Length Dependence of Muscle Inhibition in the Elbow Flexors
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Introduction
The inability to fully activate a muscle during a maximal voluntary contraction, referred to as muscle inhibition (MI), is prevalent in patients with joint pathologies (Young, 1993), but also in healthy subjects (Dowling et al., 1994, Suter and Herzog, 1997). Muscle inhibition is typically evaluated using the twitch interpolation technique (Allen et al., 1998), which requires application of an electrical twitch to the muscle or its motor nerve during a maximal voluntary contraction. In case of submaximal motor unit activation, the superimposed twitch will evoke an additional force, from which MI can be estimated (Allen et al., 1998, Dowling et al., 1994).

Using this technique, MI in the knee extensors has been found to increase with increasing maximal voluntary force as a function of knee angle (Suter and Herzog, 1997). We speculated that the increased MI may be directly related to the isometric force through inhibition of the Golgi tendon organ pathways. If this speculation was correct, and constituted a general mechanism, the same relationship between MI and isometric force (as a function of muscle length) would have to be observed in other muscle groups. The purpose of this study was to determine inhibition in the human elbow flexors at different muscle lengths. Specifically, we tested the hypothesis that increasing isometric muscle forces were associated with increasing MI, thereby lending support to the idea that Golgi tendon pathways were partly responsible for the observed length dependence of muscle inhibition.

Methods
Elbow flexor forces, electromyographic (EMG) activity of biceps and triceps brachii, and MI were measured in a convenience sample of 33 healthy subjects (mean age: 28.7 ± 5.0 yrs). Subjects gave informed consent to participate in the study, which was approved by the conjoint Ethics Committee at the University of Calgary. Isometric elbow flexor strength was measured using a custom-built upper extremity dynamometer. Bipolar surface EMG (Biovision) was obtained from biceps and triceps brachialis. Electrical twitches (doublets of 0.8 ms duration and 8 ms inter-pulse interval) were applied to the motor point of the biceps brachii using a Grass S88 stimulator (Quincy, MA, USA). Subjects performed isometric elbow flexor contractions at five elbow angles from 30° to 120°. A superimposed twitch was given approximately 2s after the maximal force was reached. In order to estimate percent muscle inhibition, the interpolated twitch moment was normalized to the moment produced when an identical twitch was given to the relaxed muscle. Forces and EMGs were normalized across angles to the peak values for each subject. Values were calculated as median and SD. The level of significance was α=0.05.

Results
Muscle inhibition was the same across all angles tested, with median values ranging from 2.8-6.9%. Isometric forces were greatest at the 70° angle, and never fell below 70% of the peak force at any of the tested angles. Normalized biceps EMGs were similar for all elbow angles (75-83%).

Discussion
Although the twitch interpolation technique has found wide application, angle dependency of MI has not been systematically investigated. A previous study on the knee extensors revealed that MI changes as a function of knee angle, and therefore, as a function of muscle length and force (Suter and Herzog, 1997). This finding could not be confirmed for the biceps brachii, as MI was the same across all angles tested. Force-dependent modulation of MI may not have occurred in the elbow flexors because maximal isometric force remained relatively close (within 30%) of the peak force. In contrast, MI decreased in the knee extensors at the most extended angles, where force had dropped to 50% or less of the maximal knee extensor force. We speculate that human maximal voluntary contractions are not associated with a given
activation. Rather, activation is modulated by force-dependent feedback at force levels below 70% of the absolute peak force, which manifests itself in a change of MI that parallels the level of maximal isometric force in voluntary contractions.

References: