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Eccentric Exercise in Coronary Patients: Central Hemodynamic and Metabolic Responses
[CLINICAL SCIENCES: Clinical Investigations]

MEYER, KATHARINA[1]; STEINER, ROGER[1]; LASTAYO, PAUL[2]; LIPPUNER, KURT[3]; ALLEMANN, YVES[1]; EBERLI, FRANZ[1]; SCHMID, JEAN[1]; SANER, HUGO[1]; HOPPELER, HANS[4]

[1]Swiss Cardiovascular Center Bern, Cardiology, University Clinic, University of Bern, SWITZERLAND;

[2]University of Utah, Salt Lake City, UT;

[3]Osteoporosis Unit, University Clinic, and

[4]Department of Anatomy, University of Bern, SWITZERLAND

Address for correspondence: PD Dr. Katharina Meyer, FACSM, University of Bern & Swiss Health Observatory, Espace de l'Europe, 2010 Neuchatel, Switzerland; E-mail: katharina.e.meyer@freesurf.ch.

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ABSTRACT

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Purpose: With lengthening (eccentric) muscle contractions, the magnitude of locomotor-muscle mass and strength increase has been demonstrated to be greater compared with shortening (concentric) muscle contractions. In healthy subjects, energy demand and heart rate responses with eccentric exercise are small relative to the amount of muscle force produced. Thus, eccentric exercise may be an attractive alternative to resistance exercise for patients with limited cardiovascular exercise tolerance.

Methods: We tested the cardiovascular tolerance of eccentric exercise in 13 coronary patients (ages 40-66) with preserved and/or mild reduced left ventricular function. Patients were randomly assigned to either an eccentric (ECC; $N = 7$) or a concentric (CON; $N = 6$) training group and trained for 8 wk. Training workload was increased progressively (from week 1 to 5) to an intensity equivalent to 60% $\dot{V}O_{2peak}$.

Results: On average, maximum power output achieved with ECC was fourfold compared with CON (357 ± 96 W vs 97 ± 21 W; $P < 0.005$), whereas measures of oxygen uptake and blood lactate were significantly lower ($P < 0.05$ each), and ratings of perceived exertion were similar for ECC and CON. During a 20-min session of ECC and CON, central hemodynamics was measured by means of right heart catheterization. During ECC, responses of mean arterial blood pressure, systemic vascular resistance, pulmonary capillary pressure, cardiac index, and stroke work of the left ventricle on average were in the normal range of values and similar to those observed during CON. Compared with baseline, after 8 wk of training, echocardiographic left ventricular function was unchanged.

Conclusion: The results indicate uncoupling of skeletal muscle load and cardiovascular stress during ECC. For low-risk patients with coronary heart disease without angina, inducible ischemia, or left ventricular dysfunction, ECC can be recommended as a safe new approach to perform high-load muscular exercise training with minimal cardiovascular stress.

To improve muscle mass and strength in patients with cardiovascular disease, a training method would be desirable which would allow high intense muscular load with resulting low cardiovascular stress. Fifty years ago, it was demonstrated that eccentric muscle work (i.e., lengthening of muscle while producing force (2)) has certain advantages over concentric work (i.e., shortening of muscle while producing force). When muscles produce tension eccentrically, greater torque is developed than in concentric contractions, particularly at high angular velocities (8,9,11). Furthermore, eccentric contractions not only produce greater torque but also do so at a greatly reduced oxygen requirement (1,3). During submaximal cycling, the eccentric oxygen demand has been reported to be only one sixth to one seventh of that of cycling concentrically at the same workload (3). Previously, it was demonstrated in healthy subjects that 8 wk of eccentric cycle ergometer training (ECC) resulted in a 40% increase in both muscle strength and apparent cross-sectional area of biopsied muscle fibers, whereas cardiovascular stress and metabolic demand were kept at a low level (10,13). Thus, in principle, ECC could be an attractive alternative to resistance exercise for patients with limited cardiovascular exercise tolerance. Currently, there are no data on central hemodynamic variables obtained during ECC. To train coronary patients safely, this information is needed. This study was designed as a pilot project in patients with coronary heart disease to assess central hemodynamic and metabolic responses during ECC as compared with traditional conventional concentric cycle ergometer training (CON).