# Exercise-based cardiac rehabilitation in twelve European countries results of the European cardiac rehabilitation registry☆

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## ARTICLE INFO

## ABSTRACT

*Aim:* Results from EuroCaReD study should serve as a benchmark to improve guideline adherence and treatment quality of cardiac rehabilitation (CR) in Europe.
*Methods and results:* Data from 2.054 CR patients in 12 European countries were derived from 69 centres. 76% were male. Indication for CR differed between countries being predominantly ACS in Switzerland (79%), Portugal (62%) and Germany (61%), elective PCI in Greece (37%), Austria (36%) and Spain (32%), and CABG in Croatia and Russia (36%). A minority of patients presented with chronic heart failure (4%). At CR start, most patients already were under medication according to current guidelines for the treatment of CV risk factors. A wide range of CR programme designs was found (duration 3 to 24 weeks; total number of sessions 30 to 196). Patient programme adherence after admission was high (85%). With reservations that eCRF follow-up data exchange remained incomplete, patient CV risk profiles experienced only small improvements. CR success as defined by an increase of exercise capacity > 25 W was significantly higher in young patients and those who were employed. Results differed by countries. After CR only 9% of patients were admitted to a structured post-CR programme.
*Conclusions:* Clinical characteristics of CR patients, indications and programmes in Europe are different. Guideline adherence is poor. Thus, patient selection and CR programme designs should become more evidence-based. Routine eCRF documentation of CR results throughout European countries was not sufficient in its first application because of incomplete data exchange. Therefore better adherence of CR centres to minimal routine clinical standards is requested.

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## 1. Introduction

Cardiovascular (CV) disease is the leading cause of death. It is responsible for almost a quarter of the disease burden in Europe resulting in substantial direct and indirect healthcare costs [1]. However, the enormous engagement in the development and availability of high technology diagnostic and therapeutic procedures for treatment of CV disease in recent decades is associated with increased survival and

reduced age-adjusted mortality in many European countries [2]. Since CV conditions are chronic and often reflect long-term patterns of unhealthy lifestyles and/or deconditioning of patients, benefit is not automatically achieved through high technology interventions and pharmacological management alone. Several studies suggest that preventive measures are responsible for at least half of the improvement [3]. Therefore patients need to be professionally supported to regain or maintain physical capacity and to achieve changes in lifestyle, risk factor management, better well-being and social and vocational participation [4]. Cardiac rehabilitation (CR) is the structured and multicomponent intervention to deliver these services [5].

Evidence of the benefits of CR has been well established [6–8]. In its consequence CR is categorised as a Class I recommendation in the ACRF/AHA guidelines for the management of patients with ST-elevation myocardial infarction [9], and a Class IIa recommendation in the ESC Guidelines for patients after acute myocardial infarction [10].

Effectiveness of CR, however, strongly depends on minimal standards to be delivered and guaranteed during all day care in clinical practice. Therefore the need for a continuous and interactive quality assurance process is crucial. An effective quality assurance, however, only can be achieved by a regular and structured exchange of institutional and clinical data including their continuous scientific evaluation. The first representative evaluation of CR activities in European Union Member States was the Carinex Survey published in 2002 [11]. In 2008 the EACPR introduced the European Cardiac Rehabilitation Inventory Survey (ECRIS) to investigate the status of CR in European countries [12]. The ECRIS study provided information on the CR structure, legislation, funding mechanisms and national guidelines. However, neither Carinex nor ECRIS was designed to deliver information about baseline clinical variables and outcome data of patients admitted to CR. But the success of CR service provision depends on data collection and quality assessment provided by a common, international core database and data standard across Europe.

Therefore the European Cardiac Rehabilitation Registry and Database (EuroCaReD) was introduced as the next step after Carinex and ECRIS to get information about CR across Europe from a predominantly clinical perspective. Cardiology Audit and Registration Data Standards (CARDS) for Europe and collection of a common core dataset across CR centres in European countries has been promoted earlier [13]. Based on this core dataset EuroCaReD aimed to assess the current CR practice in clinical all day care using a web-based data collection system.

The purpose of the EuroCaReD project was to put together information on the clinical status of CR across European countries by using an electronic case report form (eCRF) to consider how this data match in different countries and what parts of the CR have to be better standardised in accordance with the current guidelines to improve treatment results.

## 2. Methods

### 2.1. Study aims and characteristics

The aims were to develop and test the feasibility and practicability of a web-based registry in European countries that routinely provides data on CR settings, contents and interventions, clinical characteristics of patients and outcomes and thereby serves as basis for a regular European quality assessment of CR services and results. Participation to EuroCaReD was voluntary.

EuroCaReD was designed as a central internet database (http://www.eurocared.org) being connected to national registries and local databases of individual CR centres. The database itself was located in the European Heart House, Sophia Antipolis, France, hosted by Solarys IT Company, Götzis, Austria. All data were collected electronically using a web-based data entry system. The datasets were based on the CARDS model [13], and include items reflecting characteristics of the

individual institution, patient's characteristics and actual CR performance standards [14].

### 2.2. Enrolment of study population

All European countries being members of the European Association for Cardiovascular Prevention and Rehabilitation (EACPR) have been invited to be part of the survey and 69 CR centres in 12 European countries could be selected by the national study coordinators to participate. Following the "snapshot" design of this study, for consecutive enrolment of patients undergoing CR a predefined time window of 8 weeks has initially been arranged. Because of insufficient patient inclusion within the first time period, a second prolonged time period of another 24 weeks has been offered to the participating CR centres for data collection. Except of Germany, participating only the second period, all centres collected their data within both time frames (October 1st, 2010 to November 30th, 2010, and October 1st, 2011 to February 28th, 2012). Informed consent of all participating patients was obtained according to the national regulations of the participating country.

### 2.3. Electronic case report form (eCRF)

The selection of variables aimed to closely mirror CR all day care and included the initiating clinical event (Table 1), demographic details (age, gender, employment status), history of CV risk factors (hypertension, hyperlipidaemia, diabetes, overweight/obesity, smoking, physical inactivity, depression) (Table 2), and CV risk factors as evaluated at the CR start and CR end (blood pressure, LDL-cholesterol, fasting glucose, body mass index, smoking status, watts achieved during exercise testing) (Table 4). Current medication at CR start has also been evaluated (Table 3). All these items have been tested for conformity in the participating countries. A complete overview on all eCRF items is given in Appendix 1.

### 2.4. Follow-up

Follow-up was limited to the duration of the individual rehabilitation programme, which varied considerably between 3 weeks (Hungary, Germany) and 24 weeks (Greece). Clinical follow-up data entered into the EuroCaReD database at the end of the regular CR programme included clinical events during CR, premature ending of the CR-programme, current risk factors, exercise capacity and medication.

### 2.5. Testing CR success

Due to limited follow-up time and data acquisition not monitored by an independent clinical research organisation (CRO), CR success could not be evaluated by its effect on clinical prognosis. Moreover, as management of CV risk factors like hypertension, hyperlipidaemia and diabetes already is started by therapeutic attempts preceding CR these items cannot serve as prognostic surrogate parameters. From this background and because all participating centres were offering bicycle exercise training as a major programme content, CR success has retrospectively been defined as "exercise capacity" gained during the CR process. Therefore, CR was regarded to be successful, if the "gain of exercise capacity" during CR was >25 W from CR start. This assumption is based on the experience in clinical practice and the need to reflect a heterogeneous population with a large variety of exercise capacities at baseline.

### 2.6. Data management

Data were anonymously entered online into the eCRF at each individual study site and stored in the central EuroCaReD database. To maintain patient's anonymity, only the identification number of each study participant was transferred to the central database. Patient's re-identification

**Table 1**
Clinical events and diagnoses leading to CR referral.

| Country | Total number of patients recruited | UAP (%)[a] (numbers)[b] | NSTEMI (%)[a] (numbers)[b] | STEMI (%)[a] (numbers)[b] | Elective PCI (%)[a] (numbers)[b] | CABG (%)[a] (numbers)[b] | Non CABG cardiac surgery (%)[a] (numbers)[b] | Chronic heart failure (%)[a] (numbers)[b] | Others[c] (%)[a] (numbers)[b] |
|---|---|---|---|---|---|---|---|---|---|
| Austria | 544 | 0.0 | 17.4 (51/293) | 21.8 (64/293) | 36.5 (107/293) | 8.9 (26/293) | 7.5 (22/293) | 5.5 (16/293) | 2.4 (7/293) |
| Belgium | 232 | 0.4 (1/225) | 10.2 (23/225) | 16.9 (38/225) | 24.9 (56/225) | 20.0 (45/225) | 14.7 (33/225) | 10.2 (23/225) | 2.7 (6/225) |
| Croatia | 93 | 0.0 (0/92) | 10.9 (10/92) | 29.3 (27/92) | 3.3 (3/92) | 35.9 33/92 | 19.6 (18/92) | 0.0 (0/92) | 1.1 (1/92) |
| Denmark | 153 | 4.1 (6/148) | 18.9 (28/148) | 18.2 (27/148) | 29.7 (44/148) | 17.6 (26/148) | 2.7 (4/148) | 2.7 (4/148) | 6.1 (9/148) |
| Germany | 204 | 3.0 (6/199) | 22.1 (44/199) | 39.2 (78/199) | 1.0 (2/199) | 20.1 (40/199) | 8.5 (17/199) | 2.0 (4/199) | 4.5 (7/199) |
| Greece | 139 | 0.0 (0/139) | 0.0 (0/139) | 3.6 (5/139) | 37.4 (52/139) | 28.1 (39/139) | 1.4 (2/139) | 25.9 (36/139) | 3.6 (5/139) |
| Hungary | 120 | 0.0 (0/120) | 8.3 (10/120) | 25.8 (1/120) | 28.3 (34/120) | 23.3 (28/120) | 10.0 (12/120) | 0.8 (1/120) | 3.3 (4/120) |
| Portugal | 157 | 1.3 (2/157) | 23.6 (37/157) | 38.2 (60/157) | 15.9 (25/157) | 8.9 (14/157) | 5.1 (8/157) | 3.8 (6/157) | 3.2 (5/157) |
| Romania | 169 | 1.2 (2/168) | 4.2 (7/168) | 21.4 (36/168) | 14.3 (24/168) | 17.3 (29/168) | 1.2 (2/168) | 10.1 (17/168) | 32.4[d] (51/168) |
| Russia | 151 | 0.0 (0/151) | 13.2 (20/151) | 25.8 (39/151) | 18.5 (28/151) | 35.8 (54/151) | 4.0 (6/151) | 0.0 (0/151) | 2.6 (4/151) |
| Spain | 38 | 0.0 (0/38) | 13.2 (5/38) | 26.3 (10/38) | 31.6 (12/38) | 10.5 (4/38) | 15.8 (6/38) | 2.6 (1/38) | 0.0 (0/38) |
| Switzerland | 54 | 4.2 (2/48) | 33.3 (16/48) | 41.7 (20/48) | 0.0 (0/48) | 6.3 (3/48) | 6.3 (3/48) | 2.1 (1/48) | 6.3 (3/48) |

[a] Percentages of patients being evaluated.

[b] Number of patients with the index diagnosis versus total numbers of patients being evaluated (compare also with the total number of patients being recruited, left column).

[c] Includes patients with ICD-system, pacemaker, stable angina.

[d] Romania: 23.8% patients with stable angina; yellow background = referral diagnosis represents 10–30%; grey background = above 30%.

was possible only at the sites, where patients originally were enrolled to enable additional information if needed. The Institut für Herzinfarktforschung (IHF) Ludwigshafen, Germany provided overall data management, statistical analysis and site-specific reports.

All collected data were offered to the national coordinators for benchmarking and quality control within the country where the data have been collected. Benchmarking of individual centres' data with the pooled data of the other centres was possible after permission by the EuroCaReD steering committee and the national coordinators. No data from any individual centre were released to other centres.

### 2.7. Statistical analysis

Continuous variables are presented as means with standard deviations medians with 25th and 75th percentiles and were compared by using Wilcoxon test. Categorical variables and completeness of documentation (data availability) are presented as absolute numbers or percentages and were compared by using chi-square test. The statistical comparisons were two-tailed, and p-values <0.05 were considered as statistically significant. For identifying independent predictors of drop-out from CR a logistic regression analysis was done. All analyses were performed using SAS version 9.3 (SAS Institute Inc., Cary, NC, USA).

### 2.8. Ethical review board approval

The national coordinators of the EuroCaReD project were responsible for getting approval of the national or local ethical committees, according to the prevailing national requirements.

**Table 2**
Demographic characteristics and cardiovascular risk factors in history of patients referred to CR.

| Country | Total number of patients | Age (years)[a] female (%)[a] | Retired (%) (DA %)[b] | Hyper-tension (%) (DA %)[b] | Elevated LDL-cholesterol (%) (DA %)[b] | Diabetes mellitus (%) (DA %)[b] | Overweight obesity (%) (DA %)[b] | Smoking (%) (DA %)[b] | Low/no physical activity (%) (DA %)[b] | Depression (%) (DA %)[b] |
|---|---|---|---|---|---|---|---|---|---|---|
| Austria | 544 | 59.0 19.7 | 50.7 (94) | 50.7 (92) | 59.6 (92) | 13.1 (92) | 29.0 (92) | 54.7 (33) | 29.0 (92) | NA |
| Belgium | 232 | 62.5 23.3 | 51.4 (60) | 47.7 (92) | 66.8 (90) | 19.2 (92) | 36.9 (89) | 29.0 (92) | 55.6 (84) | 11.6 (75) |
| Croatia | 93 | 62.0 23.7 | 59.1 (100) | 86.0 (100) | 94.6 (99) | 34.8 (99) | 35.5 (100) | 31.2 (100) | 55.9 (100) | 1.1 (75) |
| Croatia | 153 | 61.0 24.8 | 52.1 (86) | 52.1 (94) | 86.1 (94) | 22 (95) | 44.7 (92) | 47.6 (93) | 46.5 (54) | 7.6 (86) |
| Germany | 204 | 58.0 20.6 | 36.2 (99) | 72.3 (99) | 88.0 (98) | 23.6 (99) | 44.1 (100) | 38.4 (99) | 62.0 (84) | 13.2 (93) |
| Greece | 139 | 65.0 30.2 | 72.8 (98) | 84.1 (99) | 71.9 (100) | 23.7 (100) | 16.5 (100) | 33.8 (98) | 80.3 (95) | 3.6 (99) |
| Hungary | 120 | 60.0 24.2 | 52.5 (100) | 85.7 (99) | 73.9 (99) | 29.7 (99) | 43.7 (99) | 55.9 (99) | 73.9 (99) | 3.4 (98) |
| Portugal | 157 | 59.0 19.7 | 35.5 (99) | 55.8 (99) | 69.0 (99) | 24.3 (97) | 34.0 (97) | 35.9 (99) | 83.8 (99) | 16 (99) |
| Romania | 169 | 62.0 42.6 | 62.8 (81) | 78.1 (100) | 58.0 (100) | 25.4 (100) | 42.0 (100) | 32.1 (98) | 72.3 (88) | 17.6 (88) |
| Russia | 151 | 57.0 23.8 | 29.3 (99) | 84.1 (100) | 60.7 (99) | 15.9 (100) | 47.3 (99) | 43.3 (99) | 43 (99) | 9 (95) |
| Spain | 38 | 57.0 10.5 | 34.8 (61) | 50.0 (100) | 57.9 (100) | 35.1 (99) | 40.5 (99) | 44.4 (99) | 63.2 (100) | 11.1 (99) |
| Switzerland | 54 | 60.5 22.2 | 61 (78) | 63.0 (100) | 51.9 (100) | 16.7 (100) | 29.6 (100) | 52.8 (99) | 42.3 (98) | 7.4 (100) |
| Total population | 2054 | 61.0 23.8 | 48.7 (90.0) | 64.4 (96.4) | 69.0 (96.0) | 16.9 (96.1) | 36.0 (95.8) | 32.4 (80.1) | 53.7 (91.4) | 9.8 (67.8) |

[a] Median.
[b] DA, data availability defined as % of patients of the study population being evaluated for the individual item under consideration.

## 3. Results

### 3.1. Study population

Primarily 2.095 patients from 71 CR centres in 14 European countries have been enrolled during the predefined study periods. After examination for minimal requirements of data completeness two countries were excluded. Thereby data from 2.054 patients from 69 CR centres of 12 European countries were suitable for the final analysis. The numbers of patients being enrolled in each country are given in Tables 1–4.

### 3.2. Clinical events initiating CR

Regarding the entire study population, patients with coronary artery disease (CAD) represented the vast majority of CR patients (83%). The most common initiating events for CR referral were acute coronary syndrome (ACS) (40%) and elective PCI (22%), followed by patients after CABG (19%) (Table 1). The number of patients admitted for CR because of chronic heart failure (CHF) was low (4%). The most relevant comorbidities were musculoskeletal disorders (18%) and COPD (11%).

**Table 3**
Patients prescribed medication at CR programme start.

| Country | N | Medication as applied in % of patients evaluated (patients treated/patients evaluated) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | ASS | TP | BB | ACE-I | ARB | Statin | Oral diabetes control | Insulin |
| Austria | 544 | 81 (29) | 64.6 (29) | 80.4 (29) | 49.4 (29) | NA | 81.6 (29) | 9.5 (29) | 2.5 (29) |
| Belgium | 232 | 91 (63) | 36.4 (62) | 85 (63) | 47.2 (61) | 5.9 (59) | 81.4 (63) | 16.1 (62) | 4.2 (62) |
| Croatia | 93 | 83.7 (99) | 58.7 (99) | 96.7 (99) | 65.2 (99) | 19.8 (98) | 91.3 (99) | 23.3 (97) | 3.3 (98) |
| Denmark | 153 | 92.9 79/85 | 64.2 43/67 | 79.2 61/77 | 44.3 31/70 | 17.2 11/64 | 91.9 79/86 | 19.7 13/66 | 9.4 6/64 |
| Germany | 204 | 83.7 (99) | 56.7 (98) | 86.1 (99) | 63.9 (99) | 17.8 (99) | 81.2 (99) | 15.5 (98) | 9.5 (99) |
| Greece | 139 | 80 96/120 | 31.4 38/121 | 93.4 113/121 | 86 104/121 | 14.2 17/120 | 93.4 113/121 | 16.5 20/121 | 2.5 3/121 |
| Hungary | 120 | 89.2 107/120 | 62.5 75/120 | 97.5 117/120 | 75.8 91/120 | 16.8 20/119 | 87.5 105/120 | 21.8 26/119 | 7.6 9/119 |
| Portugal | 157 | 95 148/155 | 87.2 136/156 | 86.3 132/153 | 72.9 113/155 | 12.9 20/155 | 94.2 146/155 | 21.3 33/155 | 8.4 13/155 |
| Romania | 169 | 84.7 (116/137) | 46 (63/137) | 88.3 (121/137) | 73 (100/137) | 14 (19/136) | 85.3 (116/136) | 17.6 (24/136) | 2.2 (3/137) |
| Russia | 151 | 94.5 (137/145) | 51 (74/145) | 91.7 (133/145) | 77.2 (112/145) | 5.5 (8/145) | 93.8 (136/145) | 9.7 (14/145) | 0.0 (0/145) |
| Spain | 38 | 94.4 (17/18) | 44.4 (8/18) | 77.8 (14/18) | 55.6 (10/18) | 16.7 (3/18) | 100 (18/18) | 22.2 (4/18) | 0.0 (0.18) |
| Switzerland | 54 | 81.4 (35/43) | 81.4 (35/43) | 88.4 (38/43) | 65.1 (28/43) | 25.6 (11/43) | 88.4 (38/43) | 4.7 (2/43) | 9.5 (4/42) |

The distribution of initiating events exhibited a considerable heterogeneity between the participating countries. Whereas ACS dominated in Switzerland (79%), Portugal (62%) and Germany (61%), elective PCI for stable CAD was prominent in Greece (37%), Austria (36%) and Spain (32%). Only in Switzerland CR referral of patients with NSTEMI (33%) was comparable to the group of patients with STEMI, whereas in some countries NSTEMI patients were not represented at all within this survey (e.g. Greece). Patients after CABG represented the largest group in Croatia and Russia (36% each).

### 3.3. Demographic characteristics and history of CV risk factors

The mean age of the total population was 58 ± 16 years with low variations between the countries. 76% of the study population were male. Female patients represented the minority in all countries and ranged from 10% in Spain to 43% in Romania. At CR start almost half of the patients were retired (49%) with a maximum in Greece (73%) and a minimum in Russia (29%).

Most patients had a typical CV risk profile with a history of hyperlipidaemia (69%), hypertension (64%), lack of regular physical activity (54%) and smoking (40%). However, the distribution of the individual risk factors in patients' history considerably varied between countries. Percentages were displayed in Table 2. The distribution was in hypertension from 48% (Belgium) to 84% (Russia); in hyperlipidaemia from 52% (Switzerland) to 95% (Croatia); in diabetes mellitus from 13% (Austria) to 35% (Spain); in overweight/obesity form 16% (Greece) to 47% (Russia); in smoking from 29% (Belgium) to 53% Switzerland; in low/no physical activity from 29% (Austria) to 84% (Portugal); and in depression from 1% (Croatia) to 18% (Romania).

### 3.4. Baseline hemodynamic parameters and medication prescription in patients referred to CR

The large majority of patients were in sinus rhythm. At CR start mean heart rate at rest was 69 bpm and mean left ventricular ejection fraction (LVEF) 54%. All patients were on guideline-adjusted medication before starting the CR programme (Table 3).

### 3.5. Changes of individual risk factors during CR programme

Table 4 presents CV risk factor data at CR start and end of those patients with the individual risk factors reported in history (Table 2). With respect to blood pressure, LDL-cholesterol and baseline glucose, patients were already on medication at CR start but the values still could be optimized during CR (values at CR start and change as measured at CR end: systolic blood pressure 131 = minus 5 mm Hg; LDL-cholesterol: 108 mg/dl = −18 mg/dl; and fasting glucose 136 mg/dl = −11 mg/dl. Notably, baseline measurements of these risk factors were incomplete, and controls were performed even less. Mean BMI of patients with overweight or obesity in history was 32 kg/m², and a relevant reduction could not be achieved during CR. From the group of patients with history of smoking a relevant part already stopped before CR start, however, this part showed a large variation between the countries (Table 4). Unfortunately the further course of smoking behaviour has not been reported by the CR centres. Therefore the effect of CR on smoking behaviour could not be assessed.

### 3.6. Exercise capacity and CR success

Exercise capacity given in "watts" could be documented only in 535 patients (28% of total), and an even lower number was documented at

**Table. 4**
Subgroups of patients with individual cardiovascular risk factors in history: evaluation at CR start and changes during CR.

| Country | Total number of patients recruited | Syst. blood pressure (patients with hypertension in history only)[a] change[a] (mm Hg) [patients investigated] | LDL-cholesterol (patients with hyperlipidaemia in history only)[a] change[a] (mg/dl) [patients investigated] | Baseline glucose (patients with diabetes in history only)[a] change[a] (mg/dl) [patients investigated] | Body mass index (patients with overweight in history only)[a] change[a] (kg/m²) [patients investigated] | Current smokers in history[a] at CR start[ab] (%) [patients investigated] | Exercise capacity (watts, all patients) change (watts) [patients investigated] | Exercise capacity (watts, patients with "no physical activity in history" only) change (watts) [patients investigated] |
|---|---|---|---|---|---|---|---|---|
| Austria | 544 | 128.8 [243] −3.8 [165] | 104.2 [275] −17.6 [197] | 140.9 [42] −4.9 [34] | 31.3 [144] −0.6 [101] | 54.7 [181] 50.0 [178] | 143 [40] +28 [38] | 96 [4] +19 [2] |
| Belgium | 232 | 138.3 [68] −2.5 [39] | 104.4 [71] −34.2 [29] | 126.9 [15] −29.3 [3] | 30.9 −0.2 [0.2] | 29.0 [214] 19.9 [146] | 112 [111] +22 [66] | 100 [53] +17 [29] |
| Croatia | 93 | 132.0 [80] −10.9 [78] | 87.6 [87] −7.0 [29] | 145.5 [31] −17.2 [29] | 33.9 [32] −0.5 [24] | 31.2 [93] 31.2 [93] | 106 [62] +13 [15] | 94 [31] +18 [10] |
| Denmark | 153 | 138.2 [67] +1.4 [37] | 100.0 [110] −24.2 [71] | 130.6 [23] −13.6 [9] | 30.9 [54] +0.1 [31] | 47.6 [143] 22.2 [135] | 114 [1] NA[c] | NA[c] |
| Germany | 204 | 129.7 [145] −5.9 [141] | 107.7 [165] −17.9 [136] | 135.9 [43] −14.1 [39] | 32.5 [88] −0.7 [83] | 38.4 [203] 17.2 [204] | 98 [188] +21 [148] | 95 [96] +17 [75] |
| Greece | 139 | 117.9 [109] +0.03 [104] | 111.4 [94] −1.5 [89] | 117.8 [28] −1.1 [25] | 33.8 [23] −0.3 [18] | 33.8 [136] 13.0 [138] | 106 [11] +1 [1] | 65 [3] +1 [1] |
| Hungary | 120 | 133.3 [102] −9.3 [102] | 110.0 [54] −16.0 [24] | 139.9 [27] −5.5 [25] | 32.6 [50] −0.5 [49] | 55.9 [118] 10.0 [120] | 109 [8] NA[c] | 109 [8] NA[c] |
| Portugal | 157 | 133.2 [86] −7.9 [73] | 112.9 [94] −22.6 [75] | 154.4 [33] −21.0 [28] | 31.3 [52] −1.2 [47] | 35.9 [156] 23.4 [154] | NA[c] | NA[c] |
| Romania | 169 | 138.5 [103] −8.9 [74] | 141.9 [70] −38.9 [48] | 139.3 [34] −12.7 [23] | 33.5 [60] −0.7 [45] | 32.1 [165] 21.9 [137] | 74 [62] +41 [29] | 69 [40] +44 [17] |
| Russia | 151 | 129.4 [127] −8.6 [120] | 123.2 [69] −13.4 [13] | 117.0 [24] −18.8 [19] | 31.4 [71] +0.2 [67] | 43.3 [150] 39.3 [150] | NA[c] | NA[c] |
| Spain | 38 | 128.9 [9] −12.5 [8] | 91.2 [13] −15.5 [12] | 109.1 [7] −3.4 [5] | 27.7 [8] −2.1 [7] | 44.4 [36] 20.8 [24] | NA[c] | NA[c] |
| Switzer land | 54 | 125.7 [34] +6.8 [26] | 92.9 [13] NA[c] | 142.6 [2] NA[c] | 30.6 [30.6] 0.0 [9] | 52.8 [53] 13.0 [54] | 113 [52] +30 [42] | 102 [21] +22 [16] |
| All countries | 2054 | 130.7 [1173] −5.7 [967] | 108.0 [1108] −18.3 [723] | 135.7 [309] −10.8 [239] | 31.8 [652] −0.5 [515] | 40.0 [1648] 24.7 [1533] | 104 [535] +24 [339] | 92 [257] +20 [150] |

[a] Mean values; to increase clarity of presentation standard deviations are not presented.
[b] Smoking status at the end of CR has not been sufficiently reported, and therefore cannot be presented.
[c] NA, data not available.

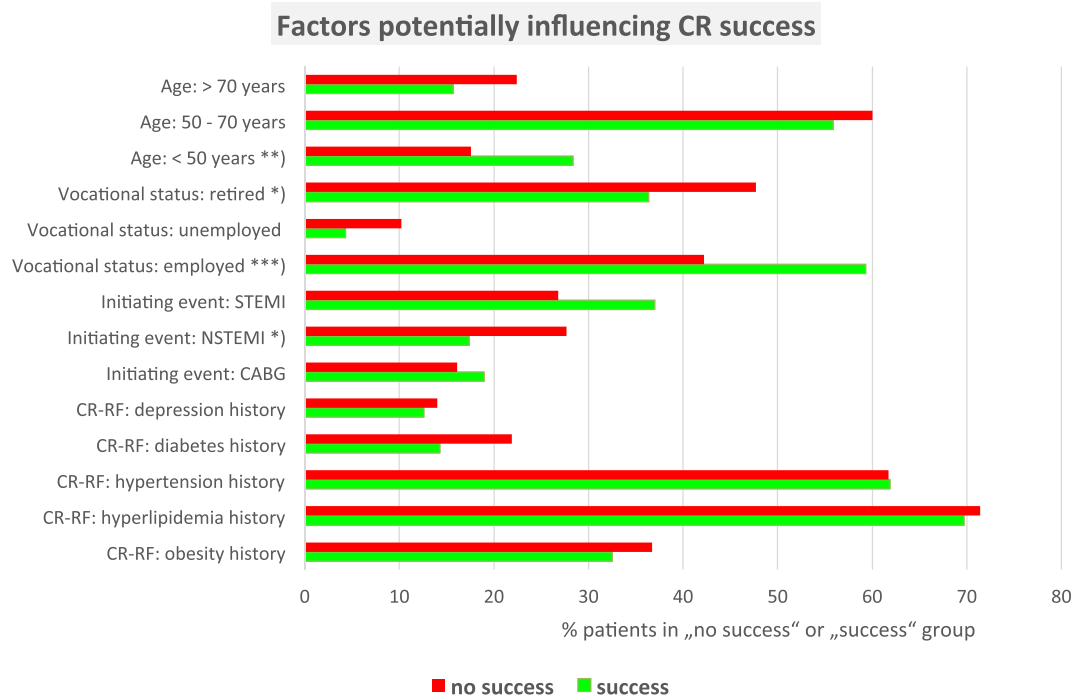## Factors potentially influencing CR success



**Fig. 1.** The diagram shows demographic, social and clinical factors potentially influencing CR success as defined by an increase of exercise capacity of >25 W. The percentages refer to the size of the individual subgroup within the success or non-success group in each category or cardiovascular risk factor. The p-values refer to the differences between the success and non-success group; *) $p < 0.05$, **) $p < 0.01$, ***) $p < 0.001$.

the end of CR too (339; 16% of total). Therefore repeat bicycle exercise test results at the end of the CR programme were available only in this small subgroup of the study population. Within this subgroup exercise capacity changed from $104 \pm 44$ W at CR start to $128 \pm 50$ W at CR end; $p < 0.0001$ (Table 4). Considering only the subgroup with patients' history of "low/no physical activity at CR start" the increase was similar from $92 \pm 38$ W at CR start to $112 \pm 41$ W at CR end; $p < 0.0001$ (Table 4).

For further differentiation "CR success" has provisionally been defined as an increase of exercise capacity of >25 W after CR. On the basis of this definition 58% (n = 198) of the subgroup of patients with repeat exercise tests during CR successfully completed their programme. The success rate varied according with the patients' baseline characteristics as outlined in Fig. 1. In the subgroup of patients aged <50 years, or being employed the number of patients with CR success significantly exceeded the number of unsuccessful patients. In contrast, in the subgroups of patients being retired or patients after NSTEMI the majority of patients remained unsuccessful in increasing their exercise capacity.

### 3.7. CR programme characteristics

CR setting, content and duration varies across countries (Table 5). Mean programme duration was 8 weeks, shortest in Hungary and longest in Greece (24 weeks). During the programmes, an average of 4.2 exercise sessions and 2.8 counselling sessions were offered weekly. The mean total number of sessions offered during CR was 43.5, highest in Greece (n = 96) and lowest in Austria, Denmark, Hungary, and Portugal (n = 30).

### 3.8. CR programme completion, recurrent CV events and drop-out rate

Of the 2.054 patients admitted for CR, 85% completed the programme. The most common reasons for patient drop-out were patient non-compliance (31%), and recurrent CV events within the CR programme timeframe (8%). But in 60% of the drop-outs the reason has not been specified.

**Table 5**
CR setting, duration and content.

| Country | Design | Exercise (sessions per week) | Counselling (sessions per week) | Duration (weeks) | Total number of sessions |
|---|---|---|---|---|---|
| Austria | Outpatient | 3 | 2 | 6 | 30 |
| Belgium | Outpatient | 3 | 1 | 12 | 48 |
| Croatia | Inpatient | 4 | 4 | 4 | 32 |
| Denmark | Outpatient | 3 | 2 | 6 | 30 |
| Germany | In- and outpatient | 12 | 8 | 3 (−4) | 60 (−80)[a] |
| Greece | Outpatient | 3 | 1 | 24 | 96 |
| Hungary | Inpatient | 5 | 5 | 3 | 30 |
| Portugal | Outpatient | 3 | 2 | 6 | 30 |
| Romania | Inpatient | 4 | 4 | 4 | 32 |
| Russia | Inpatient | 4 | 2 | 6 | 36 |
| Spain | Outpatient | 3 | 1 | 12 | 48 |
| Switzerland | Outpatient | 3 | 2 | 10 | 50 |
| Mean | | 4.2 | 2.8 | 8.0 | 43.5 |

[a] Retrospective assessment.

*3.9. Post-CR disease management*

After CR completion, patients returned to routine care by cardiologists (61%) and/or to a general practitioner or both (23%). But only 9% were admitted to a structured post-CR programme such as "heart group" or equivalent activities.

*3.10. Subgroup analysis for gender*

There was no gender difference in age of CR participants. Fewer women than men were married (70% vs. 83%; p < 0.0001) but more of them were widowed (15% vs. 4%; p < 0.0001). A higher percentage of women were retired (54% vs. 45%; p < 0.001). Significant differences could be observed in the presence of CV risk factors. Fewer women than men reported a history of smoking (28% vs. 44%; p < 0.0001), whereas more women were hypertensive (71% vs. 62%; p < 0.001) or obese (41% vs. 34%; p < 0.01). Fewer women than men were regularly physically active (35% vs. 49%; p < 0.001). More women than men had a history of depression (17% vs. 7%; p < 0.0001).

During the CR programme, similar number of recurrent events occurred in women and in men (9.6% vs. 9.0%). Dropout rates did not differ between women and men (14% vs. 15%). On CR programme completion, women experienced similar improvement of physical exercise capacity in watts (22 ± 18 vs. 25 ± 23).

*3.11. Documentation and data availability*

Availability of data was limited and varied between the participating countries (Tables 2–4). This is exemplified by the data availability of the item in patients' history "low/no physical activity" (Table 2) ranging from 54% (Denmark) to 100% (Croatia, Spain), and the item "exercise capacity — change during CR", ranging from 0% (Denmark, Hungary, Portugal, Russia, Spain) to 78% (Switzerland) (Table 4). Moreover, change of smoking behaviour during CR has not routinely been assessed. Therefore no reliable data could be gained from this item too.

## 4. Discussion

To the best of our knowledge, EuroCaReD presents the first eCRF based international registry of baseline patient characteristics, indications, treatment and outcomes in "all-comers" admitted to a CR programme in Europe. Beyond assessment, clinical registry programmes provide an important tool to monitor quality of healthcare services and thereby improve clinical outcome. Through registry evaluation, more effective and efficient systems of CR delivery can be detected. This supports a wider coverage of those patients who can benefit in the future [11]. As a continuation of the previous Carinex and ECRIS project the major tasks of EuroCaReD were:

1. to test the feasibility of a web-based eCRF for collecting clinical baseline and outcome parameters in patients surpassing a CR programme and

2. to define measures that can serve as a benchmark to improve guideline adherence and treatment quality of CR in Europe.

*4.1. Heterogeneity of CV risk factor profiles across European countries*

As EuroCaReD baseline data show, the four most common CV risk factors in patients referred to CR across Europe are hyperlipidaemia, hypertension, low/no physical activity and cigarette smoking. This observation matches with the recently published EuroAspire IV study [15]. As in EuroAspire IV, in EuroCaReD the distribution of the individual risk factors in patients' history considerably varied between the countries. But EuroCaReD findings could not confirm observations of EuroAspire IV that large proportions of CAD patients do not achieve therapeutic targets for CV disease prevention. In the EuroCaReD population most patients reported adequate prescription of medication even

before admission to CR. The different study population could explain this. Whereas in EuroAspire IV patients without documented CAD were asked about their medication, in EuroCaReD all patients presented after a CAD event. Obviously, adequate prescription of cardio-protective medication following evidence-based guidelines is considered more important in secondary than in primary prevention of CAD.

*4.2. Unity and diversity of CR patient baseline clinical parameters in different European countries*

As in most other reports EuroCaReD overall results show that patients with CAD represented the majority of CR candidates. In accordance with the guidelines for the clinical management of patients with CAD [14], the most common initiating events in patients referred for CR in European countries are ACS and elective PCI, followed by patients after CABG. But the number of patients admitted for CR because of CHF is surprisingly low and does not meet the requirements given by the current guidelines. Looking to the numbers in various European countries, despite of the current guidelines issued by the European Society of Cardiology [14] the distribution of clinical events initiating CR exhibited a considerable heterogeneity whereas ACS including NSTEMI and STEMI as an important indication for CR was adequately recognised only in Switzerland, Portugal and Germany. In some countries NSTEMI patients were not represented at all (e.g. Greece). Obviously because revascularisation strategies of CAD in Eastern European countries tend more to surgery, in Croatia and Russia patients after CABG represented the largest group of CR patients. Thus EuroCaReD results show lack of guideline adherence in terms of the most important indication for CR in several European countries.

*4.3. Heterogeneity of CR programme delivery across European countries*

As shown in ECRIS before, a surprisingly wide spread in CR programme content and length has to be noted by EuroCaReD across European countries. Whereas in Eastern Europe and Central Europe, except Austria and Germany where outpatient CR is becoming more common, a short in-patient CR setting has emerged, most other European countries contrast with the tradition of the out-patient setting, which in general is offered over a longer period. The best scientific evidence of improvement in morbidity and mortality in the literature is found for programmes with more sessions and longer duration [16]. Therefore prompted by ECRIS and now by EuroCaReD, across Europe consensus should be found in future on programme content and duration, as well as on patient characteristics for each CR setting. This should be based on scientific evidence or specific medical needs, independent of the development of traditional forms of CR, influenced by local particularities.

*4.4. CR programme patient adherence throughout Europe*

In the EuroCaReD study sites, only about 15% of patients did not complete the CR programme, mostly because of patient related reasons rather than medical complications. In a questionnaire study from Denmark, authors found 21% drop-out, with deterioration of physical conditions, lack of time, long distance from residence to hospital, transport problems and lack of understanding of the benefits of CR as the main determinants for drop-out [17]. In another more recently published report from Canada, in accordance to EuroCaReD results the reason for premature termination was most often due to patient dropout (87%) [18]. These observations provide targets to address compliance problems in CR programmes. In particular, patients who have to interrupt their programme because of medical interventions should be readmitted to CR as soon as possible. As the drop-out risk in EuroCaReD institutions was also high in patients with comorbidities, these subgroups should receive special attention. The high percentage of patients with unspecified reasons of CR programme interruption in EuroCaReD

needs further qualitative investigation to develop descriptive categories for future study.

### 4.5. CR programme success in European countries

The assumption that a CR programme was successful for the patient has to be weighted in consideration to the targets that the institution has defined with the patient based on his individual needs, CV risk profile and the current guidelines. Because all participation institutions offered exercise based CR, in EuroCaReD CR success was provisionally defined as an increase of exercise capacity of a minimum of 25 W at the end of programme. By this definition at least more than half of the subgroup of patients with repeat exercise tests during CR successfully completed their programme. Not surprisingly, patients aged <50 years, patients being employed and, because of low exercise capacity before programme start, patients after CABG or after STEMI had the highest success rate. Between countries the improvement of exercise capacity varied considerably, obviously because of wide spread in CR programme content and length. But mean improvement of exercise capacity during CR throughout European countries was comparable with results of other reports [18,19].

### 4.6. Changes of individual risk factors during CR programme

Only small improvement in CV risk factors, most likely because of the high pre-medication rate in lipid lowering, blood pressure and diabetes treatment could be documented. In our experience, many patients entered CR very soon after the initiating event and in this situation the medication was still optimally prescribed. Thus patients entering CR presented lipid levels ranging in the treatment targets and further lowering would not be expected by CR programme activities. So a major task of CR is to get patients to maintain medication and other preventive interventions and treatments by education and motivation. Consistently the EuroAspire III study results show that control of smoking and the use of cardio-protective medication works better in patients who attend a CR programme [20]. EuroCaReD results confirmed these observations. The decrease in number of cigarettes smoked during the CR time period can be rated as a positive effect because there is a linear relationship between number of cigarettes smoked and residual risk [21]. Because of the short observation period EuroCaReD results could not provide a final evaluation on adherence of CR programme effects.

### 4.7. Continuation of secondary prevention after finishing CR programme

To reach long lasting effects of the CR programme on CV risk factors and physical exercise performance effects, long-term care models are crucial. Post CR disease management programmes have been established in many European countries. In three-quarters of the countries that participated in the ECRIS registry, cardiologists are responsible for post-CR patient care often in collaboration with a specialist in internal medicine and/or physiotherapist [12]. The EuroCaReD results reflect this observation. Because of their structured offering it would be advantageous if more than the current level of less than 10% of post CR patients could be admitted to heart groups supervised by an exercise therapist depending from the country where CR patients are living.

### 4.8. Comparison of EuroCaReD patient characteristics with other CR surveys

In accordance with other registries in- and outside Europe, EuroCaReD results show that much more men than women are admitted to CR programmes. EuroCaReD findings, demonstrating equal CR benefit for women and men, highlight the need of measures to increase the participation rate of women in CR programmes. In accordance to other parts of the world most patients are admitted for CR because of CAD. But at least in Western Europe more patients after ACS are admitted (40% of all admitted) as e.g. in Canada (20% of all admitted) [18]. Therefore EuroCaReD patient characteristics and indications for CR correspond more to recently published reports that show the prevalence of ACS as the CR initiating event [19,22]. In comparison to the experience of the national investigators of the ECRIS survey, EuroCaReD reported most patients after ACS admitted to CR, but similarly few patients with CHF [12]. Thus EuroCaReD results confirm findings reported in other surveys that CHF patients are underrepresented in exercise-based CR programmes [23]. Although in CHF patients, exercise-based CR does not significantly decrease the risk of all-cause and CV mortality [24], but it reduces hospital readmissions and confers important improvements in health-related quality of life [25,26]. Therefore much more CHF patients should be admitted in CR programmes than currently practiced.

### 4.9. Strengths and limitations of the study

In terms of strengths, the EuroCaReD prospective study documents clinical characteristics, treatments and programme outcomes of patients admitted to CR in different European countries representing usual care across Europe. The registry covers a large population, providing an overview over similarities but also heterogeneity of CR programmes. Because of the standardised data collection following the CARDS system, the EuroCaReD eCRF can be used as a benchmark throughout European countries. This should enable the CR community to establish more uniform programmes with unified objectives to achieve better treatment results.

This study has several limitations. Availability of data was limited and varied between the participating countries. Therefore caution is warranted when interpreting the data, primarily due to generalizability. In terms of generalizability it has also to be noted that our findings are limited to only 12 European countries where CR institutions were able to contribute data. There is also a possibility that CR centres participating in the survey are most motivated regarding quality assessment and more adherent to evidence-based guidelines. This might result in a selection bias.

Lessons from the limitations of this study caution against lengthy data collection aspirations although the source of collection is a routine clinical programme. EuroCaReD eCRF data collection shows that implementing of electronic reporting alone is not enough relief to achieve sufficient data. To collect high quality data, a robust audit system seems to be crucial. Extra scrutiny should be applied to units where the data collection processes appear to be inadequate.

## 5. Conclusions

To test guideline adherence and treatment quality of CR in Europe this survey provides data of "all-comers" admitted to a CR programme in 12 European countries. Overall patient baseline characteristics at CR programme admission meet the evidence-based guidelines. This also applies to the cardio-protective medication prescription before admission to CR. Nevertheless there are still differences in guideline adherence between countries. Underutilization of CR could be discovered in Europe especially in women and patients with CHF, and in some countries in ACS patients too. This clearly demonstrates a lack of evidence-based guideline adherence. Therefore subgroups where the benefit of CR is underestimated should be specially targeted even because the adherence of patients to CR programmes after admission is high. Deficits could also be found in the uniformity of CR programmes throughout Europe. The heterogeneity of programme design and duration requires better measures that lead to better treatment results, particularly because this first application of eCRF documentation of CR results in European countries was not sufficient enough.

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## Conflict of interest

None declared.

## Appendix 1

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