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# K<sup>+</sup> -induced force potentiation.

Jean-François Couvrette

Jean-Marc Renaud (Supervisor)

Department of Cellular and Molecular Medicine,



uOttawa

## INTRODUCTION

It is well known that twitch force increases following a tetanic contraction, a phenomenon known as post-tetanic twitch potentiation. Post-tetanic twitch potentiation is observed in fast twitch muscle such as the EDL, but not in slow twitch muscle like the soleus. Twitch force is also potentiated when the extracellular [K<sup>+</sup>] ([K<sup>+</sup>]<sub>e</sub>) is increased up to 12 mM at 37°C (5). Contrary to post-tetanic twitch potentiation, K<sup>+</sup>-induced twitch potentiation is observed in both EDL and soleus muscles.

A twitch contraction is, however, not physiological. Normally, soleus muscles are *in situ* stimulated at frequencies between 10 and 40 Hz while EDL muscles are stimulated at 90-110 Hz.

## OBJECTIVE

The objective was to determine whether the K<sup>+</sup>-induced twitch potentiation is also observed at frequencies at which EDL and soleus are normally stimulated.

## METHODS

**SOLUTIONS.** Control saline solution contained (in mM): 118.5 NaCl, 4.7 KCl, 2.4 CaCl<sub>2</sub>, 3.1 MgCl<sub>2</sub>, 25 NaHCO<sub>3</sub>, 2 NaH<sub>2</sub>PO<sub>4</sub>; 5.5 D-glucose, 95% O<sub>2</sub>; 5% CO<sub>2</sub>, pH 7.4. Solutions containing 9 mM K<sup>+</sup> were prepared by adding the proper amount of KCl. **Experimental temperature was 37°C.**

**STIMULATION.** Twitch contractions were elicited with 0.3 ms, 6 volt square pulses. Tetanic contractions were elicited every 100 s with 400 ms train of pulses at frequencies varying from 10 to 200 Hz.

**PROTOCOL.** Twitch or tetanic contractions were elicited every 100 sec throughout an experiment. Tetanic contractions were elicited only when force-frequency curves were measured; at all other times twitch contractions were elicited to minimize muscle deterioration over time.

**Effects of 9 mM K<sup>+</sup>.** Force-velocity curves were first measured while EDL and soleus were exposed to 4.7 mM K<sup>+</sup> and then after 1 and 2 hours at either 4.7 or 9 mM K<sup>+</sup>. Different muscles were used for each [K<sup>+</sup>]<sub>e</sub>.

## CONCLUSION

The results showed that the K<sup>+</sup>-induced force potentiation is not limited to the twitch contraction. It is in fact observed at frequencies seen by EDL and soleus *in situ*. Interestingly, the potentiation in soleus was limited to 10-30 Hz while for the EDL it was observed up to 110 Hz, which are the physiological ranges of stimulation frequencies for each of the two muscles.

Considering that a moderate biking exercise can increase interstitial K<sup>+</sup> concentration to 12-14 mM within 5 min, these results suggest that such increases may actually improve muscle performance at the onset of exercise.

FIGURE 1

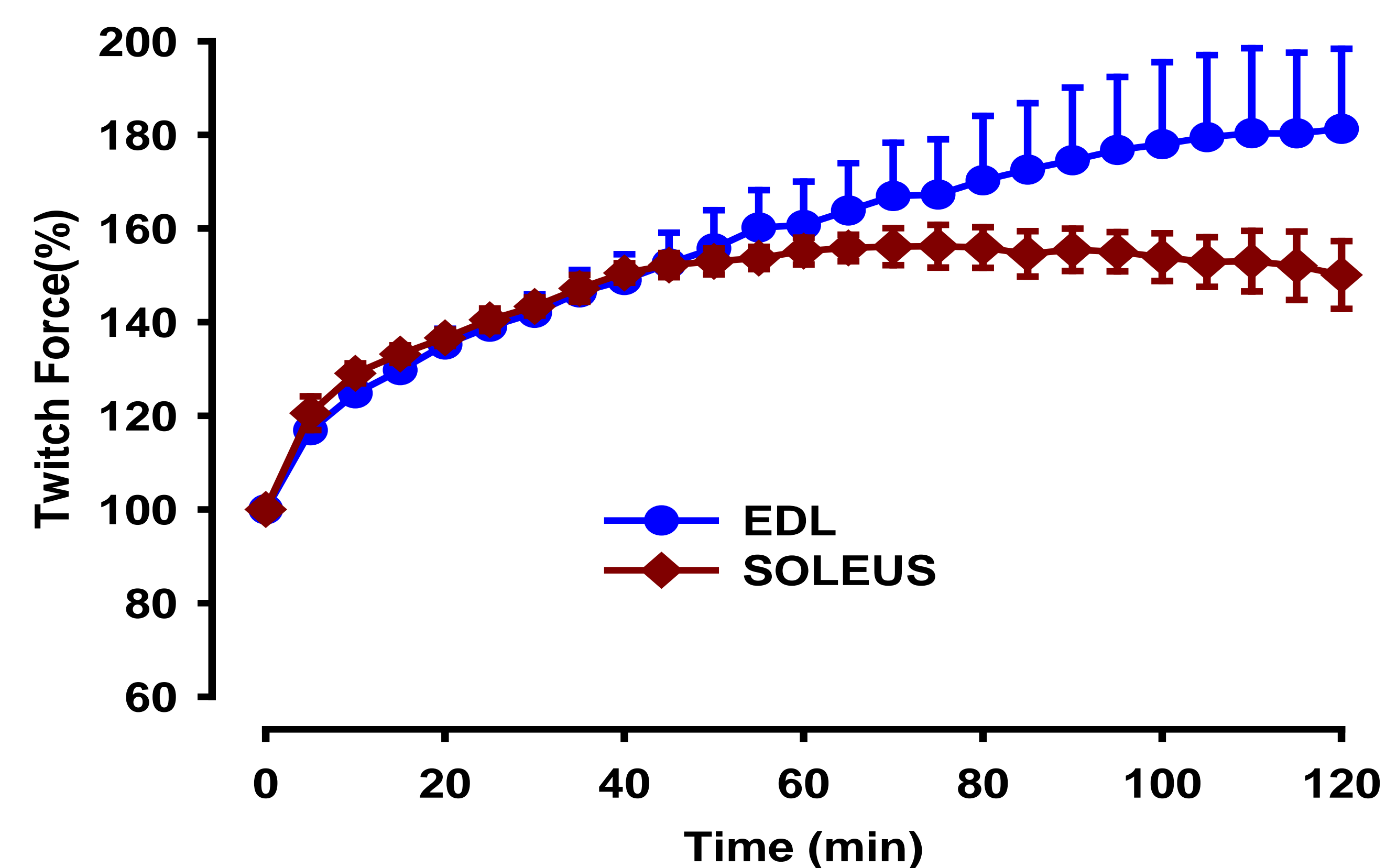


Figure 1. Time course of the K<sup>+</sup>-twitch potentiation. Muscles were first incubated at 4.7 mM K<sup>+</sup> before it was increased to 9 mM K<sup>+</sup> at time 0 min. Peak twitch force is expressed as a percent of the force at time 0 min. Peak twitch force reached a new steady state after one hour in soleus and 2 hrs in EDL. Vertical bars represent the S.E. of 3 muscles.

FIGURE 2

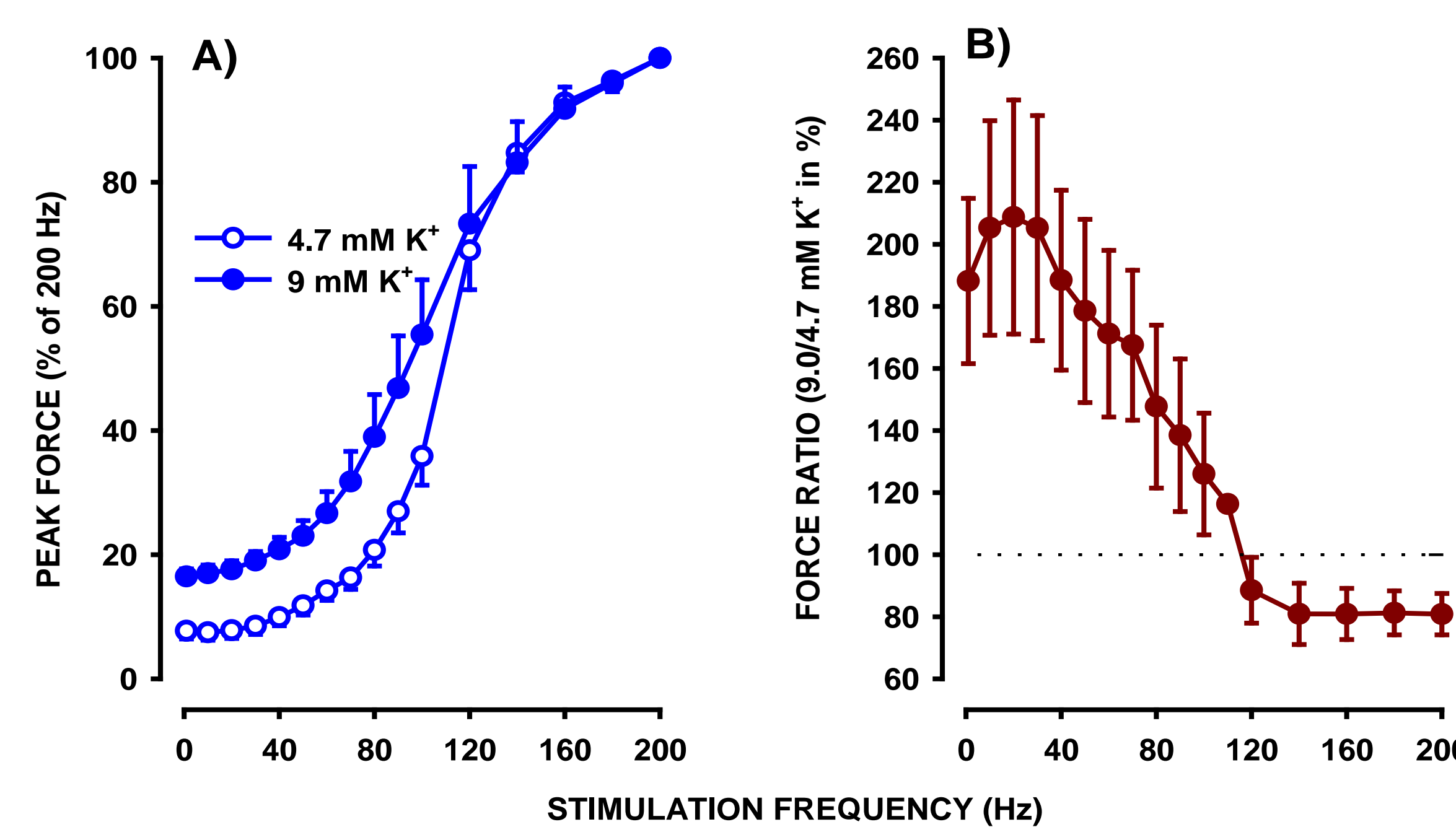


Figure 2. In EDL, K<sup>+</sup>-induced force potentiation is observed at stimulation frequency from 1 to 110 Hz. A) Force-frequency curves were first measured at 4.7 mM K<sup>+</sup> and then at 9 mM K<sup>+</sup>. Peak force at each frequency is expressed as a percent of the force at 200 Hz for each of the two K<sup>+</sup> concentration. B) For each stimulation frequency, the peak force at 9 mM K<sup>+</sup> is expressed as a percent of the force at 4.7 mM K<sup>+</sup>. Vertical bars represent the S.E. of 3 muscles.

FIGURE 3

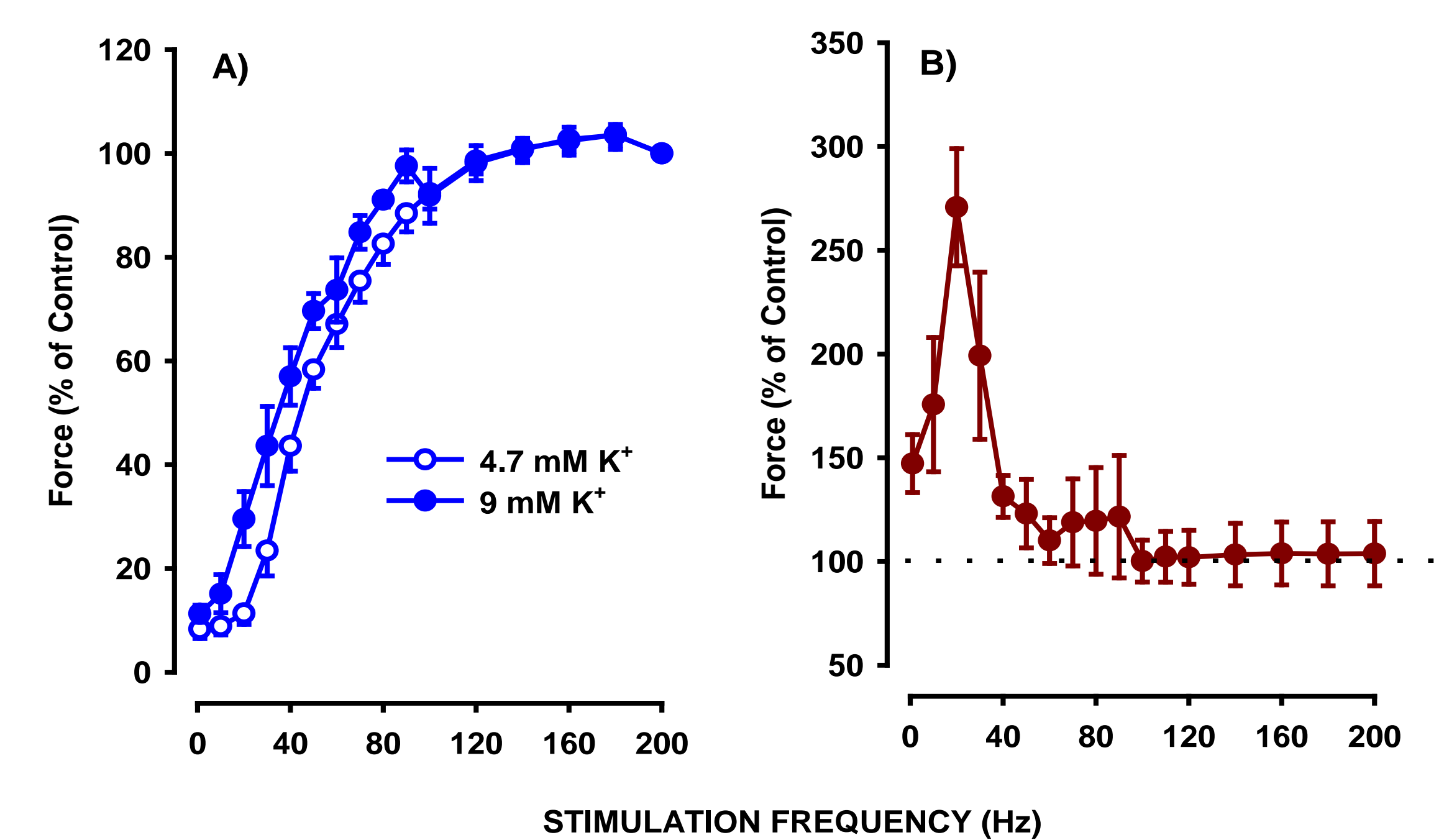


Figure 3. In soleus, K<sup>+</sup>-induced force potentiation is observed at stimulation frequency from 1 to 30 Hz. A) Force-frequency curves were first measured at 4.7 mM K<sup>+</sup> and then at 9 mM K<sup>+</sup>. Peak force at each frequency is expressed as a percent of the force at 200 Hz for each of the two K<sup>+</sup> concentration. B) For each stimulation frequency, the peak force at 9 mM K<sup>+</sup> is expressed as a percent of the force at 4.7 mM K<sup>+</sup>. Vertical bars represent the S.E. of 3 muscles.

## REFERENCES

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