IN-VIVO MUSCLE BEHAVIOUR DURING STATIC AND DYNAMIC CONTRACTIONS

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Introduction

Although much is known regarding muscle-joint function during isometric and dynamic contractions, little is known regarding the changes to internal muscle structure during these actions. The internal muscle structure, known as muscle architecture is an important determinant of a muscles functional characteristics (1). Recently, it has been possible to study muscle architecture *in vivo* non-invasively at rest and during muscle contraction using ultrasonography . The aim of the present study was to investigate *in vivo* the changes in muscle architecture during static and dynamic contractions.

Methods

Eight subjects (4 males, age: 25 ± 3 years, height 1.75 ± .07 m, body mass: 70 ± 10 kg, means ± SD) performed dorsiflexion contractions using an isokinetic dynamometer. Maximal isometric voluntary contractions were performed at a range of ankle joint angles from 20 deg of dorsiflexion to 30 deg of plantarflexion. Concentric and eccentric contractions were performed at a range of isokinetic angular velocities from 50 to 250 $deg \cdot s^{-1}$. At rest and during contraction, the tibialis anterior muscle architecture was examined *in vivo* in the sagittal plane using ultrasonography. Muscle fascicle lengths and pennation angles (the insertion of the fascicle into the intramuscular tendinous tissue) were measured from the ultrasound scans.

Results

During isometric contractions (averaged across all joint angles tested) muscle fascicles actually shortened by 25%, from 72 ± 2 mm at rest to 54 ± 3 mm during maximal isometric contraction ($P < 0.01$). Also during isometric contractions (averaged across all joint angles tested) pennation angles increased by 45%, from 9.6 ± 0.5 deg at rest to 13.9 ± 0.7 deg during maximal isometric contraction ($P < 0.01$). Both muscle fascicle lengths and pennation angles were dependent upon changes in joint angle. Fascicles were at their longest and pennation angles at their smallest at the longest muscle length ($P < 0.01$). Measured at the same ankle joint angle during concentric muscle actions, the length of muscle fascicles increased curvilinearly from 50 ± 3 mm during isometric contraction to 70 ± 5 mm at 250 $deg \cdot s^{-1}$ ($P < 0.01$). During concentric muscle actions pennation angles measured at a constant joint angle decreased progressively with increasing angular velocity from 14.8 ± 0.8 deg during isometric contraction to 9.8 ± 0.9 deg at 250 $deg \cdot s^{-1}$ ($P < 0.01$). During eccentric muscle actions, the length of muscle fascicles measured at a constant joint angle were not significantly different from those during isometric contraction ($P > 0.05$).

Discussion

The present study has shown in conjunction with previous findings , that “fixed-end” contractions are not “isometric” *in vivo* and that considerable shortening of muscle fascicles occurs in the transition from rest to maximal isometric contraction. The internal shortening occurs due to elongation of the tendinous tissue. The degree of fascicle shortening is dictated by the contractile forces generated and by the stiffness of the tendinous structures. During concentric muscle actions, muscle fascicle lengths increased progressively with increasing angular velocities when measured at a constant joint angle . This behaviour reflects the elongation of tendinous structures by the contractile forces, which declines with increasing angular velocity during concentric contraction. During eccentric muscle actions, fascicles behaved quasi-isometrically and were not affected by changes in angular velocity. The *in vivo* behaviour of muscle fascicles during eccentric muscle actions reflects the relatively constant elongation of tendinous structures caused by the relatively stable force during these contractions. These measurements allow inferences regarding the tendon mechanical properties and provide information of *in vivo* muscle function. Possible applications of this technique might be to study changes with ageing or to monitor rehabilitation following a musculoskeletal injury.

Conclusions

The present study has revealed the changes in muscle architecture occurring *in vivo* during static and dynamic contractions. Muscle fascicle behaviour reflected the elongation applied to tendinous structures by the contractile forces generated during these types of muscle actions. This non-invasive *in vivo* technique has many applications for studying skeletal muscle in health and disease.