EDITORIAL FOCUS

Exercise training in heart failure: which training modality works best?

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Training in Heart Failure—from Contraindication to Guideline Therapy

During the last three decades, exercise interventions in chronic heart failure patients have seen a remarkable career: Until the late 1980s, standard cardiology textbooks recommended a reduction of physical activity levels as standard of care in heart failure patients. It was a true paradigm shift when Coats et al. (3) compared exercise training and activity restriction in a prospective randomized crossover trial for the first time and proved that exercise training was safe and significantly improved exercise tolerance, peak oxygen consumption, and symptoms. Coats et al. (3) were able to show that there is no correlation between left ventricular ejection fraction (LVEF) and exercise capacity in heart failure (HF) patients but a clear relation between skeletal muscle mass and exercise capacity. In consequence, peripheral factors became therapeutic targets for training interventions: skeletal muscle atrophy and metabolic dysfunction, reduced strength of respiratory muscles, endothelial dysfunction, and systemic inflammatory activation. Due to its practicability, safety, and the ease to monitor blood pressure, heart rate, and ECG steady state, aerobic ergometer training became a standard modality for exercise training in heart failure. However, there are multiple ways to change the training method:

1. Training intensity (% of \( \dot{V}_{\text{O}_2}\max \) or max. heart rate);
2. Type of training (endurance, resistance, combined);
3. Method of training (continuous or steady state, intermittent, interval);
4. Training modality (concentric vs. eccentric);
5. Training target (systemic vs. regional training, e.g., respiratory training);
6. Training control (supervised vs. nonsupervised); and
7. Training location (hospital based, outpatient, home based).

Of these, 1 to 3 and 5 to 7 have been extensively studied. Since only moderate-intensity endurance training has shown prognostic benefits for the patient [reduced rehospitalization rate (10), reduced mortality (6, 11)], only this type of training received a IA guideline recommendation (12). Recently, hopes that high-intensity interval training would receive a IA guideline recommendation (12) Training location (hospital based, outpatient, home based).

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Of these, 1 to 3 and 5 to 7 have been extensively studied. Since only moderate-intensity endurance training has shown prognostic benefits for the patient [reduced rehospitalization rate (10), reduced mortality (6, 11)], only this type of training received a IA guideline recommendation (12). Recently, hopes that high-intensity interval training would prove better results than continuous steady-state training were shattered by the publication of the SMARTTEX study, in which previous results of single center studies regarding better exercise capacity after high-intensity interval training (14) could not be reproduced (4). Pure resistance training is ineffective in improving exercise capacity in heart failure patients while combined endurance-resistance training is effective in improving exercise capacity and vascular function (9).

What Exactly Is Eccentric Exercise and Why Could It Offer Certain Advantages for Patients with Reduced Exercise Capacity?

“When the force applied to a muscle exceeds the force produced by the muscle it will lengthen, absorbing mechanical energy. These eccentric contractions, which result in both braking and storing elastic recoil energy in normal locomotion, require very little metabolic energy, yet they are characterized by high force production” (8). This excellent description of eccentric exercise by Lindstedt et al. (8) describes the physiologic principle of eccentric training: The contraction of the muscle while lengthening. The classical example is downhill walking.

Interestingly, downhill walking of stairs was first applied as a training modality in HFrEF patients and yielded similar improvements of muscle strength as compared with stair ascending (13). However, average heart rate for the descending group was lower during the last minute of exercise compared with the ascending group (98 ± 5 vs. 139 ± 7 beats/min, respectively). In addition, based on the Borg rating, average perceived exertion was lower during the last minute for the descending group compared with the ascending group (8.1 ± 1.3 vs. 13.6 ± 1.9, respectively). This reduced cardiovascular stress theoretically makes eccentric training an interesting alternative for HFrEF patients (Fig. 1).

This year, Chasland et al. (2) reported lower \( \dot{V}_{\text{O}_2} \) for similar workload in eccentric vs. concentric training (eccentric cycling) in the same patient cohort with HFrEF included in the paper of Haynes et al. (5). The report of Haynes et al. now focuses on physiological effect of eccentric training on vascular function and platelet function: potential surrogate markers for improvements in outcome. Both parameters (platelet function as measured by flow cytometric determination of glycoprotein IIb/IIa activation and granule exocytosis in the presence and absence of platelet agonists) and flow-mediated dilatation were unchanged after eccentric training. The authors take their findings as arguments in favor of the safety profile of eccentric training in HFrEF patients (5).
Why Can Eccentric Training Not Replace Aerobic Endurance Training in HFrEF?

Although there are good theoretical reasons to favor eccentric over concentric training, the HFrEF study of Haynes et al. (5) should be cautiously interpreted.

First, the chronic training effects are disconnected from the acute response to a single bout of exercise. They follow an entirely different long-term physiological adaptation process. It may well be that the lower VO2 during eccentric vs. concentric training could turn out to lead to lower than expected prognostic benefits. Until now, only training interventions in HFrEF resulting in significantly improved VO2max reduced mortality and hospitalization, in proportion to the relative gain in VO2max (6). It is therefore premature to advocate eccentric training as a new standard of care and Haynes et al. (5) are prudent to end their article with words of caution.

Second, the sample size in the current proof-of-principle study is small. While the acute effects of eccentric cycling on vascular function and platelet activation with eccentric training did not differ from concentric cycling training, both larger and longer eccentric training studies are clearly needed to corroborate the findings.

Finally, despite the enthusiasm to look for more effective training methods in HFrEF, it must be emphasized the we should be equally enthusiastic in implementing the class IA guideline recommendation for moderate-intensity aerobic endurance training (concentric) in both the US and European heart failure guidelines in our patients (12). Today, <20% of all patients benefit from well-established rehabilitation programs with documented benefits in quality of life, exercise capacity, and prognosis (7, 11).

DISCLOSURES

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

AUTHOR CONTRIBUTIONS

S.G. drafted manuscript; S.G. edited and revised manuscript; S.G. approved final version of manuscript.

REFERENCES