Title: Stretching of voluntarily-activated muscles evokes greater acute and chronic adaptive changes than (traditional) static stretching

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Purpose: To determine whether acute (single session) and chronic (prolonged training) increases in joint range of motion (ROM) are greater if muscles are voluntarily activated before being stretched (i.e. active muscle stretching) when compared to traditional, static stretching.

Methods: In experiment 1, 18 physically-active subjects completed two static (SS1, SS2) and active (AMS1, AMS2) calf muscle stretch sessions, with each session separated by 48–72 h. SS sessions comprised 5 sets of 30-s static stretches, whilst AMS comprised 5 sets of 10 repetitions of 3-s stretches imposed on maximally contracted muscle (both interventions = 150 s). In experiment 2, 13 subjects performed twice-weekly AMS for 6 weeks (5 × 12 repetitions, 3-s maximally-active muscle stretches 10°/s, 20° plantarflexion to 10° dorsiflexion) on an isokinetic dynamometer. Maximal isometric plantarflexor strength, dorsiflexion ROM, peak passive tension, and muscle, tendon and muscle-tendon unit (MTU) stiffness were measured using isokinetic dynamometry, real-time ultrasound and 3D motion analyses before and after both the acute (experiment 1) and chronic (experiment 2) interventions.

Results: In experiment 1, a significantly greater increase in ROM was observed in AMS (5.9–7.7°) than SS (2.2–3.0°), with ROM significantly greater after AMS2 than all other trials (+3.3–5.8°). A significant ROM increase was already detected after the first set in AMS trials (2.2–3.1°), and this was similar to the magnitude of change after 5 sets of SS. Similar decreases in the passive moment slope occurred after SS (7.3–11.7%) and AMS (10.1–15.3%), however significant increases in peak passive moment (30.7–34.7%) and elastic energy storage (54.3–68.2%) occurred only after AMS. A significant reduction in maximal isometric strength occurred only after SS1 (6.5%). In experiment 2, plantarflexor MVC (47.1%), dorsiflexion ROM (14.7°) and stretch tolerance (108%) increased significantly after training, while no change was found in MTU stiffness (passive moment at the same joint angle; 2.5%). A significant decrease in passive muscle stiffness (20.6%) but increase in tendon stiffness (27.7%) was observed.

Discussion: A more than 2-fold greater acute increase in ROM was evoked after AMS than SS; the similar results in the second session (SS2 and AMS2) indicate that the finding is not due to muscle damage from unaccustomed training session. A stretch-induced muscle strength decrease was observed after SS but not AMS. After 6-week AMS training, substantial increases in ROM, strength, tendon stiffness and elastic energy storage, but reduction in muscle stiffness, demonstrate that AMS can provide significant physical function benefits whilst reducing risk of muscle injury.