

Review

Comparison of Different Forms of Exercise Training in Patients With Cardiac Disease: Where Does High-Intensity Interval Training Fit?

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ABSTRACT

In this review, we discuss the most recent forms of exercise training available to patients with cardiac disease and their comparison or their combination (or both) during short- and long-term (phase II and III) cardiac rehabilitation programs. Exercise training modalities to be discussed include inspiratory muscle training (IMT), resistance training (RT), continuous aerobic exercise training (CAET), and high-intensity interval training (HIIT). Particular emphasis is placed on HIIT compared or combined (or both) with other forms such as CAET or RT. For example, IMT combined with CAET was shown to be superior to CAET alone for improving functional capacity, ventilatory function, and quality of life in patients with chronic heart failure. Similarly, RT combined with CAET was shown to optimize benefits with respect to functional capacity, muscle function, and quality of life. Furthermore, in recent years, HIIT has emerged as an alternative or complementary (or both) exercise modality to CAET, providing equivalent if not superior benefits to conventional continuous aerobic training with respect to aerobic fitness, cardiovascular function, quality of life, efficiency,

RÉSUMÉ

Dans le cadre de cet article, nous discuterons des plus récents types d'exercice physique offerts aux patients atteints d'une maladie cardiaque de même que de leur comparaison ou de leur combinaison, ou encore des deux, dans le cadre de programmes de réadaptation cardiaque à court et à long terme (programmes de phases II et III). Parmi les types d'exercices abordés, on retrouve notamment l'entraînement des muscles inspiratoires, l'entraînement contre résistance, l'entraînement aérobique en continu et l'entraînement par intervalles à haute intensité. Un accent particulier a été mis sur l'entraînement par intervalles à haute intensité comparé ou combiné (ou les deux) à d'autres types d'exercices, notamment l'entraînement aérobique en continu et l'entraînement contre résistance. Par exemple, il a été démontré que l'entraînement des muscles inspiratoires combiné à l'entraînement aérobique en continu était supérieur à l'entraînement aérobique en continu seul pour améliorer la capacité fonctionnelle, la fonction ventilatoire et la qualité de vie des patients souffrant d'insuffisance cardiaque chronique. De même, il a été démontré que

Peak oxygen uptake ($\dot{V}O_{2peak}$) is closely associated with morbidity and mortality in patients with cardiac disease.^{1–3} Also, cardiac rehabilitation that includes an exercise training component was shown to be safe and to improve prognosis both in individuals with coronary heart disease (CHD) and in those with chronic heart failure (CHF).^{4–9} Numerous other clinical benefits of exercise training in patients with cardiac disease are well documented and include improvements in

cardiovascular, lung, and skeletal muscle functions; endurance; quality of life; inflammation; depressive symptoms; stress; and cognitive functions.^{10–12} Therefore, exercise training is now a cornerstone of the nonpharmacologic treatment of patients with CHD and CHF and is well integrated into North American and European cardiology guidelines.^{10,13,14} However, there is still a need to understand which components of exercise training prescription—including frequency, intensity, time (duration), type (modality),¹¹ and their combination—are the most efficient at improving cardiovascular adaptations to exercise training. The purpose of this article is to review the different forms of exercise training in an effort to optimize exercise training adaptations both in individuals with CHD and in those with CHF. We have chosen to focus on 3 different forms of exercise training that may represent complementary approaches, including inspiratory muscle training (IMT), resistance training (RT), and

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safety, tolerance, and exercise adherence in both short- and long-term training studies. Finally, short-interval HIIT was shown to be useful in the initiation and improvement phases of cardiac rehabilitation, whereas moderate- or longer-interval (or both) HIIT protocols appear to be more appropriate for the improvement and maintenance phases because of their high physiological stimulus. We now propose progressive models of exercise training (phases II-III) for patients with cardiac disease, including a more appropriate application of HIIT based on the scientific literature in the context of a multimodal cardiac rehabilitation program.

aerobic exercise training (both continuous and high-intensity interval training [HIIT]). Only phases II (short-term) and III (long-term/maintenance) of cardiac rehabilitation are discussed. Finally, we propose how HIIT may be incorporated appropriately into progressive phase II and phase III exercise training models (phase II/III), based on current scientific evidence.

IMT in Patients With Cardiac Disease

Respiratory muscle training (especially inspiratory muscles) has been prescribed in patients with cardiac disease, essentially in patients with CHF but also in patients with CHD.¹⁵⁻¹⁷ Inspiratory muscle weakness (IMW) is highly prevalent in CHF; this muscle dysfunction occurs in approximately 30%-50% of patients.¹⁸ This condition is defined as a maximal inspiratory pressure (P_{imax}) < 70% of predicted values and is an independent predictor of mortality in patients with CHF, even those treated with β -blockers.^{19,20} The benefits of IMT alone in patients with cardiac disease are well described, especially in those with CHF and IMW.^{16,18,21-23} They include improvements in $\dot{V}O_2$ peak, $\dot{V}O_2$ kinetics during recovery, ventilatory efficiency ($\dot{V}E/\dot{V}CO_2$ slope), dyspnea, and functional capacity (6-minute walk test distance).^{16,18,21,22} Inspiratory muscle training is prescribed using a percentage of P_{imax},²⁴ starting at 30%, with adjustment of the intensity every 7-10 days (up to 60% of P_{imax}), depending on symptoms and response to treatment. The total session time may vary between 20 and 90 min/d (continuous or not) and the frequencies between 3 and 7 times/wk.^{17,19,22-24} Furthermore, total session time can be divided into 2-3 sessions during the day. With respect to duration of IMT, some benefits were observed after only 4 weeks,^{16,25} and the duration reported across IMT studies was from 4-12 weeks in patients with cardiac disease.¹⁵ In general, IMT can be performed at home with hand-held devices that are very

l'entraînement contre résistance combiné à l'entraînement aérobique en continu optimisait les bienfaits obtenus relativement à la capacité fonctionnelle, à la fonction musculaire et à la qualité de vie. De plus, au cours des dernières années, l'entraînement par intervalles à haute intensité s'est révélé une modalité d'exercice pouvant remplacer ou compléter (ou les deux) l'entraînement aérobique en continu puisqu'il a donné lieu à des bienfaits équivalents sinon supérieurs à l'entraînement aérobique en continu traditionnel en ce qui a trait à la capacité aérobique, à la fonction cardiovasculaire, à la qualité de vie, à l'efficacité, à l'innocuité, à la tolérance et à l'observance du traitement dans le cadre d'études sur les programmes d'exercice à court et à long terme. Enfin, il a été démontré que l'entraînement par intervalles courts à haute intensité était utile lors des phases d'amorce et d'amélioration en réadaptation cardiaque, tandis que l'entraînement par intervalles moyens ou longs, ou les deux, à haute intensité paraissait plus adapté aux phases d'amélioration et de maintien en raison de l'important stimulus physiologique qu'il offrait. En nous basant sur des données scientifiques appliquées dans le cadre d'un programme de réadaptation cardiaque combiné, nous sommes désormais en mesure de proposer aux patients atteints d'une maladie cardiaque des modalités d'entraînement progressif (phases II et III) de même qu'une utilisation plus appropriée des divers types d'entraînement par intervalles à haute intensité.

affordable.¹⁵ In theory, this training modality should be prescribed to patients with cardiac disease who present with IMW, in addition to conventional aerobic training to optimize cardiopulmonary benefits (see next section). Considered an easy self-administrated training method (in most studies, patients have trained at home), IMT is an additional possibility for rehabilitation prescribers.

IMT Combined With Continuous Aerobic Exercise Training

The effects of IMT combined with continuous aerobic exercise training (CAET) vs CAET alone have also been studied in patients with CHF.^{21,26} Combined training was found to have superior effects (from 9%-38%) on several end points, including $\dot{V}O_2$ peak, endurance, P_{imax}, ventilatory efficiency, muscle function, and quality of life.^{21,26} In summary, given its benefits, IMT should not be overlooked in the context of a complete cardiac rehabilitation program and would appear to be particularly useful in patients with CHF, who are more likely to suffer from IMW, although this training modality is also indicated for debilitated patients with CHD. A practical guide to the application of IMT (progressive training model) is given in [Supplemental Tables S1 and S2](#).

RT in Patients With Cardiac Disease

RT is recommended as a complement to aerobic training, providing additional benefits with respect to glucose metabolism, body composition, bone density, and muscle composition strength and endurance in patients with cardiac disease.^{10,11,27} In particular, patients with CHF often demonstrate altered skeletal muscle function and muscle wasting, which are important determinants of exercise intolerance and can severely impact activities of daily living.^{10,11,27} An RT

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