Impact of Resistance Training on Endurance Performance
A New Form of Cross-Training?

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Summary

In accordance with the principles of training specificity, resistance and endurance training induce distinct muscular adaptations. Endurance training, for example, decreases the activity of the glycolytic enzymes, but increases intramuscular substrate stores, oxidative enzyme activities, and capillary, as well as mitochondrial, density. In contrast, resistance or strength training reduces mitochondrial density, while marginally impacting capillary density, metabolic enzyme activities and intramuscular substrate stores (except muscle glycogen). The training modalities do induce one common muscular adaptation: they transform type IIb myofibres into IIa myofibres. This transformation is coupled with opposite changes in fibre size (resistance training increases, and endurance training decreases, fibre size), and, in general, myofibre contractile properties. As a result of these distinct muscular adaptations, endurance training facilitates aerobic processes, whereas resistance training increases muscular strength and anaerobic power. Exercise performance data do not fit this paradigm, however, as they indicate that resistance training or the addition of resistance training to an ongoing endurance exercise regimen, including running or cycling, increases both short and long term endurance capacity in sedentary and trained individuals. Resistance training also appears to improve lactate threshold in untrained individuals during cycling. These improvements may be linked to the capacity of resistance training to alter myofibre size and contractile properties, adaptations that may increase muscular force production. In contrast to running and cycling, traditional dry land resistance training or combined swim and resistance training does not appear to
enhance swimming performance in untrained individuals or competitive swimmers, despite substantially increasing upper body strength. Combined swim and swim-specific ‘in-water’ resistance training programmes, however, increase a competitive swimmer’s velocity over distances up to 200m. Traditional resistance training may be a valuable adjunct to the exercise programmes followed by endurance runners or cyclists, but not swimmers; these latter athletes need more specific forms of resistance training to realise performance improvement.

Traditional endurance training increases the ability to perform low load, high repetition exercise, but only marginally affects muscular strength and anaerobic power. In contrast, resistance training improves ability to perform high load, low repetition exercise, but marginally affects endurance. Therefore, it seems inconsistent to prescribe resistance training to athletes who only seek to improve endurance, as such a prescription violates the principles of training specificity; i.e., training programmes should simulate the athlete’s mode of exercise.[1]

To be successful in endurance sports, however, competitive athletes need more than an enhanced long term work capacity; they also require muscular strength and anaerobic power, abilities needed for hill climbing, attacking, and final sprinting during the race.[2,3] To obtain proficiency at these skills, endurance athletes typically perform intense short duration interval training,[4] but many coaches and trainers have recently started to prescribe resistance training in conjunction with or in lieu of interval training. This prescription is presumably based on the capacity of resistance training to improve muscular strength and anaerobic power, and in turn, possibly endurance performance. In this capacity, resistance training may be viewed as a form of cross-training, albeit an untraditional application of the concept. Traditionally, cross-training involves activities that produce a common goal, such as improving maximal oxygen uptake (VO2max).[5] Resistance training fits this paradigm, but from a different perspective; as with short interval training, it enhances anaerobic power. The body of scientific literature, however, is equivocal concerning the impact of resistance training on endurance performance.

Accordingly, the purpose of this article is to review research on resistance, endurance and combined resistance and endurance training in order to examine the physiological basis for adding resistance exercises to the endurance athlete’s training regimen. To tighten our focus, we will concentrate primarily on the muscular adaptations induced by these aforementioned training modalities. In the remaining sections, we will examine the impact of resistance training on running, cycling and swimming performance, the 3 forms of exercise traditionally integrated into a cross-training regimen.[5]

1. Physiological Adaptations to Resistance and Endurance Training

Traditional resistance training involves high load, low repetition muscular contractions, whereas endurance training involves low load, high repetition muscular contractions. As a result of these differences, each training mode produces distinct physiological adaptations in the trained musculature.[1] Resistance training, for example, induces muscle hypertrophy as measured by increased cross-sectional area in all fibre types or just type II fibres.[6-10] This hypertrophy reflects an increase in muscle protein content, resulting in increased fibre size and possibly fibre number.[8,11,12] Resistance training also alters the ratio of the type II fibres; as the percentage of type IIA fibre increases and that of IIB (more recently referred to as IIX)[13,14] fibre decreases, there is a concomitant change reflecting a IIB to IIA fibre transformation at a histochemical and myosin isoform level.[6-8,15-17]

In contrast to these structural changes, resistance training induces little to no change in activities of phosphagen and glycolytic and oxidative