# **SUPPLEMENTARY FILE 1**

**Effect of tendon vibration on motor unit firing and force production**

The magnitude of skeletal muscle force production is proportional to the neural drive received from both voluntary (efferent) and sensory (afferent) inputs to the muscle’s motoneurons (i.e. to the “motoneuron pool”)(1). Thus, manipulation of sensory inputs should influence muscle force production capacity. Even when imposed at small amplitudes of 0.2 – 0.5 mm, local muscle or tendon vibration strongly activates the faciliatory Ia afferents (velocity-dependent stretch reflex primary endings)(2), encouraging them to discharge rapidly (~80 Hz but with inter-ending variability of 30 – 180 Hz)(2, 3) without strong activation of potentially-inhibitory II (length-dependent stretch reflex secondary endings (2) or Golgi (Ib) afferents (3). These signals strongly activate supraspinal centers (4) and also affect spinal centers leading to an enhanced reflexive facilitatory drive onto the motoneurons. As a result, brief bursts of tendon vibration tend to reduce MU recruitment thresholds, increase the number of active units (5) and thus increase muscle force in low-to-moderate force contractions (6), although high- and maximal force contractions are not strongly affected (6, 7). It may also partially overcome the loss of muscle force production resulting from fatiguing muscle contractions (6), making it a potentially useful intervention during highly fatiguing NMES muscle contractions. Thus, brief application of tendon, or muscle, vibration might be expected to prove beneficial to NMES-evoked muscle forces.

Its potential may be enhanced by the fact that tendon vibration recruits MUs according to the size principle, with fatigue-resistant lower-threshold units being engaged before more fatigable higher-order units (8), and this might be expected to partly circumvent issues around the rapid fatigue of NMES-activated muscles during which random MU recruitment and phase-locked (synchronous) MU activity is thought to induce rapid fatigue. Furthermore, vibration alone can trigger the development of persistent inward (probably calcium) currents (PICs) at motoneuron dendrites (9). PIC activation can enhance motoneuron excitability and thus reduce recruitment thresholds and increase maximum possible firing rates (10). When sufficiently strong, PICs also allow motoneurons to continue to fire even when descending drive is reduced below that which was required to initiate their firing (firing rate hysteresis). When triggered by vibration during repeated bursts of NMES, muscular force remains above zero and the total impulse provided by the muscle, and thus the stimulus for muscular adaptation, becomes greater than from NMES alone (11), at least when relatively few contractions are performed. Alternatively, force production is also augmented when bursts of vibration (2 s, 100 Hz) are imposed over ongoing NMES (20 Hz)(12). Thus, the possibility exists that tendon vibration during NMES may directly enhance motoneuron excitability, and thus increase the total impulse produced during a set of NMES contractions.

Nonetheless, even relatively brief bouts of tendon vibration imposed during maximal voluntary contractions has been found to reduce maximal force in non-fatigued muscles (13) or to have only a very brief beneficial effect on motor unit firing at onset of vibration in fatigued muscle, followed by a rapid fatigue (6). These results may be explained by reductions in spindle activity leading to reduced Ia discharge rates (6), reflex amplitudes (14) and motoneuron excitability (15), and thus reduced afferent facilitation. Additionally, time to fatigue may also be negatively impacted (e.g. static load holding ~5 min to failure)(16), or at least not improved (e.g. isometric contraction against immovable resistance)(17), when vibration is applied during submaximal isometric tasks. Thus, vibration of the duration required to complete a series of muscle contractions (e.g. 30 - 180 s) may not provide a meaningful benefit, or may speculatively reduce voluntary muscle force production.

The main question from the point of view of the present brief review, therefore, is whether the addition of tendon vibration maintained through a series of relatively low force, NMES-evoked contractions has a detectible effect on either force production or fatigue accumulation, and thus the total impulse and metabolic work done by the muscle.

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