Learning from legacies: fiber types, phenotypes, and human performance

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“Men love to wonder, and that is the seed of our science . . . .”
—Ralph Waldo Emerson (4)

EMERSON, echoing Aristotle’s famous dictum, suggests that scientific inquiry begins in wonder. In the comparatively new discipline of exercise physiology, this wonder often has its roots in our own abilities (or inabilities) to perform work, to compete, to sustain exercise at a high level. For example, inspired by his background as a track athlete (1), Nobel laureate A. V. Hill made pioneering investigations into muscle energetics, some of which George Brooks would later dispel after he pondered why lactic acid had to hinder his 400-m performance (personal communication). Hill’s work provided the intellectual impetus for much of the extraordinary efforts of the Harvard Fatigue Laboratory, the “birthplace” of exercise physiology in the United States (1, 3). In time, the field increasingly shifted from ability to disability, to address questions regarding the role of exercise in the prevention and treatment of chronic diseases. However, as Chakraverty and Booth (2) have forcefully argued, regular physical activity has, in all likelihood, been the “norm” for much of the course of human history. More to the point, understanding the phenotype (behavioral, anatomic, and metabolic) of those individuals who are resistant to disease is arguably just as important as describing the disease phenotype. Thus the study of healthy, physically active individuals can be both informative and “fun,” as it reminds us of our roots, both as a discipline and as an organism.

The work of Luden et al. (7) in this issue of the Journal of Applied Physiology is refreshing precisely because it reminds us of these roots. Dr. Scott Trappe and his brother Dr. Todd Trappe continue a legacy started by the lab’s founder and their mentor, Dr. Dave Costill. Dr. Costill’s long and productive career was characterized by a combination of the intellectual curiosity noted above with the creative application of techniques/methods to answer questions about the integrative physiology of human performance. The Trappe brothers are also integrating the legacy of another prominent scientist into their current work. Dr. Bob Fitts, one of the world’s leading experts on the physiology of human skeletal muscle, has a longstanding interest in characterizing skeletal muscle adaptations to changes in the environment (microgravity in particular) at the single-fiber level. Originally described by Wood et al. (9) in 1975, the skinned human skeletal muscle fiber preparation has been widely applied to study contractile dynamics, fiber type plasticity, calcium sensitivity, atrophy, and a range of other important questions. Scott Trappe trained for his post-doc under Bob Fitts’ direction, and the combined influence of the “Costill-Fitts” (both exceptionally gifted athletes, it should be noted) legacy is apparent in his work; it is creative, integrative, and important.

In the current work, the authors studied adaptations to a 3-wk taper in competitive male collegiate runners. The outcomes focused on integrating whole body and muscle-specific phenotypic adaptations to the change in training stimulus. While it seems clear that cardiovascular and metabolic changes in response to a taper are small (6), less is known about changes in contractile dynamics in skeletal muscle posttaper. The current study confirmed previous work describing improved performance (3% improvement in time to complete a cross-country race) despite no increase in maximal oxygen consumption ($V_{O_{2}}$max). The increase in performance was related to increased peak power in type IIa fibers only, without a change in peak force or maximal velocity ($V_{max}$). The data support the group’s assertion that single-fiber peak power is a meaningful performance outcome (8).

Interestingly, there was a differential mRNA response to a fixed stimulus pre- and posttaper. Although the authors suggest that the mRNA responses explain the changes in cross-sectional area (CSA) of the type IIa fibers, there is no discussion regarding the differential fiber-type sensitivity to tapering. Alterations in exercise overload during the taper (i.e., increased “rest”) may be involved. Since type I fibers (especially in the gastrocnemius where the biopsies were taken) are chronically active, perhaps the increased “rest” is not a large relative change in stimulus. However, in type IIa fibers that are not necessarily chronically active, the increase in rest is physiologically relevant. In support of a “rest” response is the study of Hansen et al. (5). This study compared exercise once per day every day (High) vs. twice per day every other day (Low) and found a greater increase in exercise performance in the Low group. The authors and others have concluded that increases in performance were the result of exercising once in the glycogen-depleted state. However, what is often overlooked is that Low was also getting twice the rest since it had twice as many days without exercise. Finally, the differential transcript response was mirrored by differential changes in single-fiber CSA where only the type IIa fibers responded to the taper. This finding is interesting because one does not usually associate aerobic exercise with hypertrophy. While the MuRF-1 and MRF-4 mRNA responses are plausible candidates to explain the hypertrophy, the fiber-specific sensitivity to the taper awaits explanation.

Luden et al. (7) describe an integrated performance phenotype. It is not any single method, but the creative application of several to address an interesting question that makes the work noteworthy. It is clear from the present work that future studies that characterize the transcriptional response to tapering can provide additional information that the present study cannot fully address. Moreover, continued work on the differential plasticity of skeletal muscle fiber types in the same individual merits attention. What is it about IIa fibers that appear to make them more sensitive to changes in overload (at least in the present conditions) and why does the same stimulus lead to an...
improved outcome because of a relative decrease in training volume?

It should be apparent from the foregoing that Luden et al. (7) do not provide data which have direct clinical implications. However, the approach described by these authors can be, and has been, profitably applied in a variety of settings to provide integrated information on the effect of aging, inactivity, and the presence of chronic disease on the integrated phenotype (tissue to organism). To this extent, the authors are to be commended for a work that creatively combines several techniques to address a simple question: “I wonder what physiological changes explain the improved performance following a taper in runners?”

DISCLOSURES

No conflicts of interest (financial or otherwise) are declared by the authors.

REFERENCES


