INSIDE JEB

Additional nuclei don't give exercising muscles the edge

Laboratory rats in the Nagoya Institute of Technology, Japan. Photo credit: Satoru Ato.

Packed with multiple nuclei, it would appear that individual muscle cells should be well prepared to churn out new proteins when building muscle after exercise, with the cells containing the largest numbers of nuclei producing the most protein. But the plain truth was, no one knew for sure. 'The relationship between the number of myonuclei [nuclei in muscle cells] and the ability to synthesise muscle proteins had not been clarified', says Riki Ogasawara from the Nagoya Institute of Technology, Japan, because keeping track of protein synthesis levels relative to the number of nuclei in a single muscle fibre was technically too difficult. However, a novel technique, known as SUnSET – which allows scientists to light up newly synthesised proteins with fluorescent tags – had recently become available, offering Ogasawara and postdoc Satoru Ato the opportunity to investigate whether muscle fibres with larger numbers of nuclei are capable of synthesising more proteins in response to exercise.

Instead of testing the muscles of human athletes, Ogasawara and Ato turned to a lab athlete, the rat. Realising that simply getting the rats to run on a treadmill was unlikely to cause muscles to rebuild sufficiently, the duo stimulated individual rat legs to contract strongly with mild electric shocks over several 100 s training sessions, to simulate a high-intensity workout. They then waited almost 6 h after the simulated workout, to give the rat a chance to begin building new muscle, before injecting the animals with an antibiotic, puromycin, which becomes incorporated as a marker into newly made proteins. Collecting samples of the rats' shin muscles (tibialis anterior) 15 min later, the pair then began the painstaking task of tracking whether the muscles with more nuclei per muscle cell resulted in higher protein production in response to their workout.

However, when they compared numerous muscle fibres from the exercised rat legs, they found there was no correlation. Having larger numbers of nuclei per muscle fibre was no guarantee that the fibre would be able to produce more new proteins to build up the muscle in response to exercise.

In contrast, when the duo checked out whether another key stage in the process of making new proteins – the transcription of DNA into mRNA by ribosomes – it was clear that muscle fibres with the largest numbers of ribosomes were producing the most new proteins. And, when they checked the shin muscle from the rat's other hindleg – which had not experienced the simulated exercise regime – the muscle cells with larger numbers of nuclei did produce slightly more new proteins to maintain a healthy muscle, in line with their expectations.

'I was surprised that the number of myonuclei was not associated with the ability to synthesise proteins through exercise', says Ato; however, he points out that muscles continue to rebuild up to 48 h after a burst of high-intensity exercise, so it is possible that the quantity of nuclei per muscle cell may have an impact on protein synthesis later in the process. He adds, 'A better understanding of the role of the increasing number of nuclei in exercise-induced muscle growth may also reveal why vertebrate muscle cells have so many nuclei'.

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Kathryn Knight
kathryn.knight@biologists.com