

MAXIMAL KNEE EXTENSION STRETCH SHORTEN CYCLES ON AN ISOVELOCITY DYNAMOMETER TO EXAMINE ACTIVE FORCE ENHANCEMENT

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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]. These studies using isolated joint motions, have been limited to stretch and hold they have not followed the hold with a controlled concentric contraction.

In contrast, studies examining the stretch shorten cycle *in vivo* have focussed on compound actions such as countermovement jumps. Investigations of force enhancement within a stretch shorten cycle in a controlled *in vivo* environment, such as used in the studies of paragraph one, would seem a useful intermediary.

This study aimed to measure *in vivo* force enhancement following muscle stretch on the subsequent hold and concentric action for maximum voluntary contractions of the human quadriceps femoris.

METHODS

Seven athletic subjects (5 male, 2 female, age 22.4 ± 0.6 years; height 178 ± 12 cm; weight 79.8 ± 8.7 kg) gave informed consent in accordance with Loughborough University ethical committee. Three sets of maximum voluntary knee extensions were conducted on a CON-TREX dynamometer (CMV AG, Switzerland).

The first set were maximum effort eccentric-isometric-concentric (EIC) contractions. These were conducted for six isometric coupling times (CT) (0.07, 0.3, 0.6, 1, 2, 4 s) and three velocities (30°s^{-1} , 60°s^{-1} and 100°s^{-1}). Initial knee angle was set to 10° of flexion and subjects were asked to maximally resist forced flexion through a 70° range

of motion (to 80° of flexion) and to continue pushing maximally throughout the isometric and concentric phases. The second set were maximum effort eccentric-isometric contractions. These employed the same eccentric velocities and isometric angle (80° of flexion) as in the first set of trials. In all trials the isometric contraction was held for 4 s. Finally, subjects also performed an isolated maximum effort isometric contraction again using a knee angle of 80° of flexion.

For the first two sets of trials, mean torque over consecutive 100 ms time intervals throughout the isometric contraction was determined. These torques were normalised based on the isolated isometric value to enable 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 isolated isometric trial and were inconsistent during the subsequent hold and concentric contractions (Figures 1(b) and 1(d)). However, other subjects produced more consistent performances. Eccentric torque exceeded the isolated isometric value then progressively dropped off during the hold and concentric contractions (Figures 1(a) and 1(c)) as has been reported previously for the quadriceps [3].

Consequently, pooling results to give the group average voluntary torque profile during the isometric hold section of the EIC contractions gave poor agreement with *in vitro* observations and a force decrement throughout the hold phase (Figure 2(a)). This is consistent with many previous studies showing the inability of subjects to maximally activate large muscles during eccentric contractions [4]. Where force enhancement in individuals was found it was small and decayed, roughly exponentially, to isometric levels after 1 s.

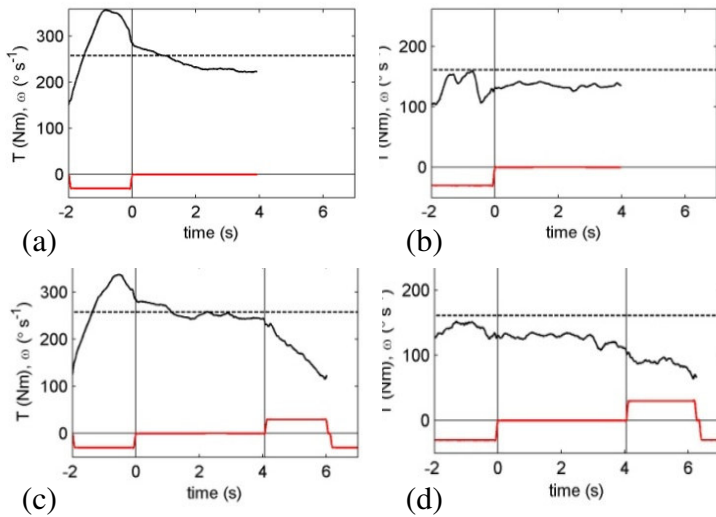


Figure 1. Torque vs. time and velocity vs. time profiles from eccentric-isometric trials and EIC trials: (a) and (c) subject 6 at 30°s^{-1} ; (b) and (d) subject 3 at 30°s^{-1} . Horizontal dashed line is the isolated isometric torque.

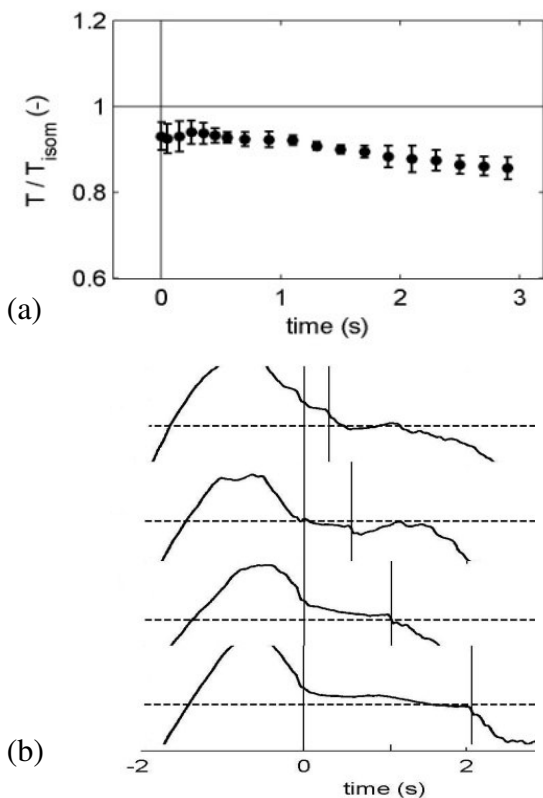


Figure 2. (a) Normalised isometric torque (to isolated isometric value) in EIC trials (mean \pm SD all subjects and velocities); (b) EIC torque for subject 6, and CT = 0.3, 0.6, 1 and 2 s. 1st line is isometric onset, 2nd line is concentric onset. A dashed line is isolated isometric torque.

For those subjects who achieved eccentric torques above the isometric value, a small drop in torque was observed at the start of the concentric contraction that appeared to be independent of the torque level and CT (Figure 2(b)). Also, the concentric contraction could start at a higher torque value than the isolated isometric torque and continue above this level 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.

CONCLUSIONS

During experiments involving voluntary maximal eccentric activation, the between subjects variability in torque profiles and force enhancement was large. Some subjects were unable to reach isometric levels during eccentric contractions, despite being active and regularly participating in sport. Some were also unable to reach isometric torque levels despite an extended time to achieve this during an isometric contraction following stretch.

In subjects who showed limited force enhancement the following concentric contraction could start at higher than the isolated isometric torque and remain above this level for a brief period. However, the reason for this enhanced force is undetermined.

The inability of subjects to produce maximal activation can be a limiting factor in experiments designed to investigate fundamental *in vivo* muscle properties.

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