Blood flow restriction training induces systemic muscle strength adaptations

A.K. May, A.P. Russell and S.A. Warmington, Deakin University, Centre for Physical Activity and Nutrition Research, School of Exercise and Nutrition Sciences, Burwood, VIC 3125, Australia.

Introduction: During resistance training, the increase in muscle strength occurs not only in the trained limb, but also in the contralateral limb by cross-education through a mechanism within the central nervous system (CNS) (Lee & Carroll, 2008). However, an increase in muscle strength does not occur ipsilaterally along the superior-inferior axis (West *et al*. 2007). Contrary to this, Madarame *et al*. (2008) found that muscle strength and size increased not only in muscles that performed blood flow restriction (BFR) exercise but also in ipsilateral muscles that did not perform BFR exercise, but were lightly active during the same training sessions. The present study aimed to validate this effect.

Methods : Twenty participants were allocated to a BFR (n=9) or control (CON; n=11) group and performed a seven-week resistance training program (3 sessions per week). During training sessions, both groups performed three sets of bicep curls in the dominant arm only (50% 1 repetition maximum (1-RM)) followed by four sets each of bilateral leg extension and knee flexion exercises (30% 1-RM). The BFR group performed leg exercises with pressurised cuffs applied proximally to both upper thighs and inflated to 60% of limb occlusion pressure (125 ± 12 mmHg; mean ± SD). Maximum dynamic muscle strength was measured *via* 1-RM using unilateral bicep curls in both arms individually, and bilateral leg exercises. Total muscle cross-sectional area was measured *via* peripheral quantitative computed tomography at 50% humerus length in both arms individually, and at 25% femur length in the dominant leg.

Results: A significantly greater increase in bilateral leg extension 1-RM was observed in the BFR group (16.7 ± 1.6 kg; mean ± SEM) when compared with CON (8.0 ± 1.7 kg) ($P<0.05$). Bilateral knee flexion strength increased similarly between groups. Trained arm bicep curl 1-RM also increased to a significantly greater extent in the BFR group (2.5 ± 0.4 kg) compared with the untrained arm of the BFR group (1.1 ± 0.4 kg), and the trained arm of CON (0.7 ± 0.4 kg). Total muscle cross-sectional area of the legs and trained arms increased similarly between groups, whereas muscle cross-sectional area did not change in the untrained arms.

Conclusions: The present study provides evidence to support light-intensity BFR training of the lower-limbs to increase dynamic strength in upper-limb muscle that is active, but not undertaking heavy-load resistance training. This effect of BFR was in the absence of any detectable change in muscle size (cross-sectional area) in comparison with CON, and so suggests that BFR training may induce an ipsilateral transfer of strength to sensitised (lightly active) muscle. The mechanism for this effect is unknown, but may be derived *via* the CNS, akin to contralateral cross-education, or *via* an unknown systemic circulatory mechanism. Both of which require further exploration.

Lee M, Carroll TJ (2007). Cross Education. *Sports Med* **37**, 1-14.

Madarame H, Neya M, Ochi E, Nakazato K, Sato Y, Ishii N (2008). Cross-transfer effects of resistance training with blood flow restriction. *Med Sci Sports Exerc* **40**, 258-263.

West DWD, Burd NA, Tang JE, Moore DR, Staples AW, Holwerda AM, Baker SK, Phillips SM (2010). Elevations in ostensibly anabolic hormones with resistance exercise enhance neither training-induced muscle hypertrophy nor strength of the elbow flexors. *J Appl Physiol* **108**, 60-7.