FACTORS INFLUENCING MAXIMUM ROM AT THE ANKLE JOINT: DIFFERENT RESULTS FROM CROSS-SECTIONAL VS. LONGITUDINAL STUDIES.

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Introduction
The ability to move through large joint ranges of motion (ROM) is important for the successful performance of activities of daily living and athletic tasks, however the factors affecting ROM are not currently known. Two common approaches to studying these factors are to: (1) compare neuromuscular differences between 'flexible' and 'inflexible' subjects, and (2) determine which neuromuscular factors change temporally with ROM. We have compared the results obtained by these two approaches.

Methods
In study one, 21 healthy men were divided into two groups (flexible, n=11; inflexible, n=10) based on their maximum dorsiflexion ROM (median = 46 deg) measured on an isokinetic dynamometer with the knee straight. Muscle and tendon lengths, passive muscle and tendon stiffness, fascicle length, angle, strain (lengthening) and rotation, peak passive torque (i.e. stretch tolerance), gastrocnemius and soleus EMG records, and H wave amplitudes (maximum and at 10% Mmax) were measured using dual-transducer ultrasound, isokinetic dynamometry, EMG and tibial nerve stimulation procedures. In study two, these measures were obtained in 12 subjects who performed twice daily straight-leg plantarflexion stretches for 3 weeks and 9 subjects who acted as non-stretching controls. Five additional subjects were tested for fascicle length, strain and rotation only, in order to improve statistical power.

Results
In study one, subjects with a greater ROM (flexible) tolerated a greater peak passive torque (48.6%) and exhibited greater fascicle rotation during stretch to 30 deg dorsiflexion (9.7 vs. 5.9%) than inflexible subjects; there was a greater tendon length at stretch termination only due to the greater loads tolerated. There were no differences in H-reflex magnitudes, EMG maximum amplitudes or EMG at stretch termination, but there was a moderate correlation between the angle of EMG onset and maximum ROM ($r=0.60$, $p<0.05$). There were no other between-group differences. In study two, subjects who performed stretching training showed an increased peak passive torque (28.1%), greater fascicle strain measured to 30 deg (27.2%), lower muscle stiffness (-18.0%) without change in tendon stiffness, and a depression of the H reflex measured in plantarflexed and neutral joint positions only.

Discussion
In both studies, the ability to tolerate stretch appeared to be a key factor influencing maximum ROM. However, the later onset of EMG and greater fascicle rotation appeared to be characteristics of more flexible subjects, whilst reductions in fascicle and muscle stiffness were associated with improvements in flexibility with training. Thus, the neuromuscular factors that contribute to between-subject variability in flexibility are largely different to those that are associated with improvements in flexibility with training.