Cardiac rehabilitation: how much pain for the optimal gain?

J. A. Snoek • M. J. M. Cramer • F. J. G. Backx

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Exercise-based cardiac rehabilitation (CR) is effective in reducing total and cardiovascular mortality and hospital admissions with a reported relative risk of 0.87 (95 % CI 0.75, 0.99), 0.74 (95 % CI 0.63, 0.87) and 0.69 (95 % CI 0.51, 0.93) respectively [1]. This is a similar relative risk reduction as quitting smoking [2]. For all patients with an acute coronary syndrome (ACS), and for those who have undergone coronary artery bypass grafting (CABG), valvular surgery or even percutaneous coronary interventions (PCI) CR is widely recommended [3, 4].

Supervised CR (hospital or CR centre) is cost-effective for patients with myocardial infarction (MI) and heart failure compared with usual care (e.g. drug therapy) [5]. The present literature evaluating home-based and alternative delivery models of cardiac rehabilitation is insufficient to draw definite conclusions about cost-effectiveness. One of the few studies that evaluated the cost-effectiveness of supervised exercise-based CR by combining cost information with time trade-off measures of health-related quality of life and data on mortality, concluded that CR was an efficient use of health-care resources and may be economically justified [6]. In 2004, Yu et al. demonstrated, with a cost-utility analysis, a savings of \$668 per QALY gained at the end of 2 years of CR in a sample of MI and PTCA patients in Hong

Kong [7]. Both studies show that the cost/QALY are well under the accepted range of \$20,000/QALY. This is considered highly cost-effective.

Nevertheless despite the evidence for the reduction in morbidity and mortality and the cost effectiveness of CR, less than a third of the patients eligible for CR actually receive CR in the Netherlands [8]. Van Engen-Verheul et al. demonstrated that among patients who were diagnosed with an acute coronary syndrome (ACS) and/or therapeutic interventions (CABG, valve surgery or PCI, only 28.5 % received CR within the following year [8]. Among patients with chronic cardiovascular disease, CR participation was even lower. Determinants associated with lower CR uptake were: female gender, older age, type of intervention (i.e. higher CR uptake after CABG and lower CR uptake after elective PCI as compared with acute PCI), diagnosis (i.e. lower CR uptake in patients with unstable AP as compared with myocardial infarction), comorbidity, and a larger distance to the nearest CR provider.

In 2011 the Netherlands Society of Cardiology and the Dutch Heart Association updated their guideline for CR [2]. CR has become a multidisciplinary multifaceted intervention aiming not only at achieving physical goals, but also psychological, social and important secondary goals to induce lifestyle changes and improvement of medication adherence [9]. The new guideline states that patients entering CR should be offered an individualised rehabilitation program with a typical duration of 6–12 weeks, consisting of group-based therapies (exercise training, relaxation and stress management training, education therapy, and/or lifestyle change therapy) and, when indicated, additional individual counselling (e.g. by a psychotherapist or dietician) [8].

Also the Royal Dutch Society for Physical Therapy updated their guideline in 2012 [10]. Alongside classical exercise modalities as aerobic and strength training, high intensity interval training (4×4 min 80–90 % VO₂ max) is

J. A. Snoek (✉)
Sport Medicine Department, Isala Clinics Zwolle, PO Box 10500,
8000 GM, Zwolle, the Netherlands
e-mail: j.a.snoek@isala.nl

M. J. M. Cramer
Cardiology Department, University Medical Centre Utrecht,
Utrecht, Netherlands

F. J. G. Backx
Sport Medicine Department, University Medical Centre Utrecht,
Utrecht, Netherlands

advocated. While amongst health care workers this remains a controversial issue, recent studies show that it is safe and can even be more effective than aerobic endurance training [11–15]. This finding is in consistence with an old adage of exercise physiology: ‘No pain, no gain’. Near-maximal exercise intensities result in greater improvement of VO₂ max (maximal oxygen uptake) than moderate to vigorous intensities [16]. Central and peripheral adaptations in oxygen transport and utilisation are training-modality dependant variables. Interval training has the potential to improve both central and peripheral components of VO₂ max whereas continuous training (endurance training at the same speed/intensity) is mainly associated with greater oxygen extraction [17]. In sedentary subjects Daussin et al. showed that fluctuations of workload and oxygen uptake during training sessions, rather than exercise duration or global energy expenditure, are key factors in improving muscle oxidative capacities [18]. Recently, in an excellent overview, Mann and Rosenzweig summarised the systemic and cardiac specific effect of exercise (e.g. skeletal and cardiac muscle hypertrophy and hyperplasia, improved vascular flow, vaso-reactivity, angiogenesis, insulin sensitivity, oxidative phosphorylation, stroke volume, cardiac output and cardiac protection by less ischaemic injury etc.) [19]. Exercise physiological knowledge can help patients to achieve higher VO₂ max, less hospital admissions and a lower morbidity and mortality. A careful examination of possible contraindications for near-maximal exercise intensities remains of course essential.

In our opinion the importance and the exact content of an adequate CR exercise protocol is not always sufficiently appreciated. The Cochrane review from Heran shows a

training frequency variation between two times weekly for 4 weeks and three times weekly for 12 months [1]. Apparently there is no uniformity in training volume applied to CR programs. Insight into what CR centres dictate is therefore mandatory to develop strategies and interventions to improve the quality of exercise-based CR. Vromen et al. demonstrate in an interesting and relevant study that Dutch CR centres show considerable variation in methods for determining and prescribing exercise intensity and volume [20]. They performed a survey among CR centres in the Netherlands showing that not all centres use a symptom-limited exercise test to determine exercise capacity and while all CR centres applied aerobic training, strength training was less frequently prescribed. There was also considerable variation in training intensity for both aerobic and strength training, as well as in training volume (1–20 h and 1–18 h respectively). In total 45 centres completed the questionnaires (58 %).

Several internal and external barriers for successful CR are summarised by Vromen et al. Future research should focus on these barriers to improve the implementation of CR guidelines. Lack of resources and budget ceilings of course play a role. In the coming years this will be a recurring problem with planned cuts in health care.

To reduce costs and to differentiate between patient groups, e-health solutions might be helpful in the future. New applications on mobile phones (Fig. 1) have the possibility to make customised training programs focused on individual goals and needs for different patient groups based on current guidelines. Also the possibility to stimulate, monitor and adjust the training program at home can help to achieve a higher exercise capacity and maintenance 1 year after starting CR. The cardiology and sports medicine departments of both the UMC Utrecht and the Isala Clinics Zwolle intend to set up a multi-centre prospective RCT to evaluate the (cost) effectiveness of e-health solution and CR. Total time exercised and exercise intensity will be wirelessly transmitted to a secure database. Both patients and health care workers gain insight into exercise patterns. A new look at e-health CR has a real chance to enhance secondary prevention.

Fig. 1 Mobile phone with Mobihealth training application and Zephyr Heart rate monitor. The Bluetooth heart rate belt transmits wireless heart rate frequency and variability to the mobile phone

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