Very intense exercise-training is extremely potent and time efficient: a reminder

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THIS ISSUE of the *Journal of Applied Physiology* contains a report by Burgomaster et al. (2) that reminds us of the "potency" of very intense exercise, performed as 30-s sprints, for stimulating metabolic adaptations within skeletal muscle. This group employed "sprint interval training" on a bicycle ergometer, involving 30-s sprints performed "all out," with 4 min of recovery. Recreationally active college students performed only 2–4 min of exercise per session and just six sessions over 2 wk. The remarkable finding of this study was that this small total amount of very intense exercise training was sufficient to "double" the length of time that intense aerobic exercise could be maintained (i.e.; from 26 to 51 min). Although peak oxygen uptake was not increased, aerobic adaptations did occur within active skeletal muscle as reflected by a 38% increase in activity of the mitochondrial enzyme citrate synthase.

This study is significant because it contains a "documented" first, and more importantly it serves as a reminder to the scientific community and society. It appears that this is the first scientific documentation that very intense sprint training in untrained people can markedly increase aerobic endurance and that the total "dose" of exercise over the 2-wk period, performed in six sessions, amounted to only 15 min. This serves as a dramatic reminder of the potency of exercise intensity for stimulating adaptations in skeletal muscle that improve performance and have implications for improving health. In other words, we are reminded that intense sprint interval training is very time efficient with much "bang for the buck."

The findings of Burgomaster et al. (2) challenge the concept that aerobic endurance performance is only enhanced by aerobic endurance training. On the surface, this concept seems logical, but it has been long ago proven wrong both in the realm of athletics as well as muscle biochemistry. In athletics, this concept is not generally held by elite athletes competing in middle-distance running because they incorporate sprint interval training to improve aerobic endurance. Sprint interval training was introduced by Woldemar Gerschler 70 yr ago and was followed by world-record performances. Indeed, it is likely that if an experienced runner or bicyclist had only 2 wk and very limited time to prepare for a race of ~30-min duration, that sprint interval training would become a mainstay of their preparation. Therefore, this scientific report of the potency of sprint interval training appears to have practical support in athletics. Furthermore, it seems to have gained some recent popularity in the fitness and health club industry in the form of "spinning" cycling classes. From the perspective of muscle biochemistry, it has long been recognized that 6–8 wk of sprint interval training increases aerobic enzyme activity in muscle (5, 6, 9, 10).

The authors Burgomaster et al. (2) "hope that the present observations will stimulate additional research to clarify the precise nature, time course, and significance of the physiological adaptations induced by short sprint interval training." The large increase in citrate synthase activity in skeletal muscle, a marker of mitochondrial activity, implies that a host of adaptations typical of aerobic endurance training have been initiated. The exercise stimulus that promotes mitochondrial biogenesis also appears to stimulate other healthy metabolic adaptations in skeletal muscle, such as improved insulin action, improved lipoprotein lipase activity, and greater clearance of plasma triglycerides (1, 3, 8). Future research might focus on the ability of short-term sprint interval training for promoting these healthy adaptations. Given the growing epidemic of physical inactivity in today's modern society, the effectiveness of all types of exercise and methods of delivery needs to be considered. As discussed by Chakravarthy and Booth (3), "a continuous sedentary lifestyle has resulted in a stalling of glycogen and triglyceride stores at high levels in skeletal muscle and of those proteins producing their cycling with physical activity-rest cycles. Conceivably, such metabolic stalling may cause the organism to cross a biological threshold, beyond which chronic health conditions develop." Sprint interval training has promise as an efficient method to reverse metabolic stalling in skeletal muscle in a segment of the sedentary population.

Obviously, sprint interval training performed all-out and repeatedly requires a high level of motivation, and it causes a feeling of severe fatigue lasting for at least 10–20 min. That is the "price" for its effectiveness and remarkable time efficiency. It remains to be determined which populations, depending on age, health status, and psychology, are mostly likely to adhere and benefit from sprint interval training. As mentioned, competitive endurance athletes have long realized its importance. They have also come to appreciate the need for a coach and training partners to provide accountability and motivation during such training. Exercise physiologists, working with other health care professionals, need to better develop a clinical application of sprint interval training. Additionally, the incidence of injury needs to be studied. Chance for impact injury during sprint stationary cycling or swimming seems low and might be compared with sprint running, for example.

The literature contains a number of reports that 6–8 wk of either sprint interval training or "prolonged submaximal aerobic exercise training" promotes increased mitochondrial enzyme activity in skeletal muscle (5, 6). It has also been demonstrated that significant increases in skeletal muscle mitochondria activity can be displayed after only 7–10 days of aerobic training when it is performed daily for 2 h at 65% peak oxygen uptake (11). It is likely that the potency of all-out sprint interval training is derived in large part from the high level of motor unit activation. All-out sprint training especially stresses recruitment and adaptation of type II (i.e., fast twitch) muscle fibers that are remarkably and equally responsive as type I (i.e., slow twitch) muscle fibers in their ability to increase mitochondrial enzyme activity to high absolute levels (4, 5, 7). In fact, the low-intensity aerobic exercise that is typically prescribed for endurance training or health is not very effective at increasing aerobic enzyme activity in type II muscle fibers, which comprise approximately one-half of the fibers within the thigh (vastus) and calf (gastrocnemius) muscle in most people (6). Thus low-intensity aerobic training is not a very effective or efficient method for maximizing aerobic adaptations in skeletal muscle because it generally does not recruit type II muscle fibers. The present report by Burgomaster et al. (2) provides a reminder of the effectiveness of sprint interval training, performed three times per week, and it demonstrates that large increases in aerobic enzyme activity and aerobic performance capacity previously measured after 7–8 wk (6) can occur after as little as 2 wk and only six sessions.

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