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Economic evaluation of exercise-based cardiac rehabilitation in patients with a recent acute coronary syndrome

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Health care decision-making requires evidence of the cost-effectiveness of medical therapies. We evaluated the cost-effectiveness of exercise-based cardiac rehabilitation (ECR) implemented according to guidelines. All the patients (n = 204) had experienced a recent acute coronary syndrome and were randomized to a 1-year ECR (n = 109) or usual care (UC) group (n = 95). The patients' health-related quality of life was followed using the 15D instrument and health care costs were collected from electronic health registries. The cost-effectiveness of ECR was estimated based on intervention and health care costs and quality-adjusted life years (QALYs) gained. The total average cost per patient was lower in ECR than in UC. The incremental cost was divided by the baseline-adjusted incremental QALYs (0.045), yielding an incremental cost-effectiveness ratio of −€24511/QALYs. A combined endpoint of mortality, recurrent coronary event, or hospitalization for a heart failure occurred for five patients in ECR and 16 patients in UC (HR 3.9, 95% CI 1.4–10.6, P = 0.004, relative risk reduction 73%, number needed to treat eight). ECR is a dominant treatment option and decreases the occurrence of adverse cardiac events. These results are useful for decision-making when planning optimal utilization of resources in Finnish health care.

Exercise-based cardiac rehabilitation (ECR) in low-risk patients after myocardial infarction, percutaneous coronary intervention (PCI), or heart failure has reduced hospital admissions and improved health-related quality of life compared with usual care (UC) alone in many western societies (Anderson & Taylor, 2014). ECR programs have also reduced overall premature mortality by about 20% and cardiac deaths by about 30% in comparison with UC of cardiac patients (Jolliffe et al., 2001; Taylor et al., 2004; Heran et al., 2011; Lawler et al., 2011). Despite the proven clinical effectiveness of ECR (Fletcher et al., 2013), many patients faced with a coronary artery disease (CAD) do not become or remain regularly active, mainly due to low cardiac rehabilitation referral, uptake, and adherence rates (Kotseva et al., 2013). Therefore, there is an urgent need for comprehensive ECR programs with effective risk factor management, appropriately adapted to the medical, cultural, and economic settings of a country.

The escalation of health care costs over the past years has restricted financing for expansion of ECR and prompted the need for sound evidence of the cost-effectiveness of ECR before it is taken into use more widely and incorporated into health care. ECR programs have been found to significantly reduce health care costs in the U.S.A. (Ades et al., 1992, 1997; Oldridge et al., 2008). Similarly, a German study indicated that 12-month ECR for CAD patients led to significantly less new cardiac events and improved functional capacity with lower health care cost compared with PCI-treated patients (Hambrecht et al., 2004). Although international evidence shows that ECR reduces health care costs, this information cannot be directly applied to the economic settings of each country. Health care systems, care practices, and relative prices of health care investments vary from country to country. Therefore, it is important to have country-specific data to support decision-making (Salo & Sintonen, 2002). The aim of the present study is to assess the cost-effectiveness of

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ECR compared with UC in the Finnish health care setting.

Material and methods

Subjects and study protocol

The present EFEX-CARE (Effectiveness of Exercise Cardiac Rehabilitation) study has been registered at ClinicalTrials.gov, Identifier Record NCT01916525. CAD patients who suffered from acute coronary syndrome (ACS) were recruited from a consecutive series of patients in the Division of Cardiology of Oulu University Hospital. They all underwent coronary angiography to confirm the CAD. There were 876 ACS patients in the EFEX-CARE database from February 2011 through May 2014. Of those patients, 548 were excluded from the study due to the following criteria: NYHA class ≥III, scheduled or emergency procedure for bypass surgery, unstable angina pectoris, severe peripheral atherosclerosis, diabetic retinopathy or neuropathy, or inability to perform regular home-based exercises, for example, due to severe musculo-skeletal problems. A group of patients ($n = 124$) declined to participate, for example, because of a lack of time or motivation or because of work commitments. Altogether 204 patients were willing to participate and were selected into the ECR and UC groups. In total, 109 patients in the exercise training group and 95 patients in the control group took part in the study and were included in the analyses according to the intention-to-treat principle (Fig. 1). The study was carried out according to the Declaration of Helsinki, the local committee of research ethics of the Northern Ostrobothnia Hospital District approved the protocol, and all the subjects gave written informed consent.

Exercise-based cardiac rehabilitation

The ECR program started as soon as possible after hospital discharge, as suggested earlier (Pack et al., 2013). Patients willing to participate were randomized to ECR or UC and were called about 1 week after their hospital discharge to inform them about which group they belonged to. The patients in the ECR group were invited to the Verve Rehabilitation Center (Oulu, Finland) to start the 1-year ECR program, which included four to five exercise sessions on a weekly basis. During the first 6 months, once a week they visited our Cardiac Rehab gym equipped with aerobic and strength exercise devices (Smart Card system, Ab HUR Oy, Kokkola, Finland), where they were individually guided in both gym and home-based exercise training by a physical therapist. On the first two visits to the gym they were guided individually by a physical therapist, including instruction on use of the gym, a home-based exercise training program for the first month, how to fill in the exercise training diary, use of the perceived ratings of exertion (RPE) scale from 6 to 20 (Borg, 1982) to evaluate the average intensity of a single exercise session, a schedule for gym visits, and use of an accelerometer. Thereafter, the patients exercised in the gym in groups of no more than eight patients at the same time. However, if they needed help, a physical therapist was always available.

To improve motivation and the rate of adherence to ECR (Davies et al., 2010), we included, in addition to weekly visits to the gym, also a wrist-worn accelerometer (Polar Active, Polar Electro Oy, Kempele, Finland) in each patient's program for the first 6 months. The patients were instructed to continuously wear the accelerometer and they were able to monitor their own realized daily physical activity exceeding 3.5 metabolic equivalents (METs) from the display of the accelerometer (min/day). The physical therapist also gave feedback to the patients after each gym visit from indirectly measured peak exercise capacity during warm-up (Hautala et al., 2013). In addition, the core components of cardiac rehabilitation (Corra et al., 2010; Fletcher et al., 2013) were took into account, for example, dietary counseling for each patient or a checkup by a medical doctor when appropriate. After 6 months, home-based ECR continued and only checkpoint visits to monitor the progression of exercise training were scheduled at 9 and 12 months.

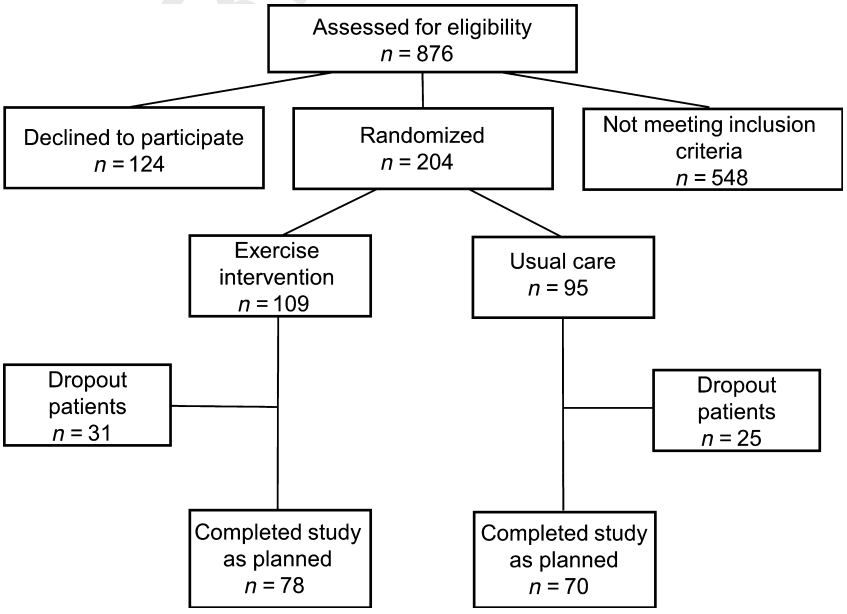

Fig. 1. Patient selection protocol from the EFEX-CARE database.

The exercise training was planned according to the current guidelines (Corra et al., 2010; Fletcher et al., 2013). The 1-year exercise training intervention consisted of home-based aerobic (30–40 min) and strength exercises (30–40 min). The intensity of the aerobic exercises was stated as between 12–15 RPE and it consisted of walking, running, cycling, or cross-country skiing. The strength exercises were circuit training targeted at the body's major muscle groups at moderate intensity (2–3 × 7 sets, ≥10 repetitions/set) targeted at 13 RPE. During the first 6 months on a weekly basis, and at the time points of 9 and 12 months, the controlled strength exercise session at the gym included (duration 30–45 min/session) 7 min of warm-up on a bicycle and 1–3 sets of fifteen repetitions at the intensity of 13 RPE, followed by 5 min of cool-down. Single exercises for the lower extremity included leg presses and leg extensions/curls; for the upper extremity, chest presses, pushups/pull-downs, and dips/shrugs; and for the middle, abdomen/back exercises and twists. The patients were given a diary in which training days were marked with the target duration and intensity of the exercises. After each exercise session, they marked the realized training mode, duration, and mean RPE in the diary. A physical therapist checked the diaries after 1, 3, 6, and 9 months and gave them a new training program for the following months.

Monthly realized training load was calculated from the diaries by calculating training load (RPE × duration of exercise session), described earlier (Foster, 1998). Both groups were treated according to Current Care Guidelines defined by a working group appointed by the Finnish Medical Society Duodecim and the Finnish Cardiac Society (Porela et al., 2015). The patients in the UC group did not get any individually tailored exercise prescriptions.

Assessment of baseline exercise capacity

All the patients performed an incremental symptom-limited maximal exercise test (Oulu University Hospital, Oulu, Finland) on a bicycle ergometer (Monark Ergomedic 839 E; Monark Exercise AB, Vansbro, Sweden) for assessment of exercise capacity (Table 1). The test was started at 30 W, and the work rate was increased by 15 W in men and 10 W in women every minute until voluntary exhaustion or ST depression >0.2 mV in ECG was reached (CAM-14; GE Healthcare, Freiburg, Germany). Maximal workload was calculated as the average workload during the last minute of the test and maximal exercise capacity was then calculated in METs from the maximal workload.

Measurements of baseline characteristics

Body composition was assessed by measurements of weight and body mass index. Blood pressure was measured in a supine position after a 10-min resting period. The Depression Scale (DEPS) questionnaire was used to assess self-rated depression (Salokangas et al., 1995). Smoking status, history of acute myocardial infarction, and revascularization and medication were defined from the hospital registry and standard questionnaires. Left ventricular systolic function was assessed using 2-D echocardiography (Vivid 7; GE Healthcare, Wauwatosa, Wisconsin, U.S.A.). Fasting blood samples were obtained for analysis of plasma glucose and glycated hemoglobin (HbA1c) levels, insulin, blood lipids, and high-sensitivity C-reactive protein after a 12-h overnight fast using standardized methods (Oulu University Hospital, Oulu, Finland).

Table 1. Baseline demographics, clinical characteristics, and medication use according to the intention-to-treat principle

Variable	Rehabilitation (n = 109)	Usual care (n = 95)
Men, *n*	80 (73%)	67 (71%)
Patients with T2D, *n*	24 (22%)	17 (18%)
Age, years	60 ± 11	62 ± 9
Weight, kg	81 ± 15	83 ± 16
BMI, kg/m^2	27.6 ± 4.3	28.0 ± 4.6
Systolic BP, mmHg*	136 ± 22	139 ± 24
Diastolic BP, mmHg*	77 ± 11	79 ± 11
Exercise capacity, MET*	6.0 ± 1.7	5.7 ± 1.7
Depression score*	5.2 ± 5.3	4.8 ± 5.2
Current smokers, *n*	16 (15%)	16 (17%)
History of AMI		
NSTEMI, *n**	47 (48%)	45 (58%)
STEMI, *n**	44 (45%)	28 (36%)
Revascularization		
PCI, *n*	95 (87%)	83 (87%)
Earlier CABG, *n*	5 (5%)	8 (8%)
Cardiac function		
LVEF, %*	62 ± 8	62 ± 8
CCS class*	1.4 ± 0.6	1.6 ± 0.6
Laboratory analyses		
HbA1c, %*	6.0 ± 0.8	6.0 ± 0.9
Fasting plasma glucose, mmol/L*	6.0 ± 1.0	6.0 ± 0.9
Total cholesterol, mmol/L*	3.8 ± 0.8	3.8 ± 0.7
HDL cholesterol, mmol/L*	1.2 ± 0.3	1.3 ± 0.3
LDL cholesterol, mmol/L*	2.2 ± 0.7	2.1 ± 0.7
Triglycerides, mmol/L*	1.5 ± 1.2	1.3 ± 0.6
hs-CRP, mg/L*	2.3 ± 4.2	2.5 ± 5.5
Medication		
Beta blockers, *n*	91 (83%)	83 (87%)
ACEI or ARB, *n**	87 (90%)	67 (86%)
Lipids, *n**	95 (98%)	77 (99%)
Anticoagulants, *n**	97 (100%)	77 (99%)
Calcium antagonists, *n**	16 (16%)	20 (26%)
Nitrates, *n**	21 (22%)	22 (28%)
Diuretics, *n**	13 (13%)	17 (22%)

Values are means ± SD or the number of subjects (proportion).

T2D, type 2 diabetes; BMI, body mass index; BP, blood pressure; MET, metabolic equivalent; AMI, acute myocardial infarction; NSTEMI, non-ST segment elevation myocardial infarction; STEMI, ST segment elevation myocardial infarction; PCI, percutaneous coronary intervention; CABG, coronary artery bypass grafting; LVEF, left ventricular ejection fraction; CCS, Canadian Cardiovascular Society grading of angina pectoris; HbA1c, glycated hemoglobin; HDL, high-density lipoprotein; LDL, low-density lipoprotein; hs-CRP, high-sensitivity C-reactive protein; ACEI, angiotensin conversion enzyme inhibitor; ARB angiotensin receptor blocker.

*n for the rehabilitation group = 97 and for the control group = 78.

Health-related quality of life

Quality-adjusted life years (QALYs) were used as a generic measure of effectiveness. Estimates of QALYs were derived from the 15D questionnaire (Sintonen, 2001), which was

completed by the participants at the baseline, after 6 months, and after 1 year. The 15D is a generic, standardized, self-administered 15D instrument intended for measuring health-related quality of life in adults. It can be used both as a profile and as a single index score measure. The 15D consists of fifteen dimensions: mobility, vision, hearing, breathing, sleeping, eating, speech, elimination, usual activities, mental function, discomfort and symptoms, depression, distress, vitality, and sexual activity. Each dimension has five levels of severity, varying from no problem to extreme difficulties (Saarni et al., 2006). The 15D represents continuous utility scores between 0 (dead) and 1 (full health). The generic minimum important change in 15D scores is ±0.015 (Alanne et al., 2015). The 15D compares favorably with other preference-based generic instruments in the important properties (reliability, validity, discriminatory power, and responsiveness to change). The 15D has been validated among several patient groups, including coronary heart disease (Kontodimopoulos et al., 2012).

All the patients filled in the 15D questionnaire at the hospital before hospital discharge. The ECR group filled in the questionnaire during their follow-up visits to the gym at 6 and 12 months. For the UC group, the questionnaire was mailed and the filled questionnaire was returned by mail. The 15D scores were converted to utility scores. The utility estimates were converted to adjusted mean QALYs by calculating the area under the curve of utility estimates for each patient, using the multiple regression model to control for baseline utility differences (Manca et al., 2005).

Health care costs

Cost estimation was done taking into account both specialized and primary health care services. The costs of occupational health care services and exercise training intervention costs were also collected. As the majority of the patients were retired (51%), productivity losses due to illness-related absence from the workplace were not estimated.

Health care costs arising from the use of health services were obtained on the part of specialized health care using social security ID numbers to determine visits for ambulatory care, number of treatment days, and use of external services. These were measured on the basis of invoicing (by utilizing diagnosis-related groups classification). The cost of using primary health care was obtained from electronic health registries using unique social security ID numbers to determine visits to the doctor, other significant examinations (e.g., large x-rays, etc.), and in-ward treatment days. In addition, the use of home care and possible institutional care (e.g., assisted care home, etc.) was determined from registries. Occupational health care service costs were estimated according to the report of the Social Insurance Institute of Finland (KELA) (Hujanen & Mikkola, 2013). The cost of ECR was estimated according to the average monthly fees in Finnish gyms where individual guidance in exercise training is led by a health care professional, for example, a physical therapist. These kinds of concepts of rehabilitation may include the use of diaries or accelerometers, for example. All costs were handled as 2015 values. Due to the 1-year time horizon of the analysis, no discounting was applied.

Cost-effectiveness analysis

The incremental cost-effectiveness ratio (ICER) was estimated ($ICER = [Cost_{ECR\ group} - Cost_{UC\ group}]/[Effectiveness_{ECR\ group} - Effectiveness_{UC\ group}]$) to compare costs and outcomes (effectiveness) between groups according to the intention-to-treat principle. Incremental cost was determined by the difference in total average cost per patient between the ECR and UC groups. Incremental effectiveness was estimated by the baseline-adjusted incremental QALYs.

Major adverse cardiac event

A major adverse cardiac event (MACE) was defined as a combination of death, recurrent acute coronary event, or hospitalization for heart failure. The follow-up data of 1 year were collected from the patient records of Oulu University Hospital.

Statistical analyses

All the patients who gave their written informed consent for the study were included in the analyses according to the intention-to-treat principle. Descriptive statistical analyses were conducted using means, standard deviations (SDs), and proportions, as appropriate. Dropouts were analyzed by logistic regression. To perform an intention-to-treat analysis, we imputed missing data using two methods.

1. last observation carried forward (replacing 15D data at 12 months with corresponding data from the 6-month follow-up), and
2. Bayesian network to predict 15D data in missing cases if the 6-month follow-up was not available.

The imputation was done with Bayesialab Academic edition (Laval Cedec, France, www.bayesialab.com), using a structural expectation maximization (structural EM) algorithm (Missing values imputation) (SAS).

A non-parametric bootstrapping approach was applied to define mean values and 95% confidence intervals for costs and QALYs at 12 months. In addition, paired non-parametric bootstrapping was applied to estimate sampling uncertainty around the ICER estimate. The results of this analysis were depicted on a cost-effectiveness plane characterizing the joint distribution of incremental costs and QALYs around the ICER value. Furthermore, the probability of cost-effectiveness when taking into account sampling uncertainty was characterized by a cost-effectiveness acceptability curve (CEAC) (Fenwick et al., 2004). After the 1-year intervention, univariate Cox regression was used to estimate hazard ratios (HRs) with 95% confidence intervals (CIs) for the association between the groups and the MACE outcome.

Kaplan–Meier survival curves were plotted to examine differences in cumulative MACE across the groups. We also calculated the number needed to treat (NNT) (Laupacis et al., 1988; Cook & Sackett, 1995), which provides an estimate of the number of patients who need to rehabilitate in ECR to prevent an additional MACE. Statistical analyses of the data were performed with SPSS software (SPSS 22, SPSS Inc., Chicago, Illinois, U.S.A.) and STATA 9.0 (Stata Corp. LP, College Station, Texas, U.S.A.). Statistical significance was defined as a P-value <0.05 for all tests.

Results

Baseline demographics, clinical characteristics, and medication use of the study participants are illustrated in Table 1. In the ERC group, the average of monthly realized exercise training (training load

15 995 ± 8076) exceeded the prescribed training (training load 10 727 ± 475) by 49% ($P < 0.0001$).

During the 1-year intervention, 31 patients (28%) in the ECR group and 25 in the UC group (26%) dropped out from the study mainly due to a lack of motivation (Fig. 1). In a logistic regression analysis, being a dropout was associated with younger age ($P = 0.004$) and lower BMI ($P = 0.009$). More specifically, in the ECR group the reasons for interruption were loss of interest (17), logistic problems (5), loss of time mainly because of work duties (5) or health-related problems (4). In the UC group, dropout patients reported loss of interest (18), loss of time (5), or health-related problems (2). However, the dropout rate did not differ between the groups ($P = 0.638$). The Kaplan–Meier survival curve shows a statistically significant difference in incidence of MACE between the groups (Fig. 2).

Health care costs and quality-adjusted life years

The total average cost per patient in the ECR group showed a tendency of being lower in the ECC group (€1944) than in the UC group (€3027), when analyzed according to the intention-to-treat principle (Table 2). In patients who completed the intervention as planned, the total average cost per patient was lower in the ECR group (€1652) than in the UC group (€2629). In the ECR group, quality of life showed a minor increase (average change in QALYs 0.013), whereas in the UC group, quality of life deteriorated (average change in QALYs −0.012) during the study period according intention-to-treat analysis.

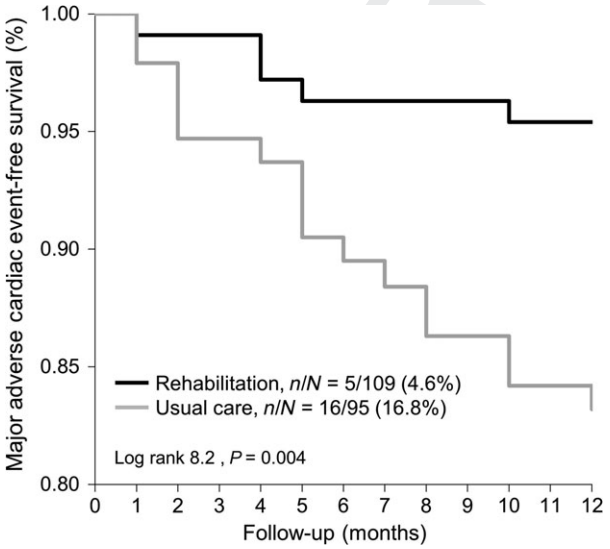

Fig. 2. Kaplan–Meier survival curves of the groups as predictors of a composite end point of cardiovascular death, acute coronary event, or hospitalization for heart failure.

Cost-effectiveness

The cost-effectiveness analysis demonstrated that the ECR program was both less costly and more effective than the UC alone, regardless of the applied data set (i.e., data with and without imputation of missing utility data). These findings were confirmed with the cost-effectiveness plane (Fig. 3), where the majority of bootstrapped replications (i.e., the joint distribution of incremental costs and QALYs) located in the southeast quadrant (i.e., indicating that ECR is less costly and more effective compared with UC alone).

A cost-effectiveness acceptability curve demonstrated that ECR is cost-effective with any value of willingness to pay (data not shown). The incremental cost was divided by the baseline-adjusted incremental QALYs (0.045), yielding an incremental cost-effectiveness ratio of −€24 511/QALYs.

Discussion

The present cost-effectiveness study demonstrated that the addition of 1 year of regular exercise training to UC according to current guidelines was a dominant treatment option (i.e., less costly and more effective) and reduced the occurrence of adverse cardiac events compared with UC alone. The additional health benefits provided by the ECR program, reflected in the ECR group's reduced rate of cardiovascular adverse events, may have been responsible for the trend observed in the changes in quality of life between the ECR and UC groups over the intervention period of 1 year.

Health-related quality of life

We used the 15D as a generic and comprehensive measure of health-related quality of life, where a single index score represents overall health-related quality of life on a 0–1 scale (1 = full health, 0 = being dead) (Sintonen, 2001). The average baseline value of the 15D index score in our study population was high (0.905), which may indicate that acute care and medication were well accepted or our post-ACS patients were stable or asymptomatic at the baseline. However, similar values of index scores (0.91) have also been reported in patients with ST-elevated myocardial infarction (Bohmer et al., 2014); respectively, high baseline values mean that expected positive changes in health-related quality of life cannot be large, which was also shown in the present study. It is also notable that baseline QALYs did not differ between the ECR and UC groups (0.908 vs 0.908) in the present study. Instead, the decline in QALYs almost exceeded the clinically or practically important minimum change in 0.015 in the UC group

Table 2. Costs, QALYs gained, and the cost-effectiveness of exercise-based cardiac rehabilitation intervention in patients with a recent acute coronary syndrome

Description of resource	Rehabilitation		Usual care	
	Mean (without imputation; $n = 78$)	Mean (with imputation; $n = 109$)	Mean (without imputation; $n = 70$)	Mean (with imputation; $n = 95$)
Primary health care costs (€)	346	357	418	483
Secondary health care costs (€)	814	1162	2142	2479
Occupational health care service costs (€)	117	126	69	65
Exercise-based cardiac rehabilitation costs (€)	375	299	0	0
Total average cost per patient (€)	1652	1944	2629	3027
Incremental cost (€)*	−865 (−1765 to −119)	−1103 (−2249 to −49)		
Average utility at the baseline	0.917	0.908	0.897	0.900
Average change in 15D utility	−0.008	0.013	−0.020	−0.012
Baseline-adjusted mean QALYs at 12 months†	0.909	0.922	0.878	0.885
Adjusted incremental QALYs gained*	0.037 (0.028–0.047)	0.045 (0.023–0.077)		
ICER	Dominant option‡	Dominant option‡		

*Means and 95% CIs are estimated using non-parametric bootstrapping.

†QALYs adjusted for baseline 15D utility using regression-based adjustment; R, rehabilitation; UC, usual care; QALY, quality-adjusted life year; ICER, incremental cost-effectiveness ratio.

‡Intervention is less costly and more effective.

(−0.012) (Alanne et al., 2015), but was the opposite in the ECR group (0.013).

Cost-effectiveness

In the current era of restrictions on health care budgets, there is an urgent need for alternative care strategies that prove to be cost-effective. Although ECR has proven an effective and safe therapy for use in the management of stable CAD patients when compared with a no exercise training control (Anderson & Taylor, 2014), ECR is underused, with poor referral and a low participation rate (Kotseva et al., 2013). From the economic point of view, the EUROASPIRE data on CAD patients showed that the effects of optimized tailored prevention (smoking cessation, diet and exercise, better management of elevated blood pressure, and/or low-density lipoprotein cholesterol) is cost-effective compared with the current degree of cardiovascular prevention with an ICER of €12 484/QALYs (De Smedt et al., 2012). The best results were found in elderly patients and patients with high blood pressure or who are not physically active. ECR programs have been found to significantly lower health care costs in the U.S.A. (Ades et al., 1997; Oldridge et al., 2008). Furthermore, in a systemic review of economic evaluations of ECR programs, it was observed that supervised (or center-based) or home-based cardiac rehabilitation was cost-effective compared with UC (Wong et al., 2012).

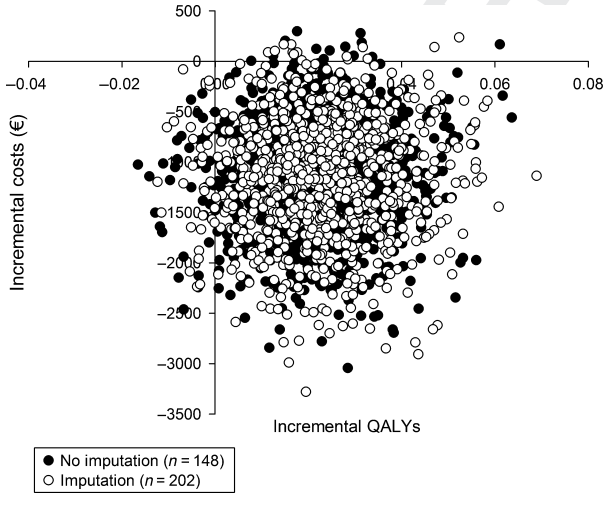

Fig. 3. Cost-effectiveness plane showing the joint distribution of incremental costs and effects (from the trial data using 1000 bootstrap replicates) when comparing exercise-based cardiac rehabilitation (ECR) intervention with usual care in patients with a recent acute coronary syndrome. The most bootstrap replications lie on the southeast quadrant, indicating that ECR is a less costly and more effective treatment option.

The cost-effectiveness study by Frederix et al. (2015) showed that center-based ECR was even more effective and efficient with incorporation of a cardiac telerehabilitation program than conventional center-based ECR alone during a 1-year follow-up. The conventional center-based ECR lasted 12 weeks and the telerehabilitation program lasted 24 weeks. Both groups were instructed to exercise 45–60 min/session at the predefined target heart rate in at least two training sessions per week. The telerehabilitation group patients were instructed to wear an accelerometer continuously and to transmit their realized

physical activity data weekly to the local server for providing the patients' feedback encouraging them to achieve predefined exercise training goals. They found that the total average cost per patient was significantly lower in the telerehabilitation group than in a conventional ECR group with an ICER of −€21 707/QALYs. In addition to home-based self-monitoring of physical activity by accelerometers, our ECR concept included structured physical therapist contacts and a weekly strength training session during the first 6 months, with feedback discussions, early appointments after discharge, and an individually guided exercise training program, which all are reported to be parts of successful interventions in cardiac rehabilitation programs (Karmali et al., 2014). We reported an ICER of −€24 511/QALYs, which emphasizes the ECR program of 1 year according to current guidelines as a dominant option. This information may be useful for policy-makers charged with deciding how limited health care resources should be allocated best in the Finnish health care system.

Exercise training and cardiovascular outcome

As mentioned earlier, the role of regular exercise training in the prevention of cardiovascular events and mortality in CAD patients has been well established (Hammill et al., 2010; Heran et al., 2011; Lawler et al., 2011). Some concerns about the effects of ECR in the current era of care have been raised because of simultaneous major advances in cardiovascular science and medicine (Nabel & Braunwald, 2012). However, a recent overview of Cochrane systematic reviews confirms that ECR reduces the risk of mortality or future hospitalizations compared with a no exercise training control in clinically stable CAD patients after myocardial infarction or PCI (Anderson & Taylor, 2014). The present study also showed a clear relative risk reduction (73%) of MACE in favor of ECR. We also provided an alternative measure (NNT) for expressing the information conveyed in the absolute risk reduction, permitting a comparison of the benefits and risk associated with the ECR approach presented. The estimated NNT for MACE in the present study was 8, which is very low. Schwaab et al. (2011) reported an NNT of 17 for the primary endpoint of mortality, myocardial infarction, and revascularization in a study setup, where 3-week inpatient cardiac rehabilitation in ACS was performed followed by a follow-up of 1 year. Taken together, with the very low NNT shown in the present study, ECR is highly effective and should be advised for all suitable patients with ACS.

Adherence to exercise training

In the present study, the dropout rate from the exercise training program (on average 27%) was on about a similar level as in some previous studies. In our previous ECR study of a 2-year intervention in CAD patients with and without type 2 diabetes, the dropout rate was about 37% (Karjalainen et al., 2014). Similarly, Marzolini et al. (2008) demonstrated that non-completion of a 12-month cardiac rehabilitation program averaged 32%, whereas 42% of patients did not complete the cardiac rehabilitation program in a study by Sanderson et al. (2003). Interestingly, the patients who completed the ECR intervention of 1 year exceeded the prescribed training load clearly (49%). This may, at least partly, emphasize the successful implementation of components described in the literature, for example, self-monitoring of physical activity and tailored counseling by a physical therapist (Karmali et al., 2014) on a weekly basis during first 6 months with the purpose of motivating weekly exercise training and increased adherence.

Strengths and limitations

Strengths of this study were that the data on use of health care services were derived from hospital records, rather than patient self-reports, thereby eliminating recall bias. The health-related quality of life data were collected directly from the participants using a tool suitable for CAD patients (Kattainen et al., 2006). Secondly, the patients in the present study were very widely characterized at the baseline, including clinical characteristics, laboratory analysis, and medication; no differences were seen in the ECR and UC groups.

A limitation of this study is that it did not take into account a full societal approach, potentially underestimating productivity gains for those patients who were still working. However, over the half of the present study population was retired, indicating this underestimation was minimal. The EFEX-CARE study was initially designed to assess the cost-effectiveness of the implemented ECR concept during a 1-year intervention, which explains why our focus was not to assess changes in physical fitness improvement or changes in risk markers after the intervention. Since the EFEX-CARE study was mainly home-based and the exercise training program was rather intensive, a high number of patients were excluded due to serious co-morbidities. Moreover, almost 38% of the patients in the EFEX-CARE study were not willing to participate in the exercise intervention although they were suitable. Typically, patients who have, for example, very low

exercise capacity or a fear of exercise after a cardiac event are not willing to participate in exercise interventions. Therefore, the patient sample in the EFEX-CARE study may be partly selected, which could limit generalizability to a broader population of ACS patients with significant co-morbidities.

Perspective

The present economic evaluation of exercise-based cardiac rehabilitation shows that exercise-based cardiac rehabilitation implemented according to current guidelines is less costly and more effective than UC in ACS patients. Exercise-based cardiac rehabilitation should be implemented for all suitable patients with CAD. These results are useful for policy-makers charged with deciding how limited health care resources should be allocated best in this era of exploding needs.

Key words: Coronary heart disease, cost-effectiveness, exercise training, rehabilitation.

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Conflict of interest

JMA is a partner of ESiOR Oy, which provides health economic and outcome research services to pharmaceutical and medical device companies. The other authors report no conflicts of interest.

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