ACTIVE FORCE ENHANCEMENT FOLLOWING STRETCH DURING ISOMETRIC CONTRACTIONS AND SUBSEQUENT CONCENTRIC CONTRACTIONS IN MAXIMAL VOLUNTARY KNEE EXTENSIONS

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INTRODUCTION

Force enhancement following muscle stretch has been widely observed in electrically stimulated muscle [1]. It has also been observed in voluntarily activated human muscle, but only for the adductor pollicis and the ankle joint muscles [2], not for larger muscles such as the quadriceps femoris [3]. Previous *in vivo* studies have been limited to stretch and hold, none have followed this with a controlled concentric contraction. This study aimed to investigate the effect of *in vivo* force enhancement following muscle stetch on the subsequent hold and concentric action for maximum voluntary contractions of the human quadriceps femoris.

METHODS

Seven athletic subjects (22.4 ± 0.6 years; 178 ± 12 cm; 79.8 ± 8.7 kg) gave informed consent. Maximum voluntary knee extensions were conducted on a CON-TREX dynamometer at three velocities (30°s^{-1}, 60°s^{-1} and 100°s^{-1}). The first set of trials were maximum effort eccentric-isometric-concentric (EIC) contractions for six isometric coupling times (CT) (0.07, 0.3, 0.6, 1, 2, 4 s) at each velocity. Initial knee angle was 10° of flexion and subjects were asked to maximally resist forced flexion through a 70° range of motion and to continue pushing maximally throughout the isometric and concentric phases. The second set of trials were maximum effort eccentric-isometric contractions using the same eccentric velocities and isometric angle (held for 4 s) as in the first set. Subjects also performed isolated isometric contractions at the same angle as in the earlier trials. For the dynamic trials, mean torque over consecutive 100 ms time intervals throughout the isometric section was determined and normalised to the isolated isometric value for comparisons across subjects.

RESULTS AND DISCUSSION

Some subjects were unable to perform the required EIC task. They failed to achieve eccentric torque or isometric torque as high as in the pure isometric trial and had inconsistent trends in isometric torque versus time (Figures 1(b) and 1(d)). However, some subjects produced more consistent performances (Figures 1(a) and 1(c)) which were very similar to previous results for the quadriceps [3]. In all cases voluntary torque profiles consistent with *in vitro* tetanic eccentric to isometric profiles could not be obtained. This is consistent with many studies showing the inability of subjects to maximally activate large muscles during eccentric contractions. Pooling results across all subjects (Figure 2(a)) shows a force decrement throughout the isometric hold. Where force enhancement in individuals was found it was small and decayed, roughly exponentially, to isometric levels after 1 s. Looking at individual results across different CT, e.g. subject 6 in Figure 2(b), a small drop in torque at the start of the concentric contraction can be seen that appears to be independent of the torque level at this point.

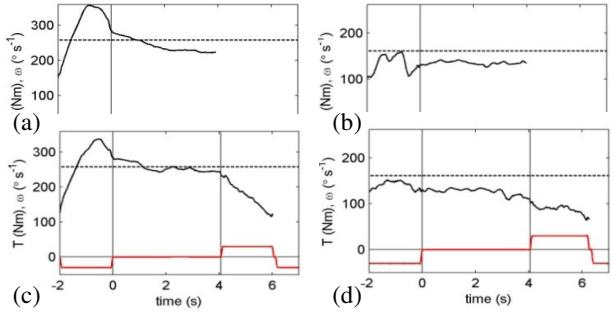

Figure 1. Torque vs. time and velocity vs. time profiles from eccentric-isometric trials and EIC trials: (a) and (c) subject 6 at 30°s^{-1}; (b) and (d) subject 3 at 30°s^{-1}.

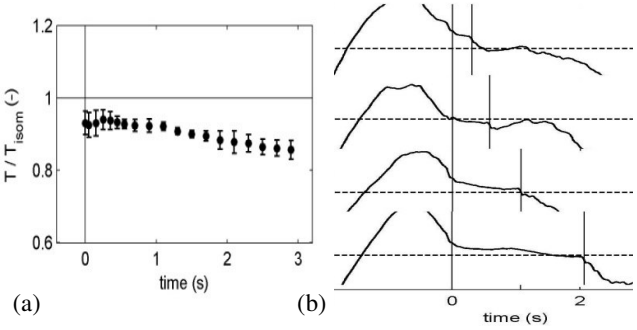

Figure 2. (a) Isometric normalised torque in EIC trials (mean ± SD all subjects and velocities); (b) Torque for subject 6, and CT = 0.3, 0.6, 1 and 2 s. 1st line is isometric onset, 2nd line is concentric onset. Dashed line is isolated isometric torque.

CONCLUSIONS

During experiments involving voluntary maximal eccentric activation, the between subject variability in torque profiles and force enhancement was large. In subjects who showed limited force enhancement the following concentric contraction could start at higher than isometric levels and continue above isometric for a brief period. However, whether this was due to errors in the true isometric level, increased activation at onset of concentric contraction, or some force enhancement not being negated as soon as the contraction starts, has not been determined. The inability to produce maximal activation can be the dominant factor, limiting experimental results that are relevant to investigating fundamental *in vivo* muscle properties.

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REFERENCES

1. Edman KA, et al., *J Physiol.* **281**:139-155, 1978.
2. Lee E-J, & Herzog W, *J Physiol.* **545**:321-330, 2002.
3. Hahn D, et al., *Eur J Appl Physiol.* **100**:701-709, 2007.