High-intensity Interval Training: A Time-efficient Strategy for Health Promotion?

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Introduction

Regular endurance training induces numerous physiologic adaptations that facilitate improved exercise tolerance and physical well-being, in large part by increasing the body's capacity to transport and utilize oxygen. In contrast, brief bouts of high-intensity, sprint-type exercise are generally thought to have less of an effect on aerobic energy metabolism. However, a growing body of evidence suggests that low-volume, high-intensity interval training (HIT) may represent a time-efficient strategy to induce adaptations normally associated with endurance training. This commentary briefly highlights recent work from my laboratory that has examined rapid adaptations in exercise capacity and aerobic energy metabolism after short-term HIT.

Short-term HIT Protocol

The model used in our studies was the Wingate Test, which involves 30 seconds of "all-out" cycling against a high resistance. The task is very demanding and power output typically falls by 25% to 50% over the course of the test as the subject fatigues. During each training session, subjects repeated the test four to seven times, separated by 4 minutes of recovery, for a total of 2 to 4 minutes of intense exercise. Six training sessions were performed over 2 weeks, resulting in a total exercise time of approximately 15 minutes and a total training time commitment (including recovery) of less than 2.5 hours. All studies were conducted on healthy college-aged men and women who were accustomed to exercise but not specifically trained in any sport.

Effect of HIT on Exercise Capacity

One of the most remarkable findings of our recent work was the dramatic improvement in exercise tolerance during tasks that rely mainly on aerobic energy metabolism, despite the very low training volume. Our initial study showed that subjects doubled the length of time that submaximal exercise could be maintained, from 26 to 51 minutes, during cycling at 80% of maximal aerobic capacity. Subsequent work showed that subjects also improved their "race performance" or ability to complete a fixed amount of work (eg, 10% less time needed to complete a simulated 30-km cycling time trial). The validity of these findings was bolstered by the fact that all subjects performed extensive familiarization trials to minimize any learning effect, and control subjects showed no change in exercise performance when tested 2 weeks apart with no training intervention.

Skeletal Muscle Adaptations to HIT

The factors responsible for training-induced improvements in exercise capacity are extremely complex and determined by numerous physiologic (eg, cardiovascular, muscle metabolic, respiratory, neural) and psychologic (eg, mood, motivation, perception of effort) attributes. Our studies have utilized the percutaneous needle biopsy technique to examine changes in skeletal muscle metabolic control. We have consistently found a significantly increased muscle oxidative capacity (assessed using the maximal activity or protein content of mitochondrial enzymes such as citrate synthase) ranging from approximately 10% to 35% after only 2 weeks of HIT. A higher muscle oxidative capacity is associated with an improved ability to oxidize fats and a reduced risk for metabolic disorders such as insulin resistance. We have also shown other adaptations normally associated with traditional endurance training, including an increased glycogen content and reduced rate of glycogen utilization and lactate production during matched-work exercise.

How Does HIT Compare with Traditional Endurance Training?

In one study we directly compared a group of subjects who performed our HIT protocol (six sessions of repeated 30-second sprints over 2 weeks) versus another group who performed 90 to 120 minutes of continuous moderate-intensity cycling per session. The total training time commitment was approximately 2.5 and 10.5 hours for the sprint and endurance groups, respectively, and total exercise volume was approximately 90% lower for the sprint group. The two very diverse training protocols induced remarkably similar changes in muscle oxidative capacity and exercise capacity. Although a few other studies have compared interval versus continuous training using matched-work designs, to our knowledge this was the first study to demonstrate that HIT is indeed a very time-efficient training strategy.

Why Is HIT So Effective?

The potency of high-intensity interval training to elicit rapid skeletal muscle remodeling is no doubt related to its high level of muscle fiber recruitment, and the potential to stress type II fibers in particular. Contraction-induced metabolic disturbances activate several kinases and phosphatases involved in signal transduction, including the AMP-activated protein kinase, calcium/calmodulin-dependent protein kinase, and mitogen-activated protein kinase cascades. These signaling pathways have been shown to play a role in promoting specific coactivators involved in mitochondrial biogenesis and metabolism, including expression of peroxisome proliferator-activated receptor coactivator-1. Additional research is warranted to clarify the effect of different acute exercise impulses on molecular signaling events in various fiber types and the precise time course and mechanisms responsible for the contraction-induced changes that facilitate the training adaptation.

Implications: How Much Exercise Is Enough?

Although there is consensus regarding the importance of physical activity, the minimum dose necessary to improve health status is unclear. Public health guidelines generally recommend 30 to 60 minutes of moderate-intensity exercise on most days of the week. However, despite overwhelming scientific evidence that regular physical activity is effective in the prevention of chronic diseases and premature death, most adults fail to meet even the minimum physical activity guidelines. Countless studies have shown that the most commonly cited reason for not exercising is a "lack of time." This finding is ubiquitous; regardless of age, ethnicity, sex, or health status, people report that a lack of time is the primary reason for their failure to exercise on a regular basis. Given that lack of time is such a common barrier to exercise participation, exercise prescription innovations that yield benefits with minimal time commitments represent a potentially valuable approach to increasing population activity levels and population health. HIT is often dismissed outright as unsafe, impractical, or intolerable for many individuals. However, there is growing appreciation of the potential for intense, interval-based training to stimulate improvements in health and fitness in a range of populations, including persons with coronary artery disease. In addition, some data suggest that a low-frequency, high-intensity approach to training is associated with greater long-term adherence as compared with a high-frequency, low-intensity approach.

Limitations and Perspective

Our recent studies should not be interpreted to suggest that low-volume interval training provides all of the benefits normally associated with traditional endurance training. The duration of the training programs in our published work to date was relatively short (six sessions over 2 weeks) and it remains to be determined whether similar adaptations are manifest after many months of low-volume interval and high-volume continuous training. It is possible that the time course for physiologic adjustments differs between training protocols; the very intense nature of interval training may stimulate rapid changes, whereas the adaptations induced by traditional endurance training may occur more slowly. Second, the Wingate-based training model requires a specialized cycle ergometer and an extremely high level of subject motivation. Given the extreme nature of the exercise, it is doubtful that the general population could safely or practically adopt the model. Future studies should examine modified interval-based approaches to identify the optimal combination of training intensity and volume necessary to induce adaptations in a practical, time-efficient manner across various populations. Finally, to date we have only examined a few specific variables in skeletal muscle from young active people, and future studies should examine whether low-volume interval training induces other physiologic adaptations normally associated with high-volume endurance training in different populations (eg, increased capacity for lipid oxidation, improved cardiovascular function, and changes in health status markers such as insulin sensitivity).

Conclusions

Elite endurance athletes have long appreciated the role of high intensity interval exercise in a comprehensive training program. Recent data from our laboratory suggest that—in young healthy persons of average fitness—intense interval exercise is a time-efficient strategy to stimulate skeletal muscle adaptations comparable with traditional endurance training. However, fundamental questions remain regarding the minimum volume of exercise necessary to improve physiologic and psychologic wellbeing in various populations, the effectiveness of alternative (less extreme) interval training strategies, and the magnitude of adaptations that can be elicited and maintained over the long term. A comprehensive evaluation of adaptations induced by different interval training strategies in a wide range of populations will permit evidence-based recommendations that may provide an alternative to current exercise prescriptions for time-pressed individuals.

Recommended Reading

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