PASSIVE MECHANICAL BEHAVIOUR OF MUSCLE FASCICLES AND TENDONS IN HUMAN GASTROCNEMIUS MUSCLE-TENDON UNITS IN VIVO

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SUMMARY
Ultrasound imaging was used to investigate fascicle length changes during passive lengthening of human gastrocnemius muscle-tendon units.

INTRODUCTION
There have been few investigations of the passive mechanical properties of muscles in vivo. It is known that at least some muscles fall slack at short but physiological lengths, and that tendons can contribute substantially to the total compliance of resting muscle-tendon units.

In this study, ultrasound imaging was used to investigate muscle fascicle length changes in human gastrocnemius muscles in vivo.

METHODS
Participants were 15 healthy males and 10 healthy females aged 21-86 years.

Two ultrasound systems (Esaote MyLab25 systems with LA522E linear transducers, 9 MHz) were coupled together to provide images with a wide field of view (110 mm). Sagittal plane images of the medial gastrocnemius muscle were obtained. Video sequences (15 Hz) were collected as the ankle was manually rotated through the full physiological range of motion at 5-15 degrees/sec with the knee near-fully flexed. Subjects were asked to remain relaxed and muscle activity was monitored with surface EMG.

Customised software was used to track changes in muscle fascicle length and pennation from ultrasound image sequences.

RESULTS AND DISCUSSION
At short muscle-tendon lengths, increases in muscle-tendon length were not accompanied by increases in muscle fascicle length. This implies the fascicles were slack at those muscle-tendon lengths.

Further lengthening of the muscle-tendon unit resulted in an abrupt onset of lengthening of muscle fascicles. Muscle-tendon lengths at which the onset of muscle fascicle shortening occurred were widely distributed: they varied from 3 to 79% of the physiological range (mean 37%, SD 20%).

At muscle-tendon lengths greater than those at which fascicles were slack, muscle fascicle length increased, but always by much less than the increase in muscle-tendon length. At the longest muscle-tendon length measured (mean 70% of maximum physiological length) 27% of the total change in muscle-tendon length was due to change in muscle fascicle length, 6% was due to decreases in pennation, and 67% was due to change in length of tendons.

CONCLUSIONS
The muscle-tendon length at which muscle fascicles fall slack is highly variable. This suggests that, as the passive muscle-tendon unit is lengthened, muscle fascicles are progressively “recruited” and contribute sequentially to muscle stiffness. Even above slack lengths, muscle fascicles contribute only a small part of the total change in muscle-tendon length.

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