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Review

High-intensity interval training (HIIT) for patients with chronic diseases

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Abstract

Exercise training provides physiological benefits for both improving athletic performance and maintaining good health. Different exercise training modalities and strategies exist. Two common exercise strategies are high-intensity interval training (HIIT) and moderate-intensity continuous exercise training (MCT). HIIT was first used early in the 20th century and popularized later that century for improving performance of Olympic athletes. The primary premise underlying HIIT is that, compared to energy expenditure-matched MCT, a greater amount of work is performed at a higher intensity during a single exercise session which is achieved by alternating high-intensity exercise intervals with low-intensity exercise or rest intervals. Emerging research suggests that this same training method can provide beneficial effects for patients with a chronic disease and should be included in the comprehensive medical management plan. Accordingly, a major consideration in developing an individual exercise prescription for a patient with a chronic disease is the selection of an appropriate exercise strategy. In order to maximize exercise training benefits, this strategy should be tailored to the individual's need. The focus of this paper is to provide a brief summary of the current literature regarding the use of HIIT to enhance the functional capacity of individuals with cardiovascular, pulmonary, and diabetes diseases.

Keywords: Cardiovascular disease; Diabetes; Low-intensity exercise interval training; Medical management plan; Oxygen consumption; Pulmonary disease

1. Introduction

High-intensity interval training (HIIT) became popular for training athletes during the early 1950s when Emil Zátopek, an Olympic champion long-distance runner, won the 1952 Helsinki Olympic 10,000 m race after utilizing HIIT.[1,2] HIIT utilizes repeated short to long bouts of relatively high-intensity exercise alternated with recovery periods of either low-intensity exercise or rest.[3] As described by this broad definition, this review highlights present research literature for various forms of HIIT in comparison to traditional moderate-intensity continuous exercise training (MCT).

The basic premise underlying HIIT is that a greater volume of higher intensity exercise is accumulated during a single exercise session compared to energy expenditure-matched steady state MCT.[1,4] Cardiovascular fitness improvements are reported with HIIT, and these improvements are similar or superior to steady state MCT performed by healthy adults. Reindell and Roskamm[5] described the ability of HIIT to enhance both anaerobic and aerobic fitness to higher levels when HIIT alternates periods of high-intensity exercise greater than 75% maximal oxygen consumption (VO_{2max}) with accompanying low-to-moderate-intensity recovery periods performed at 40%–50% of VO_{2max}.[1] In the past several decades, scientists have had renewed interest to better understand the use of HIIT as part of the medical management plan for individuals with a chronic disease. The focus of this paper is to briefly summarize the current literature pertaining to the use of HIIT to enhance functional capacity of individuals with cardiovascular, pulmonary, and type 2 diabetes (T2D) diseases. These diseases are highlighted because they were the first to have widely adopted exercise rehabilitation programs.

2. HIIT

HIIT encompasses exercise prescriptions that are tailored to individual needs and can be used in most any exercise setting. This ability to adapt makes HIIT a valuable tool in the exercise programming of patients with a chronic disease.[2,6] Before

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Table 1
Examples of high-intensity interval training.

Population	Work to recovery ratio	High-intensity	Low-intensity	Number of cycles
Sedentary	2:1	30 s each: push-ups, squats, butt kicks, triceps dips, side lunges, jumping jacks, sit-ups	15 s recovery between each activity; 1 min between each cycle	3 (1 cycle = 30 s per exercise alternated with 15 s recovery)
Recreationally trained	2:1	20 s each: squat jacks, push-ups with oblique knee (alternating), star jumps, mountain climbers, thigh slap jumps, burpees, high knees, jumping lunges	20 s between every other activity; 1 min between each cycle	4 (1 cycle = 2 exercises (20 s each) alternated with 20 s recovery)
Running (sprint)	1:9	30 s maximal effort sprint (9+ on 1–10 RPE scale)	4.5 min low-intensity jog (4–5 on 1–10 RPE scale)	4
Swimming	1:1	50 m sprint—freestyle (8+ on 1–10 RPE scale)	50 m slow—breast stroke (4–5 on 1–10 RPE scale)	6
Soccer	1:6 fartleks	Runner at the back of a 6-person line sprint to the front of the line (9+ on 1–10 RPE scale)	Low-intensity jog (4–5 on 1–10 RPE scale) until you become the runner at the back of the line	30 min total
Basketball	Shuttle runs	Sprint from baseline to given point on court (near free throw line, top of near 3 point arch, mid court, top of far 3 point arch, far free throw line, far baseline) and back	15 s rest between each distance; 1 min between each cycle	5

Abbreviation: RPE = rating of perceived exertion.

discussing the use of HIIT in patients with chronic diseases, a brief description of HIIT programming in healthy individuals is presented. Using healthy individuals, Midgley et al.[7] reported that the high-intensity components of HIIT resulted in greater training improvements in maximal aerobic capacity compared to the improvements elicited by MCT. The precise mechanism responsible for this effect is not well understood, but various physiological pathways exist that might explain this adaptation. One proposed mechanism is that HIIT increases aerobic capacity and thus delays the onset of exhaustion. This enhanced aerobic capacity slows the depletion of anaerobic fuel stores prolonging time to exhaustion.[7] In healthy trained subjects, Billat et al.[8] compared intermittent running (30 s at VO_{2max} alternated with 30 s at 50%VO_{2max}) to continuous, strenuous running. The high-intensity components of intermittent running provided a greater exercise training stimulus than continuous running and are potentially responsible for the greater VO_{2max} improvements that are correlated with oxygen consumption found after exercise training.

Exercise intensity for both high-intensity interval (referred to as the work interval) and low-intensity exercise interval (referred to as the recovery interval) is measured by any of the following methods: percentage heart rate maximum (%HR_{max}), percentage heart rate reserve (%HRR), percentage VO_{2max}, percentage VO_2 reserve (%VO_2R), rating of perceived exertion (RPE), metabolic equivalence, or competition pace. These measures are used to develop the work to recovery ratio. A typical ratio is 1 min of high-intensity exercise followed by 1 min of low-intensity exercise (ratio of 1:1) (refer to Table 1 for other examples of HIIT programming).

3. Chronic disease management

A cycle of deconditioning is started when an individual with a chronic disease becomes less physically active. In turn, this deconditioning leads to a loss of functional capacity and subsequent further reductions in the ability to perform both exercise and activities of daily living. If this cycle of deconditioning is not stopped, the consequences of poor long-term health and suboptimal quality of life are greatly increased. In order to stop this downward cycle, individuals with a chronic disease should receive counseling regarding the safety, effectiveness, and proper use of physical activity and prescribed exercise to enhance health.[9–12] Considerable evidence exists regarding the use of exercise training strategies as part of the medical management plan for patients with a chronic disease that demonstrate significant improvements in exercise tolerance and quality of life.[9,11] In the past several decades, much attention has been directed toward primary and secondary disease prevention/treatment by developing the role of physical activity and exercise to improve health and physical fitness. From a secondary disease prevention/treatment perspective, the initial goals for incorporating exercise in rehabilitation programs are to reverse the physical deconditioning resulting from sedentary behavior, optimize physical functioning by exercise programming, and enhance overall health and well-being.[10]

3.1. Cardiovascular

Of the many chronic diseases, cardiovascular disease is the most studied regarding the potential advantages for using HIIT protocols. Guiraud et al.[6] and Cornish et al.[13] reviewed HIIT and cardiac rehabilitation literature and highlighted the overall consensus for HIIT's ability to improve peak oxygen consumption (VO_{2peak}).[6] These reports emphasized that individuals using HIIT methods achieved greater positive changes in cardiovascular risk factors than did MCT. Because VO_{2peak} is a strong predictor of morbidity and mortality, clinicians are interested in the mechanisms associated with how HIIT affects these functional changes. Although the mechanisms for these changes are