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High-intensity interval training for health and fitness: can less be more?

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EXERCISE IS AN ESTABLISHED therapeutic adjunct in the management of several chronic diseases. Traditionally, the form of exercise most commonly prescribed by clinicians is continuous moderate-to-vigorous-intensity exercise that can be sustained for ~20–60 min. This is consistent with current US public health guidelines recommending that adults accumulate at least 150 min/wk of moderate-intensity physical activity or 75 min/wk of vigorous-intensity physical activity. Despite the well documented health benefits of regular physical activity and the persistent public health messages for Americans to become more active, the percentage of US adults meeting these minimal guidelines is extremely low (11). Among the many reasons for not exercising is a "perceived lack of time," which is one of the most frequently cited barriers (3). Recent research on the benefits and efficacy of low-volume, high-intensity interval training (HIIT) may help to overcome that barrier.

In this issue of the *Journal of Applied Physiology*, Little et al. (6) report that as little as 30 min of vigorous exercise *per week*, within a total exercise time commitment of 75 min/wk, improved glucose control and markers of skeletal muscle metabolism in patients with type 2 diabetes. Over 2 wk, eight subjects completed six high-intensity interval exercise sessions, with each session consisting of 10 60-s bouts on a leg cycle ergometer that elicited ~90% maximal heart rate (HR_{max}), interspersed with 60 s of rest. Average 24-h blood glucose was reduced by 13% and postprandial blood glucose by 30%. Several muscle mitochondrial proteins were increased by ~20–70%, and glucose transporter 4 protein levels were raised by 369%.

Albeit just a pilot study on eight subjects, the results of Little et al. are consistent with a number of publications within the last few years that demonstrate the benefits of HIIT (2, 4, 5, 8, 9, 13). Although many outcome measures (e.g., blood pressure) can be improved independently of exercise training intensity (5) and the documented health benefits of moderate-intensity exercise provide the scientific basis for current physical activity guidelines, HIIT has been shown to be more effective than moderate-intensity continuous exercise training for improving endothelial function and reversing left ventricular remodeling in patients with heart failure (13), for reducing central body fat and fasting plasma insulin in young women (9), and for improving maximal oxygen uptake ($\dot{V}O_{2max}$) in subjects with metabolic syndrome (8), heart failure (13), and coronary artery disease (CAD; 7). Greater improvements in $\dot{V}O_{2max}$ may positively impact longevity prospects in the general population and in patients with cardiometabolic diseases (see Refs. 7 and 13 for discussion). HIIT has also been reported to be more effective than continuous, steady-state exercise training for inducing fat loss in men and women, despite considerably less total energy expenditure required during training sessions (9, 10).

Low-volume HIIT typically consists of several bouts of high-intensity exercise lasting between 1 and 4 min, which elicit ~85–95% of HR_{max} and/or $\dot{V}O_{2max}$, interspersed with bouts of rest or active recovery (2, 5). Some versions of HIIT involve much shorter exercise intervals, lasting only 8 s, with up to 60 repetitions in a single exercise session (9). In general, HIIT involves only ~8–16 min of actual "on time" for vigorous-intensity exercise, with the total workout, including warm-up, cool-down, and rest/active recovery periods, requiring only ~20–25 min (1, 2, 4–10, 13). Gibala and McGee (2) initially introduced an "extreme" version of HIIT, using 4–6 "all-out" Wingate tests as the exercise stressor (2). Subsequently, this group modified their HIIT protocol to the less intense 10 × 60-s interval version used in the current paper. This protocol elicited ratings of perceived exertion (RPE) of only ~4–8 on a 10-point scale, suggesting that this HIIT paradigm may have clinical utility. In fact, in the few investigations that have addressed this issue, subjects appear to not only tolerate the higher exercise intensity, they actually *prefer* HIIT to the more traditional steady-state continuous exercise (1, 13). In young healthy males, Bartlett et al. (1) reported that ratings of perceived "enjoyment" were higher for HIIT than for steady-state continuous exercise, despite RPE being higher for HIIT. Similarly, patients with heart failure found HIIT more motivating than traditional steady-state exercise, which was perceived as "quite boring" (13).

Several questions need to be addressed. Safety of HIIT, particularly for high-risk patient populations, needs to be established. Large, multicenter trials using the HIIT paradigm have been advocated (5). It should be emphasized, however, that the exercise load imposed in HIIT is relative to the individual's own aerobic capacity. For patient populations with low $\dot{V}O_{2max}$ (e.g., <20 $ml \cdot kg^{-1} \cdot min^{-1}$), the individual HIIT load may be ~4–5 METs and be equivalent to walking up a slight grade at ~3 mph or stationary cycling at <100 W. Thus risk for musculoskeletal injury may be lower than anticipated. Results from small studies lasting 10–12 wk suggest that patients with CAD and heart failure tolerate HIIT quite well and that they may prefer this type of exercise (7, 13).

The optimum dosage of HIIT needs to be established. In the context of the study by Little et al., are 10 × 60-s intervals necessary? Could the same result be achieved with less? Does the intensity need to reach ~90% of HR_{max}? Could a lower intensity be equally effective? Future experiments should address the optimum combination of intensity and duration, and total number, of exercise intervals, as well as duration and relative effort of the recovery period between exercise intervals. Time-constrained exercisers will naturally want to know how little they need to do yet still reap benefits.

Perhaps most importantly, can HIIT be sustained? Most HIIT programs have been relatively short, with some lasting only 2 wk (2, 4, 6). Could a sustained "maintenance" program be reduced, perhaps to just one weekly HIIT session? Recent

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epidemiological evidence from the Norwegian HUNT study (12) indicated that just a single weekly bout of high-intensity exercise was found to reduce the risk of cardiovascular disease in both men and women (relative risk: 0.61 and 0.49, respectively). Interestingly, increasing the duration or number of exercise sessions appeared to have no additive benefits.

Ultimately, exercise professionals could use HIIT to augment a fitness portfolio akin to an "à la carte" menu of exercise options that would allow clients to pick and choose the exercise modality, duration, and type that best suits their needs and limitations. Although some clients may be less than amenable to HIIT-style regimens, many others may be more than willing to adopt this form of exercise.

With such a large percentage of the US population failing to meet even minimum physical activity guidelines, HIIT may help insufficiently active individuals overcome a major barrier to maintaining a physically active lifestyle, that of a perceived lack of time. An added bonus is that from a time:benefit perspective, HIIT may prove to be a good example where less can be more.

DISCLOSURES

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

AUTHOR CONTRIBUTIONS

Author contributions: G.A.G. and S.S.A. drafted manuscript; G.A.G. and S.S.A. edited and revised manuscript; G.A.G. and S.S.A. approved final version of manuscript.

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