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PERSPECTIVES

Recovering from eccentric exercise: get weak to become strong

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Did you ever suffer from sore muscles after hillwalking, lifting weights or trying a new type of exercise? If your answer is yes, then the exercise will have included eccentric contractions, i.e. contractions where the contracting muscle is lengthened. Eccentric contractions are the main cause of muscle soreness that usually peaks 24–48 h after exercise and which is known as a delayed onset of muscle soreness (DOMS). The evidence derived from experiments on animal models so far suggests that intense eccentric exercise causes a disruption and microinjury of contractile proteins leading to a loss of contraction force which is followed by repair, hypertrophy and remodelling of the muscle fibres and the surrounding connective tissue and ultimately increases the muscle's tolerance for eccentric exercise (Fridén & Lieber, 2001). In this issue of *The Journal of Physiology*, Peters *et al.* (2003) report the results of a detailed study where immunohistochemical and mRNA markers for contractile proteins, extracellular matrix, myogenesis and satellite cell function have been determined during the recovery from eccentric contractions. The value of this study is that the above variables have been measured at 10 time points from 0.5 h to 10 days after exercise, covering the whole recovery period with high resolution and thus giving a better insight than before into the sequence of events and some mechanisms.

The authors investigated the recovery of the z-disc connecting protein desmin, and its relationship to skeletal muscle force in order to test the hypothesis that a loss of desmin is responsible for the 40 % loss in muscle force that was observed after eccentric exercise. An earlier study had reported a rapid loss of desmin after eccentric exercise and provided experimental evidence for the above desmin hypothesis (Lieber *et al.* 1996). However, Peters *et al.* (2003) found that no more than a maximum of 250 fibres out of 15 000 fibres stained negative for desmin. Together with the finding that isometric force decreases only 25 % in a desmin knockout model compared to the wild-type (Milner *et al.* 1996) these data suggest that the loss of desmin is only responsible for a small fraction of the force decrease that occurs after eccentric exercise. Researchers will now have to search for the other factors that contribute to the observed loss of force.

Peters *et al.* (2003) also characterised the time course of myogenic signalling during the repair period. Myogenin and MyoD increased from 3 h after eccentric exercise to 5 days; this was followed by the appearance of fibres expressing embryonic myosin heavy chain from 3–10 days, probably reflecting an increased incorporation of differentiated satellite cells into muscle fibres. Surprisingly, the mRNA of the muscle growth inhibitor myostatin increased from 30 min to 12 h, which is contrary to the finding that myostatin reduces the expression of MyoD and inhibits myogenesis (Langley & Thomas, 2002). These data and the findings of a recent study that reported a higher loss of muscle mass in myostatin knockout mice during hindlimb suspension (McMahon *et al.* 2003) are important new evidence and suggest that the relationship between myostatin, myogenesis and muscle repair/growth is more complex than was initially thought.

The results of Peters *et al.* (2003) will be a good guide for future studies. The data indicate that 6 h after eccentric exercise could be a good time point to investigate the plethora of factors and pathways that regulate muscle repair and satellite function. Because of the number of players, microarrays and methods that determine the activation of signal transduction pathways are a desirable next step in order to characterise the repair signalling and other events in more detail. This will have to be followed up by localisation studies which are needed to establish whether the signalling events take place in satellite cells, muscle fibres, fibroblasts or immune cells, which are the players involved. And finally these findings will have to be verified in human beings. The eccentric exercise used in animal models is much more severe than the amount of eccentric exercise that we will ever encounter. Thus human studies need to be carried out to ensure that the findings in animal models really explain the repair that occurs in our muscles after trying new forms of exercise.

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