ESSAYS ON APS CLASSIC PAPERS

Nature vs. nurture: can exercise really alter fiber type composition in human skeletal muscle?

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This essay looks at the historical significance of two APS classic papers that are freely available online:


It is well recognized today that mammalian skeletal muscle has a remarkable potential to alter its phenotype. Since the publication of the classic 1960 paper by Buller et al. (2) demonstrating the reversal of contractile characteristics in fast- and slow-twitch muscles after cross-innervation in cat, the plasticity of skeletal muscle has been demonstrated at the molecular and cellular levels using a variety of animal models and experimental treatments. Chronic electrical stimulation, synergistic muscle ablation, hindlimb suspension, and hormone manipulation have all been used to document changes in metabolic enzymes, Ca$^{2+}$/H$^{+}$ handling proteins, myosin isoforms and regulatory proteins of skeletal muscle, as well as alterations in muscle fiber type and size. Moreover, John Holloszy’s classic 1967 paper (6) demonstrating the remarkable adaptation of the energy metabolism system in rat skeletal muscle to chronic exercise training indicated that the malleability of muscle could also be observed with a simple physiological stimulus. However, whether a stimulus such as exercise training could produce not only metabolic adaptations, but also transform fiber types in human skeletal muscle, is a question that has been long debated.

The first prospective research study that addressed this question using a fiber type classification system based on histochemical staining of myosin ATPase activity was published in the *Journal of Applied Physiology* in 1973 by Phil Gollnick (Fig. 1), Bob Armstrong, Bengt Saltin, Carl Saubert, Walt Sembrowich, and Ray Shepherd from the Department of Physical Education for Men at Washington State University (“Effect of training on enzyme activity and fiber composition of human skeletal muscle” Ref. 4). The initial interest in this question arose from the early work of Reggie Edgerton and colleagues at UCLA, whose work was critical for the development of fiber type classification systems. Furthermore, Edgerton’s doctoral dissertation at Michigan State University introduced exercise physiologists to the idea of exercise-induced fiber type transformation in rodent muscle (3). To address the idea of fiber type plasticity in human skeletal muscle, Gollnick needed expertise in the techniques of fiber typing and needle biopsy of muscle. Therefore, Bob Armstrong, a National Science Foundation Predoctoral fellow in Gollnick’s laboratory, spent the summer of 1971 learning fiber type techniques from Reggie Edgerton at UCLA. It was also at this time that Gollnick initiated his life-long research collaboration with Bengt Saltin, an Associate Professor in the Department of Applied Physiology at the Karolinska Institute in Stockholm Sweden, with expertise in the needle muscle biopsy technique and nearly 80 exercise science publications (an impressive publication record considering that he received his PhD in 1964).

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