Molecular, architectural and functional adaptations of skeletal muscle to power resistance exercise

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High-intensity resistance exercise training is prescribed to develop muscular strength and power and enhance athletic performance. Dynamic 'power' resistance exercise is characterized by complex, whole-body movements (*e.g.*, jumping, pulling, lifting) and, by comparison with conventional 'strength' resistance exercise, is performed with moderate external loads at moderate to high velocities. While the functional performance benefits of power resistance training are well described, the events within muscle that lead to the observed adaptations are less understood. We sought to ascertain molecular, architectural and functional adaptations of skeletal muscle to power resistance exercise in healthy, athletic men. Of particular and ongoing interest was the potential relevance of proteins associated with titin in the sarcomere and having mechanical stress-sensing and/or gene regulatory roles in the heart and under pathological conditions (Kojic *et al.*, 2011), in healthy and highly functional human skeletal muscle (Wette *et al.*, 2013; Wette *et al.*, 2015).

To target and elucidate the physiological responses and adaptations to power resistance exercise as practiced, we recruited 13 healthy males, aged 19-33 yr: of these, 8 were conventionally resistance trained (CRT, 80 ± 10 kg, 176 ± 5 cm) and 5 recreationally active, but not resistance trained (NRT, 76 ± 5 kg, 181 ± 3 cm). After initial *in vivo* muscle functional and architectural measurements, the CRT switched to prescribed and supervised power resistance training (PRT) exclusively for 7 wk, after which, as PRT they repeated, and the NRT completed, the same measurements. In addition, biopsy samples of *m. vastus lateralis* were obtained from participants after 3 days of no exercise (3d Rest) and 3h after 1.0h of modified (NRT) or 1.5h of maximal intensity (PRT) power resistance exercise (3h Post-Ex) with timed meals (4.4 MJ; 14% PRO, 27% FAT, 58% CHO) provided before and afterwards.

There were no differences ($P > 0.05$) between CRT and PRT in the maximal vertical ground reaction force (Fmax) during a maximal isometric front squat in parallel thigh position (Storey *et al.*, 2012), whereas the rate of force development (RFD) within 151-250 ms of contraction onset was greater in PRT. The Fmax and mean Fmax of CRT and PRT greatly exceeded that of NRT. Maximal vertical jump height during countermovement, but not squat jumps, improved from CRT to PRT (7%). Both jump type heights were greater (19-38%) in CRT and PRT than NRT. Sagittal, B-mode ultrasound images of *vastus lateralis* (Storey *et al.*, 2012) revealed a small (8%) mean increase in muscle thickness from CRT to PRT, and both were greater than NRT, whereas fascicle length and angle of pennation did not differ amongst the groups. The mRNA of muscle ankyrin repeat protein (MARP) family members Ankrd1/CARP and Ankrd2/ARPP, and CSRP3/muscle LIM protein (MLP), quantified by RT-qPCR, increased at 3h Post-Ex in NRT and PRT muscle, whereas Ankrd23/DARP, MuRF-1 and MyoD mRNA did not change. The increase in CARP in NRT was notably 10-fold that observed in PRT muscle. The exercise-induced changes in ARPP and MLP mRNA were not different between NRT and PRT (all ~2-fold). In immunostained transverse cryosections of 3d Rest and 3h Post-Ex muscle examined by fluorescence microscopy, ARPP protein immunoreactivity (Proteintech 11821-1-AP) was evident in most/all Type I fibres, in ~20% of Type IIA fibres, but no Type IIX fibres as identified by anti-myosin heavy chain (MHC) antibodies (DHSB). Immunoreactivity to anti-CARP antibodies (Proteintech 11427-1-AP) was evident in all, and only, Type I fibres. Both proteins appeared distributed across the cytoplasm/myofibrillar area of fibres with no overt differences between NRT and PRT and neither protein was detectable within myonuclei after 3d Rest or 3h Post-Ex. To provide further insight into these and other candidate mechano-sensing and signaling proteins, additional antibodies and methods are now being used. Collectively, these data provide evidence of the responses and adaptations particular to power resistance training as practiced by athletic individuals, and begin to substantiate and explain the effects of the exercise in enhancing muscular power.

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