that are innervated by muscle spindle afferents (MSA). These afferents are stretch sensitive neurons that report changes in muscle length. The muscle spindle also contain gamma motor neurons.
- Gamma motor neurons are important for proprioception and motor control as they control the length of the intrafusal muscle fibers and therefore the sensitivity of the muscle spindle afferents (MSA).
- We developed an optogenetics technique to preferentially stimulate gamma motor neurons.
- We confirmed that stimulations at low optical intensity recruit the more slowly conducting gamma motor neurons while higher optical intensities recruit the faster conducting alpha motor neurons as seen by the presence of a twitch contraction.

Methods

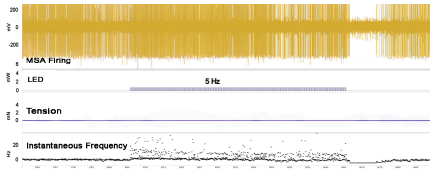
- The *in vitro* muscle preparation in interstitial fluid bath connected to the force and length transducer and controller.
- Pulled glass electrode placed on sciatic nerve to record MSA firing.
- LED m89L01 light guide (Thorlabs; 454nm) is fired on the end of the sciatic nerve coming out of the muscle.



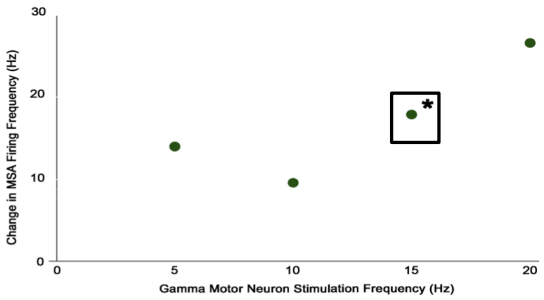
1. Latency of evoked compound action potential decreases as optical intensity increases



2. Stretch-like response of MSAs in the absence of muscle length change seen in response to gamma motor neuron stimulation



3. The MSA firing frequency increases with increasing frequency of gamma motor neuron stimulation



* Indicates firing rate during physiological stretch

Conclusions

- The lowest optical intensity stimulations recruit the more slowly conducting gamma motor neurons. Higher optical intensities recruit the shorter latency alpha motor neurons as evidenced by the presence of twitch contraction.
- Increasing frequency of optical stimulations causes a greater change in intrafusal fiber length as evidence by increased MSA firing rates.
- Gamma motor neuron stimulation leads to the expected increase in MSA firing rate and the characteristic pause after stretch. Our stimulations can cause the equivalent change in MSA firing as physiological stretch.

Future Studies

- Use this tool to study the effect of different patterns and frequency of gamma motor neuron activation on muscle spindle afferent firing.
- Use this technique to screen for changes in gamma motor neuron and/or intrafusal fiber dysfunction in neuromuscular diseases or following drug addition.
- Modify the stimulation technique to use *in vivo* to study gamma motor neuron function during motor movements.