**ACUTE EFFECTS OF CONTRACT-RELAX STRETCHING, STATIC STRETCHING AND ISOMETRIC CONTRACTIONS ON MUSCLE-TENDON MECHANICS**

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**Introduction:** Maximum joint range of motion (ROM) and resistance to joint rotation within that range (i.e. resistance to stretch) are important physical characteristics that influence the capacity to perform activities of daily living and athletic tasks [1], and are affected considerably by aging and disease [2]. The loading characteristics of different muscle stretching techniques likely influence the specific mechanisms responsible for acute increases in range of motion (ROM). Identifying mechanisms allows the determination *a priori* as to whether these interventions might be useful in different clinical populations, why such stretch interventions elicit different responses in different individuals, and to optimize/improve the methodology of, and response to, the stretch technique. Therefore, the effects of contract-relax proprioceptive neuromuscular facilitation (CR) stretching, static stretching (SS) and maximal isometric contraction (Iso) interventions were studied in 17 healthy human volunteers. **Methods:** Passive ankle moment was recorded on an isokinetic dynamometer with electromyographic (EMG) recording from the triceps surae, simultaneous real-time motion analysis, and ultrasound imaging recorded gastrocnemius medialis muscle and Achilles tendon elongation. The subjects then performed each intervention randomly on separate days before reassessment. The SS condition included 4 x 15 s plantar flexor stretches with 15 s rest between stretches, the CR condition included 10 s stretches followed immediately by a 5-s ramped maximal isometric plantar flexor contraction in a fully stretched position, repeated four times giving a total duration of 60 s; identical to the SS condition. The Iso condition included 4 x 5 s ramped maximal isometric plantar flexor contractions performed in the anatomical position, with 15 s rest between contractions. **Results:** Significant increases in dorsiflexion ROM (2.5-5.3°; $P < 0.01$) and reductions in whole muscle-tendon stiffness (10.1-21.0%; $P < 0.01$) occurred in all conditions, with significantly greater changes detected following CR ($P < 0.05$). Significant reductions in tendon stiffness (see Figure 1, A) were observed after CR and Iso (17.7-22.1%; $P < 0.01$) but not after SS ($P > 0.05$), while significant reductions in muscle stiffness (see Figure 1, B) occurred after CR and SS (16.0-20.5%; $P < 0.01$) but not after Iso ($P > 0.05$). Increases in peak passive moment (stretch tolerance) occurred after Iso (6.8%; $P < 0.05$), CR (10.6%; $P = 0.08$) and SS (5.2%; $P = 0.08$); no difference in the changes between conditions was found ($P > 0.05$). Significant correlations ($r_s = 0.69\text{-}0.82$; $P < 0.01$) were observed between the changes in peak passive moment and maximum ROM in all conditions. **Conclusion:** While similar ROM increases occurred after isometric contractions and static stretching, changes in muscle and tendon stiffness were distinct. The concomitant reductions in muscle and tendon stiffness after contract-relax stretching suggest a broader adaptive mechanical response that likely explains its superior efficacy to acutely increase ROM. These are the first data to confirm that acute changes in tendon stiffness may contribute to PNF stretching's superior efficacy to increase ROM, above other stretching modes. However, while mechanical changes appear tissue-specific between interventions, significant correlations between the change in peak passive moment and the change in ROM were observed in all conditions, indicative of a neurological adaptation (i.e. increased stretch tolerance) also being important for the acute increases in ROM. The reduction in tendon stiffness and increase in ROM detected following the Iso condition have important methodological implications as these data indicate that the performance of contractions 'on stretch' during PNF stretching may not be needed. Modifying PNF stretching to perform the contraction phase in the anatomical, rather than highly stretched position, removes the need for partner assistance, decreases the likelihood of inducing pain, tissue damage and muscle strain injury during the technique, which may enhance PNF's suitability and practicality for athletic and clinical populations.

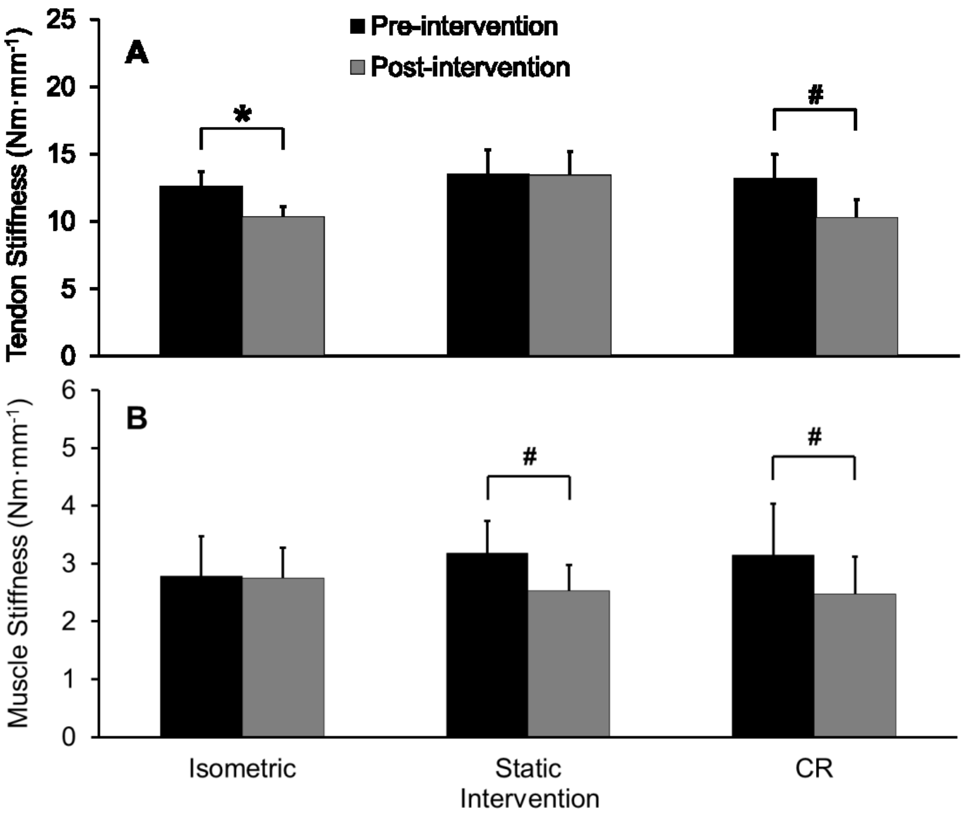


**Figure 1.** Achilles tendon stiffness [A] and gastrocnemius medialis (GM) muscle stiffness [B] pre- and post-intervention. *Significant to $P < 0.05$, #Significant to $P < 0.01$.

**Keywords:** Proprioceptive neuromuscular facilitation, range of motion, tendon stiffness, stretch tolerance, ultrasonography.

**References:**

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[2] Duffin et al., Diabet Med, 16: 125-130, 1999.