The importance of VO2max, Exercise Economy and Anaerobic Energy Turnover in a training-induced increase in Exercise Capacity during Rehabilitation of Cardiac Patients

Anette Lindahl Mikkelsen, Ole Bækgaard Nielsen, Mette Krintel, Sussie Lausten, Kristian Overgaard
Aarhus University, Denmark; Aarhus University Hospital, Denmark

Introduction

A standard method to evaluate exercise capacity is to determine VO2max during cardiopulmonary exercise testing, which is considered as the best reproducible index of cardiopulmonary function. In most studies, improvements in maximal power output (Pmax) in all-out cardiopulmonary exercise tests are closely related to improvements in VO2max. Based on a pilot study from Aarhus University Hospital, Denmark, suggesting in some patients the increase in maximal power output (Pmax) with exercise training was larger than what can be explained by increased VO2max, the aim of study was to analyse the relative contributions of the increase in VO2max, exercise economy (EC) and anaerobic energy turnover (AnET) to the training-induced increase in Pmax.

Objectives

1. the contribution of increased O2max, improved exercise economy and anaerobic energy turnover to the increased exercise capacity (Pmax) after a 8-wk rehabilitation program
2. the usefulness of individual exercise tests in clinical rehabilitation programs for cardiac patients.

Materials & Methods

In 85 cardiac patients, VO2 and power output (P) were measured during an incremental ramp-test (8-12 min) performed on a bicycle ergometer to exhaustion before and after an 8-wk exercise rehabilitation program. VO2peak measured at Pmax was taken as an estimate of VO2max. MEasured in W per L O2 as the slope between VO2 and P in the interval between 25 % of Pmax and the power at a Respiratory Exchange Ratio of 1 using regression analysis. AnET was calculated as Pmax - (EC x VO2peak). The contribution of increased VO2peak to the increased Pmax after the 8-wk rehabilitation program (ΔWatt(VO2)) was calculated as: ΔWatt(VO2) = [VO2peak(2) - VO2peak(1)] x EC(1); the contribution from EC as: ΔWatt(EC) = [EC(2)-EC(1)] x VO2peak(1); and contribution from AnET as: ΔWatt(AnET) = AnET(2)-AnET(1). The calculations are illustrated in Fig. 1.

Results & Discussion

Before the rehabilitation program Pmax and VO2max were 129 ± 44 W and 1,575 ± 485 mL O2•min-1 and increased by 12 % and 13 % (P < 0.001) (Fig. 2a and 2b), respectively, when tested after the rehabilitation program. The mean RER at Pmax was 1.20 ± 0.11 and 1.21 ± 0.10 before and after the rehabilitation program, respectively. Pmax and VO2max correlated both before and after the rehabilitation program. Consistent with this, the determinations of the contribution from changed VO2max, EC and AnET indicated that only improved VO2max contributed to the increase in Pmax for the average patient (P < 0.01). There were, however, large inter-subject variations in the relative contributions from VO2max, EC and AnET to the increase in Pmax. Thus, ΔWatt(VO2) was 22 ± 29 W, ΔWatt(EC) was 2 ± 32 W and ΔWatt(AnET) was -2 ± 24 W (Fig. 2c).

However, an unexpected negative correlation between ΔWatt(VO2) and ΔWatt(EC) (Fig 3a and 3b) indicated that a large part of the scatter in ΔWatt(VO2) and ΔWatt(EC) was caused by variation in measurements of VO2 produced by the equipment. This conclusion is supported by the observation that similar correlation could be obtained for the values for ΔWatt(VO2) and ΔWatt(EC) for the average patient just by introducing a variation in the apparent values for VO2 during the exercise test (Fig. 3b).

Conclusions

- Pmax and VO2peak increased during the rehabilitation program and showed good correlation.
- VO2peak was the only significant contributor to the increased Pmax for the average patient.
- The apparent influence of exercise economy and anaerobic energy turnover to the increase in Pmax in some patients was rather related to lack of precision of the VO2 measurements in the incremental ramp tests than to actual training-induced changes in EC and AnET.

Contact: amik@fi.au.dk