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Cardiac rehabilitation in very old patients: impact of baseline functional capacity on treatment effectiveness

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31 **Abstract**

32 **Background:** Randomized and observational studies demonstrate that cardiac rehabilitation (CR) is
33 effective in promoting functional recovery and adherence to secondary cardiovascular prevention.
34 There is a paucity of data on the efficacy of CR in elderly. We verified the effectiveness of CR in a
35 very old population after cardiac events and identified independent predictors of improvement in
36 functional capacity.

37 **Methods:** We evaluated all patients aged ≥ 75 years, referred to our outpatient Cardiac
38 Rehabilitation Unit with one of the following causes: acute coronary syndrome, cardiac artery by-
39 pass grafting or heart valve replacement/repair procedures. All enrolled patients attended a four
40 week supervised training program; and were evaluated at admission and at discharge with VO₂peak
41 (Cardiopulmonary stress test), distance walked (6-Minute Walking test) and Torque peak (isokinetic
42 dynamometer).

43 **Results:** We enrolled 160 patients (mean age 80 ± 4 years), the mean value of the three indexes of
44 physical performance considered (power, resistance, strength) improved from baseline to discharge:
45 VO₂peak +10.9%; distance walked +11.0%; Torque peak +11.5%. Performance at admission
46 emerged as an independent predictor **of improvement of 15% in all three indexes: baseline VO₂**
47 **peak OR =0.86 (95% IC=0.77-0.97); baseline 6WT OR= 0.99 (95% IC=0.99-1.00); baseline PT**
48 **90° OR=0.96 (95% IC=0.94-0.98). The higher the performance level at the admission, the**
49 **lower the improvement at discharge.**

50 **Conclusion:** In very old cardiac outpatient CR program is effective to improve exercise tolerance
51 and muscle strength. In addition our data seem to suggest the presence of basal ceiling values of
52 exercise tolerance and muscle strength, above which it is unlikely to expect a significant
53 improvement.

54 **Introduction**

55 Cardiovascular diseases, with coronary heart disease alone accounting for more than half of all
56 cardiovascular deaths, are the leading cause of death in industrialized countries (1). Their
57 prevalence rises exponentially with age and peaks to more than 70% among persons aged 75 years
58 or more. A similar pattern is observed for the incidence of first myocardial infarction (1).

59 Over the last two decades, the remarkably improved management of acute cardiovascular events has
60 reduced heart diseases mortality (2), but at the cost of an increase in the burden of disability (3).

61 Randomized clinical trials, meta-analyses, and observational studies have demonstrated that
62 structured cardiac rehabilitation (CR) is highly effective in improving functional recovery and
63 exercise tolerance, and adherence to secondary prevention measures recommended by guidelines as
64 well (4).

65 Ideally, physical exercise training in a CR program should produce sizable improvements in cardio-
66 circulatory and skeletal muscles performance, at no harm of untoward events, with the issue of
67 safety being particularly relevant in older, frail individuals.

68 Updated guidelines precisely define the core components and outcome measures of CR that is
69 considered, for patients with cardiovascular diseases, as an integral part of long-term secondary
70 prevention programs (5, 6), in which baseline assessment is essential to design an individually
71 tailored training. Accordingly, the response to baseline, symptom-limited exercise stress test has to
72 be used as a starting point to calculate the individual training workload.

73 Despite results of a randomized trial (7) suggest that, compared to younger patients, those older
74 than 75 years obtain similar, or even larger, improvements in exercise tolerance and self-reported
75 physical function from exercise-based CR, the mean age of patients enrolled in most studies of CR
76 is largely less than 75 years (8).

77 Moreover, the limited available data indicate that CR might reduce the risk of functional and
78 cognitive decline and enhance the probability of global functional recovery, thereby preserving the
79 independence in activities of daily living (9).

80 Given the paucity of evidence of CR in older persons, the present observational study was
81 conducted in patients older than 75 years with a recent cardiac event, to assess the efficacy of a CR
82 program in terms of exercise tolerance and muscle strength improvement, and to identify the
83 independent predictors of changes in functional capacity from baseline.

84

85

86

Methods

All consecutive patients aged 75 years or more, referred to the CR Unit of Careggi University Hospital between 2007 and 2010, after an acute coronary syndrome (ACS) treated or not with percutaneous coronary angioplasty, or coronary artery by-pass grafting (CABG) and/or surgical valve replacement/repair procedures, **were considered to enter in our CR a program.**

Criteria for exclusion from our study were: significant cognitive impairment (Mini Mental State Examination score <18 (10) or disability in two or more of Katz BADL (11); **significant musculoskeletal disease or any absolute or relative contraindication to exercise stress test (12);** any disease with expected negative prognosis within 6 months; heart failure diagnosed according to ESC criteria (13), left ventricular ejection fraction (LVEF) $\leq 35\%$.

~~Patients not admitted to standard CR program because of exclusion criteria were offered an ad-hoc, personalized CR program and attended periodical meetings focused on secondary cardiovascular prevention; in particular, those with heart failure were admitted to exercise sessions and educational programs specifically designed by a skilled physiotherapists.~~

The present study has been approved by Local Ethic Committee and it complies with the rules of the declaration of Helsinki. The study is also registered at ClinicalTrial.gov with n°NCT00641113.

General evaluation: At baseline, each patient received a comprehensive clinical and geriatric evaluation, including: demographics; social and medical history; **we consider sedentary patients who perform less than 20 minutes of walk at a normal pace 3 times a week (14).** Assessment of comorbidity by the Charlson-Age Comorbidity Index (**score: 0-43**) (15) of global functional status by Basic Activities of Daily Living (**preserved BADL 0-6/6**) and Instrumental Activities of Daily Living (**preserved IADL 0-8/8**) (16) scales, and of depressive symptoms by the 15-item Geriatric Depression Scale (GDS) (**score: 0-15**) (17), drug therapy. a 12-lead ECG and a mono- and two-dimensional echocardiogram.

111 *Cardiopulmonary and muscular performance tests:* at baseline and at the end of physical training
112 that was an integral component of the CR program, each patient was evaluated with the following
113 tests:

- 114 - *Cardiopulmonary stress test:* **it was performed at cycle ergometry** (Formula ESAOTE®
115 Biomedica instrument) with a progressive incremental 10 watt/min protocol associated with
116 “breath to breath” oxygen consumption analysis (CPX Medical Graphics system®). The
117 outcome measure was the O₂ consumption at peak exercise (VO₂peak, ml/kg/min).
- 118 - **Six minute walking test:** the test was conducted according to the Guyatt protocol in a 30-
119 meter corridor (18) with telemetric-ECG and O₂ saturation monitoring, without previous
120 familiarization test. The outcome measure was total distance walked (in meters).
- 121 - *Isokinetic muscle strength:* the test was performed with isokinetic dynamometer (BIODEX
122 Medical System®) with three progressive angular speed (5 repeats at 90°/sec; 8 repeats at
123 120°/sec; 10 repeats at 180°/sec), evaluating the quadriceps and hamstring muscles strength,
124 in flexion-extension of both inferior limbs. The outcome measure was the 90°Torque peak
125 (Newton for meter) (19).

126 *Exercise training program:* All patients attended a 4-weeks of aerobic training program in the Day-
127 Hospital of the CR Unit five days/week, setting the intensity at 60-70% of VO₂peak attained at
128 baseline cardiopulmonary stress test. **The CR program was individually tailored and physical**
129 **activity intensity changed weekly by using the Borg Rating of Perceived Exertion Scale (20),**
130 **maintaining an intensity of 11–13. This program reflects the routinely length of rehabilitation**
131 **provided for the national health care system.**

132 Training sessions consisted of 30-minute sessions of either biking or callisthenic exercises, on
133 alternate days. **The callisthenic program was structured by a warming period followed by a**
134 **sequence of 8 exercises (2 minutes each one followed by 1 minute at rest), with the aim to**
135 **ameliorate the strength of the leg and stretching the muscles of the trunk, to achieve a better**

136 **autonomy in daily activities. The progressive improvement of resistance was obtained**
137 **applying ankle or wrist bands of progressive weight (0.5 kg , 1 kg) on the basis of Borg Rating**
138 **of Perceived Exertion Scale, re-evaluated weekly.** All activities were performed under the
139 supervision of an expert physiotherapist, with telemetric ECG and non-invasive arterial pressure
140 monitoring.

141 During the CR program, patients and selected family members received formal courses on the
142 management of cardiac risk and emotional profile by physicians, physiotherapists, nurses, a
143 dietician and a psychologist.

144 *Statistical analysis:* All statistical analyses were performed with SPSS® v.18.0 statistical package.
145 Continuous and categorical variables are given as mean \pm standard or percentages, respectively.
146 Univariate analysis, using Pearson R statistics or Chi-square test, was used to test associations of
147 demographic, clinical and echocardiographic variables with exercise and muscle strength
148 performance indexes at the end of the CR. Significantly associated variables were then entered into
149 multivariable logistic models, to identify the independent predictors of CR program effectiveness.
150 To this purpose, the clinical effectiveness of the CR program was defined by two approaches: first,
151 by verifying the presence of improvement in the exercise performance tests from baseline to final
152 evaluation; second, by evaluating the independent predictors of the excellent or poor physical
153 performance improvement defined respectively as a modification $>15\%$ or $\leq 5\%$ in the exercise and
154 muscle strength respect to basal performance.

155 A p value <0.05 was considered statistically significant.

Results

Study population: 236 patients aged ≥ 75 yrs (66.5% males mean age 81 ± 4 yrs) were consecutively evaluated to start our usual CR program. Of these, 39 did not attend to CR program: for personal decision (n=8), for logistic or social barriers (n=12), for clinical instability or recurring hospitalization (n=16), or severe comorbidity (n=3). Other 37 started our CR program but they were not eligible for the present study because they met predefined exclusion criteria (LVEF $\leq 35\%$: n=23; severe cognitive impairment: n=9; severe muscular-skeletal disease: n=5).

Finally, the study population included 160 patients (67,8% of those initially screened; 70.6% males; mean age was 80 ± 4 years). Recent ACS accounted for the vast majority (78.1%) of cases, followed by recent CABG (15%), and cardiac valve replacement/repair (6.9%). The mean time delay between acute hospital discharge and admission to CR program was 12 ± 10 days.

Patients did not show significant disability as demonstrated by mean level of BADL (5.8 ± 0.6) and IADL (7.2 ± 1.4) or cognitive impairment (MMSE score 27.8 ± 2.1).

The clinical characteristics of the study population are reported in Table 1. The average Charlson-Age Comorbidity Index score indicated at least moderate comorbidity. Most patients were married, with a low formal education. At baseline, over 80% of patients were receiving all four classes of drugs recommended for ischemic heart disease (antiplatelets, ACE/ARB, beta-blockers and statins).

The mean number of exercise sessions performed in a 4 week program was 17 ± 3 ; 90% of patients performed $>80\%$ of sessions.

Safety: Our structured CR program proved to be safe; in fact, despite the occurrence of some medical complication, all 160 patients could completed the program. CR-related complications included 3 episodes of chest pain during exercise (treated by potentiating medical therapy), 1 hypertensive crisis during exercise, 1 paroxysmal supraventricular tachycardia during exercise, 2 falls without consequences. Other medical events during the program included 3 broncho-

186 pneumonias, 1 muscular hematoma, 1 transient ischemic attack, 1 worsening of renal function
187 resolved by interruption of ACE-I therapy, 2 episodes of gastrointestinal bleeding requiring
188 hospitalization (but not transfusion of red blood cells) with interruption of CR for less than 10 days.

189 *Efficacy:* In the study population as a whole, all three indexes of physical performance (aerobic
190 capacity, resistance, muscular strength) improved significantly from baseline to the end of CR
191 program: VO₂peak improved from 13.9±3.7 at the entry to 15.1±4.1 ml/kg/min, (p<0.001) with an
192 overall increment of 10.9 % ; the distance walked from 397.7±93.3 to 433.8±92.1 meters, (p<0.001)
193 with an overall increment of 11.0 %.and the muscular strength from 62.2±23.3 to 71.4±25.2
194 Newton for meter, (p<0.001) with an overall increment of 11.5 %. Of note, an improvement > 5%
195 in VO₂peak, distance walked and 90°Torque peak at the end of CR program has been reached
196 respectively in 57.8%, 62.5% and 73.6% .

197 In the Figure we reported the relationship between increment in final performance index defined
198 poor (≤5%) or excellent (>15%) of the three indexes respect to basal value at the entry in the
199 program. We can notice that patients with poor incremental performance results at the end of the CR
200 program had a significant higher mean value at the entry for all the three indexes and,
201 symmetrically, patients with an excellent improvement after CR program presented a significant
202 lower values in all the three indexes at the entry.

203 *Predictors of improvement in exercise tolerance and muscle strength:* The univariable associations
204 of socio-demographic and clinical variables with the two cut-off (≤5% vs. >5%; ≤15% vs. >15%)
205 changes in indicators of exercise tolerance and muscle strength from baseline to the end of CR
206 program were systematically explored **as reported in Tables 2 and 3.**

207 A marginally lower use of statins was found among those who increased VO₂peak by ≤5%
208 Compared to patients who improved by ≤15%, those who improved the 6WT by >15% were more
209 frequently females, with more prevalent depressive symptoms at baseline and sedentary lifestyle

210 prior to acute event, and less frequently diabetics; furthermore, a >15% increase in Torque peak at
211 90° was associated with lower Charlson index, greater BADL score and lower BMI.

212 **None of the other socio-demographic and clinical variables were statistically associated with**
213 **the exercise tolerance and muscle strength improvement, marital status and education level**
214 **included (data not reported in the tables).**

215 The multivariable predictors of a "poor" ($\leq 5\%$) or an "excellent" ($> 15\%$) response to the program
216 are reported in Table 4, in different models calculated for each performance index. In all models, a
217 higher baseline value was the single strongest predictor of a poor response and, conversely, a lower
218 baseline value the strongest predictor of an excellent response for each performance index;
219 increasing age was a significantly negative predictor of a poor response for VO₂peak and 6WT, use
220 of statins a predictor of a poor response for VO₂peak only, while higher Charlson index and BMI
221 and higher BADL score were respectively negative and positive predictors of an excellent response
222 for Torque peak at 90°.

223

Discussion

Despite evidence of clinical and functional efficacy, referral to CR and secondary prevention programs remains very low, particularly among older compared to middle-aged clinical populations (8).

Thus, the first interesting result of this observational study is the high proportion (more than 67%) of patients enrolled in the selected cohort of older (75+ years of age) individuals referred as candidates to outpatient CR program. A broad spectrum of factors and processes influence the rate of attendance to CR program, ranging from clinical and social factors to health professional advice (21). In fact, recent data underlined the importance of early interventions to increase patient attendance, demonstrating that an early appointment significantly improve attendance to CR (20): in particular, an early (≤ 10 days) appointment significantly increases the initial participation to CR (22). In our study, the mean time-lapse between hospital discharge to first assessment visit prior to entry in the CR program was 12 days.

A second valuable observation is the remarkably low rate of adverse events in our very old study population: indeed, no patient interrupted had to be withdrawn permanently from, nor severe cardiac or non cardiac complications requiring hospitalization occurred and, when necessary, the interruption period for any clinical reasons was less than 10 days. Therefore, our results strongly support the belief that structured CR program is safe even for very old patients.

Third, as a main result of the study, we observed a significant average enhancement of exercise capacity and muscular strength in very old patients at the end of the CR program: almost 60% of the study population improved by more than 5% in all the three performance indexes from baseline, and remarkable proportion improved by more than 15% after 4-weeks of intervention. We considered our result as a significant, whereas Ades and Coll. (23) obtained a 17% of peak aerobic capacity increase after 3 months in a population mainly composed by patients with mean age 61 ± 11 years. Our findings are consistent with those obtained by the Researchers of German

249 **Sport University of Cologne (24) that demonstrated an increment of 13.5% and 16.2 % in**
250 **distance walked at Six minute walking test and VO2 peak respectively in elderly patients after**
251 **cardiac surgery at the end of usual CR exercise 3-weeks program.**

252 In our opinion, this finding is of crucial relevance from geriatric perspective, as a significant
253 increase in global functional capacity has been reported to reduce the risk of incident disability, and
254 improve health related quality of life, social reintegration and independence (25).

255 The significant benefit in terms of exercise tolerance, endurance and muscle strength that we
256 obtained in a population with a mean age of 80 years is consistent with recent data (24), which
257 demonstrated an improvement in functional capacity over time after CABG in those participants
258 aged 80 and older in whom routine CR was integrated with resistance and balance training.

259 As reported in our multivariable analysis, the strongest predictor of poor or excellent improvement
260 at the end of CR was the baseline result of all three performance tests: the lower the baseline
261 values, the higher the increase in functional capacity at the end of the CR program. For VO₂peak,
262 this result had already been pointed out by Eder et al. (26) but, to our knowledge, no similar data
263 had been published for the two other performance indexes that represent clinically valuable
264 outcomes of CR.

265 Interestingly, the use of statin negatively predicted the VO₂peak increase at the end of CR program.

266 As reported in Table 2, statins therapy is associated with a 3-fold risk of not reaching a significant
267 improvement at the end of CR program. This results is consistent with recent evidence that
268 simvastatin attenuates the increase in cardio-respiratory fitness and skeletal muscle mitochondrial
269 content in response to exercise training in overweight patients at risk of metabolic syndrome (27);

270 **differently Rengo et al. (28) did not find any detrimental effect of statin on exercise training**
271 **response in a large cohort of middle-aged cardiac patients.**

272 The pathophysiological mechanisms involved in this negative effect of statin seem to be related to
273 a detrimental effect in mitochondrial function, to glucose intolerance and also to a decrease in
274 coenzyme Q10 content of skeletal muscle (29).

275 A high level of BADL was a positive independent predictor and a high level of comorbidity a
276 negative predictor of increase in Torque peak. Taken together, these findings could be considered
277 an indirect, proxy indicator of frailty, and we know how sarcopenia, which negatively influences
278 muscle strength performance, is a major contributor to frailty (30, 31).

279 Finally, to attempt at interpreting the results showed in Figure 1, we can identify cut-off baseline
280 values for all three performance indexes under which we can expect to obtain a significant
281 improvement at the end of CR. Conversely, above those values a structured CR program seems to
282 affect only marginally the global functional capacity of elderly patients, probably due to a ceiling
283 effect. Indeed, older cardiac patients with baseline $VO_{2peak} < 13$ ml/Kg/min, distance walked at
284 6WT < 345 meters, and a Torque peak $90^\circ < 55$ Newton could be those who obtain major benefit
285 from CR.

286 Obviously, this hypothesis has to be tested formally in an ad-hoc prospective study, but we believe
287 that these results are interesting to target the patients who may profit the most - in terms of overall
288 improvement in functional capacity - from use of limited health-care resources.

289 **Study limitations: we must underline some limitations, firstly the observational nature of the**
290 **study, which did not include a control group however the principal aim was identified**
291 **independent predictors of physical performance in elderly patients. Secondly a further**
292 **limitation is the use of only 4 weeks of CR, which may not be sufficient to maximize potential**
293 **gains in aerobic capacity and strength, especially in older adults; nevertheless our CR**
294 **program reflects the routinely length of rehabilitation provided for the national health care**
295 **system.**

296 **Third, the only 2 measurements (baseline and 4 weeks later) can not exclude the presence of**
297 **statistical effect named “*regression to the mean*” however the average of improvement is**
298 **strictly similar to the result obtained by Busch et al. (24) in very old patients attending 3-**
299 **weeks CR program after Coronary Bypass Surgery.** Finally a selection bias could be represent
300 by the exclusion of older patients with significant cognitive decline or disability were excluded,
301 and of those with at least moderate left ventricular dysfunction, which limits our results to only a
302 part of elderly patients routinely hospitalized for cardiac disease
303 Despite these limitations, we believe that our study demonstrates that a structured CR program,
304 started soon after discharge from acute cardiac medical or post-surgical wards, is safe and produces
305 remarkable improvements in exercise tolerance and muscle strength even in very old cardiac
306 patients. Data also suggest functional baseline cut-off values to be used as criteria for targeting a
307 clinical population of less fit, frail older patients, who are likely to profit the most from CR
308 programs. A result that we deem particularly valuable for optimal utilization of limited health care
309 resources in front of the progressive expansion of the population of older cardiac patients.
310

311

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313

314 **References**

- 315 1. Sidney S, Rosamond WD, Howard VJ, et al. Heart Disease and Stroke Statistics—
316 2013 Update. A report from American Heart Association. *Circulation* 2013;127:21-23.
- 317 2. Yeh RW, Sidney S, Chandra M, et al. Population trends in the incidence and outcomes of
318 acute myocardial infarction. *N Engl J Med* 2010;362:2155–2165.
- 319 3. Yazdanyar A, Newman AB. The burden of cardiovascular disease in the elderly: morbidity,
320 mortality, and costs. *Clin Geriatr Med* 2009;25:563-77.
- 321 4. Jolliffe JA, Rees K, Taylor RS, et al. Exercise-based rehabilitation for coronary heart disease.
322 *Cochrane Database Syst Rev* 2001;(1):CD001800.
- 323 5. Giannuzzi P, Temporelli PL, Marchioli R, et al. Global secondary prevention strategies to
324 limit event recurrence after myocardial infarction: results of the GOSPEL study, a multicenter,
325 randomized controlled trial from the Italian Cardiac Rehabilitation Network. *Arch Intern Med*
326 2008;168:2194-204.
- 327 6. Piepoli MF, Carre F, Heuschmann P, et al. Secondary prevention through cardiac
328 rehabilitation: physical activity counselling and exercise training: Key components of the
329 position paper from the Cardiac Rehabilitation Section of the European Association of
330 Cardiovascular Prevention and Rehabilitation. *Eur Heart J* 2010;31: 1967-1976.
- 331 7. Marchionni N, Fattirolli F, Fumagalli S, et al. Improved exercise tolerance and quality of life
332 with cardiac rehabilitation of older patients after myocardial infarction: results of a
333 randomized, controlled trial. *Circulation* 2003;107:2201-6.
- 334 8. Heran BS, Chen JM, Ebrahim S, et al. Exercise-based cardiac rehabilitation for coronary
335 heart disease. *Cochrane Database Syst Rev* 2011;(7):CD001800.
- 336 9. Pasquali SK, Alexander KP, Peterson ED. Cardiac rehabilitation in the elderly. *American*
337 *Heart Journal* 2001;142:748-55.

10. Folstein MF, Folstein SE, McHugh PR. "Mini Mental State" a practical method for grading the cognitive state of patients for the clinicians. J Psychait Res 1975;12:189-198.
11. Katz S, Ford AB, Moskowitz RW, et al. Studies of Illness in the Aged: The Index of ADL: A Standardized Measure of Biological and Psychosocial Function. JAMA 1963;185:914-919.
12. Gibbons RJ, Balady GJ, Bricker JT, et al. ACC/AHA 2002 guideline update for exercise testing: summary article. A report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Committee to Update the 1997 Exercise Testing Guidelines). J Am Coll Cardiol 2002;40:1531-40.
13. Dickstein K, Cohen-Solal A, Filippatos G, et al. ESC guidelines for the diagnosis and treatment of acute and chronic heart failure 2008: the Task Force for the diagnosis and treatment of acute and chronic heart failure 2008 of the European Society of Cardiology. Developed in collaboration with the Heart Failure Association of the ESC (HFA) and endorsed by the European Society of Intensive Care Medicine (ESICM). Eur J Heart Fail 2008;10:933-89.
14. **Pate RR, O'Neill JR, Lobelo F. The evolving definition of "sedentary". Exerc Sport Sci Rev 2008;36:173-8**
15. Charlson ME, Pompei P, Ales KL, et al. A new method of classifying prognostic comorbidity in longitudinal studies: Development and validation. Journal of Chronic Diseases 1987;40:373-83.
16. Lawton MP, Brody EM. Assessment of older people: self-maintaining and instrumental activities of daily living. Gerontologist 1969;9:179-186.
17. Sheikh JJ, Yesavage JA. Geriatric Depression Scale (GDS): recent evidence and development of a shorter version. Clin Gerontol 1986;5:165-173.
18. Guyatt GH, Sullivan MJ, Thompson PJ, et al. The 6-minute walk: a new measure of exercise capacity in patients with chronic heart failure. Can Med Assoc J 1985;132:919-923.

19. Grimby G. Progressive resistance exercise for injury rehabilitation – Special emphasis on isokinetic training. Sport Med 1989;2:309-315.
20. **Borg G. Borg's Perceived Exertion and Pain Scales. Human Kinetics 1998**
21. Suaya JA, Shepard DS, Normand SL, et al. Use of cardiac rehabilitation by Medicare beneficiaries after myocardial infarction or coronary bypass surgery. Circulation 2007;116:1653-1662.
22. Pack QR, Mansour M, Barboza JSet al. An early appointment to outpatient cardiac rehabilitation at hospital discharge improves attendance at orientation: a randomized, single-blind, controlled trial. Circulation 2013;127:349-55.
23. **Ades PA, Savage PD, Brawner CA et al. Aerobic capacity in patients entering cardiac rehabilitation. Circulation 2006;113:2706-12.**
24. Busch JC, Lillou D, Wittig G, et al. Resistance and balance training improves functional capacity in very old participants attending cardiac rehabilitation after coronary bypass surgery. J Am Geriatr Soc 2012;60:2270-6.
25. Hamm LF, Wenger NK, Arena R, et al. Cardiac rehabilitation and cardiovascular disability: role in assessment and improving functional capacity: a position statement from the American Association of Cardiovascular and Pulmonary Rehabilitation. J Cardiopulm Rehabil Prev 2013;33:1-11.
26. Eder B, Hofmann P, Von Duvillard SP, et al. Early 4-week cardiac rehabilitation exercise training in elderly patients after heart surgery. J Cardiopulm Rehabil Prev 2010;30:85-92.
27. Mikus CR, Boyle LJ, Borengasser SJ, et al. Simvastatin impairs exercise training adaptations. J Am Coll Cardiol 2013;62:709-14.
28. **Rengo JL, Savage PD, Toth MJ, Ades PA. Statin therapy does not attenuate exercise training response in cardiac rehabilitation. J Am Coll Cardiol 2014;63:2050-1.**

387 29. Larsen S, Stride N, Hey-Mogensen M, et al. Simvastatin effects on skeletal muscle: relation to
388 decreased mitochondrial function and glucose intolerance. *J Am Coll Cardiol* 2013;61:44-53.

389 30. Peterson MD, Gordon PM. Resistance exercise for the aging adult: clinical implications and
390 prescription guidelines. *Am J Med* 2011;124:194-8.

391 31. Borst SE. Interventions for sarcopenia and muscle weakness in older people. *Age Ageing*
392 2004;33:548-55.

393

394 **Table legend**

395 **Table 1:** Clinical characteristics of the study population

396 **Table 2:** Differences in clinical characteristics according to be a poor ($\Delta \leq 5\%$) performer in the
397 three indexes of performance

398 **Table 3:** Differences in clinical characteristics according to be an excellent ($\Delta > 5\%$) performer in
399 the three indexes of performance

400 **Table 4:** Independent predictors of poor ($\leq 5\%$) or excellent ($>15\%$) performance measures at the
401 end of CR (Multivariable logistic regression models)

402

403 **Figure legend**

404 **Figure:** Differences in mean basal value at the entry in CR program between poor performers and
405 excellent performers in the three performance indexes

406

407 **Tables**

408 **Table 1**

	Mean SD	Range
Age, (yrs)	80.3±4.2	75-93
Body mass index(Kg/m ²)	25.9±3.7	18-40
Heart rate (b/min)	65.8±12.1	41-103
Systolic blood pressure (mmHg)	132.1±21.8	90-195
Diastolic blood pressure (mmHg)	74.5±10.9	50-110
Left Ventricular Ejection Fraction (%)	53.5±8.8	35-74
<u>eGFR (CKDepi formula, cc/min)</u>	<u>62.3±17.5</u>	<u>22-90</u>
Comorbidity (Charlson-age score)	5.8±1.7	3-10
<u>VO2 peak (ml/kg/min)</u>	<u>13.9±3.7</u>	<u>6.5-26.2</u>
<u>6WT (mt)</u>	<u>397.7±93.3</u>	<u>140-620</u>
<u>PT 90° (Newton · mt)</u>	<u>62.2±23.3</u>	<u>10.7-123.1</u>
	N=	%
Male/Female	113/47	70.6/29.4
Marital status		
<i>Unmarried</i>	9	5.5
<i>Widow/widower</i>	40	25.0
<i>Divorced</i>	3	1.9
<i>married</i>	108	67.5
Education		
<i>Illiterate</i>	2	1.3
<i>Elementary school</i>	87	54.4
<i>Middle school</i>	29	18.1
<i>High school</i>	26	16.3
<i>Graduation degree</i>	16	10.0
Hypertension	123	76.9
Obesity	22	13.8
Diabetes	39	24.4
Hypercholesterolemia	64	40.0
<u>COPD</u>	<u>17</u>	<u>10.6</u>
Depression	28	17.5
Smoking	40	25.0
	n	%
ACE-inhibitors/ARB	144	90.0
Beta-blockers	128	80.0
Antiplatelet agents	143	89.4
Statins	140	87.5

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Table 2

Variable	Δ VO2*			Δ 6WT			Δ PTdx		
	$\leq 5\%$ N=65	$>5\%$ N=89	p	$\leq 5\%$ N=60	$>5\%$ N=100	p	$\leq 5\%$ N=42	$>5\%$ N=118	p
Age	80.8 \pm 4.4	80.0 \pm 4.2	0.250	81.1 \pm 4.3	79.8 \pm 4.1	0.053	80.1 \pm 4.4	80.3 \pm 4.2	0.814
Charlson age score	5.6 \pm 1.5	5.8 \pm 1.8	0.438	5.9 \pm 1.6	5.7 \pm 1.7	0.481	6.0 \pm 1.8	5.7 \pm 1.6	0.374
BADL	5.8 \pm 0.6	5.9 \pm 0.5	0.286	5.8 \pm 0.7	5.8 \pm 0.4	0.854	5.8 \pm 0.4	5.9 \pm 0.6	0.537
IADL	7.1 \pm 1.5	7.3 \pm 1.1	0.524	7.2 \pm 1.3	7.1 \pm 1.4	0.964	7.1 \pm 1.2	7.1 \pm 1.2	0.915
MMSE score	27.8 \pm 2.2	27.9 \pm 2.0	0.764	27.7 \pm 2.1	27.9 \pm 2.2	0.726	28.0 \pm 1.7	27.8 \pm 2.3	0.466
GDS score	3.3 \pm 3.0	3.3 \pm 2.9	0.961	3.3 \pm 2.1	3.3 \pm 3.0	0.967	3.8 \pm 3.2	3.1 \pm 2.9	0.174
BMI	25.7 \pm 3.9	26.1 \pm 3.3	0.524	26.2 \pm 3.4	25.7 \pm 3.8	0.381	26.7 \pm 4.2	25.5 \pm 3.9	0.089
Ejection fraction	53.8 \pm 9.4	53.5 \pm 8.4	0.851	53.8 \pm 9.4	53.5 \pm 8.4	0.572	53.3 \pm 9.0	53.5 \pm 8.4	0.553
eGFR (CKDepi-cc/min)	<u>64.9\pm16.3</u>	<u>60.5\pm18.2</u>	<u>0.120</u>	<u>62.7\pm15.5</u>	<u>62.2\pm18.7</u>	<u>0.876</u>	<u>63.9\pm18.4</u>	<u>61.9\pm17.3</u>	<u>0.517</u>
Females	21(32.3)	25(28.1)	0.572	16 (26.7)	31(31.0)	0.560	11(26.2)	36(30.8)	0.577
Diagnosis			0.171			0.440			0.751
ACS (126)	83.1	77.5		80.1	78.0		81.0	77.8	
CABG (23)	7.7	19.1		11.6	16.0		11.9	15.4	
VALV (11)	9.2	3.4		8.3	6.0		7.1	6.8	
Hypertension	76.9	79.8	0.670	76.7	77.0	0.961	73.8	77.8	0.602
Obesity	9.2	16.9	0.173	9.2	14.0	0.906	19.0	11.1	0.193
Diabetes	18.5	29.2	0.126	25.0	24.0	0.887	26.2	23.9	0.770
Sedentary	15.4	13.5	0.739	10.0	18.0	0.170	14.3	14.5	0.969
Dislipidemia	38.5	43.8	0.505	36.7	42.0	0.505	40.5	40.2	0.972
Depression	20.0	14.6	0.378	10.0	22.0	0.053	23.8	15.4	0.219
Smoking	26.3	23.6	0.716	25.0	25.0	1.000	21.4	26.5	0.516
COPD	<u>10.8</u>	<u>10.1</u>	<u>0.895</u>	<u>62.7</u>	<u>18.7</u>	<u>0.208</u>	<u>14.3</u>	<u>9.4</u>	<u>0.381</u>
Antiplatelets	87.7)	91.0)	0.505	90.0)	89.0)	0.942	85.7	90.6.	0.380
ACE/ARB	89.2)	91.0)	0.713	91.7)	89.0)	0.568	85.7	91.5.	0.289
Betablockers	75.4)	83.1)	0.235	76.7)	82.0)	0.414	73.8	82.1	0.253
Statins	81.5)	92.1)	0.048	85.0)	89.0)	0.459	81.0	89.7	0.141

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Table 3

Variable	Δ VO2*			Δ 6WT			Δ PTdx		
	≤ 15% N=113	>15% N=47	p	≤ 15% N=115	>15% N=45	p	≤ 15% N=82	>15% N=77	p
Age	80.4±4.3	80.0±4.2	0.792	80.4±4.4	79.8±3.8	0.428	80.0±4.3	80.5±4.1	0.396
Charlson age score	5.7±1.6	6.0±1.8	0.316	5.8±1.7	5.7±1.6	0.652	6.0±1.8	5.5±1.5	0.045
BADL	5.8±0.5	5.9±0.6	0.304	5.8±0.6	5.8±0.5	0.717	5.7±0.6	5.9±0.4	0.038
IADL	7.2±1.3	7.2±1.2	0.951	7.1±1.3	7.2±1.5	0.843	7.0±1.5	7.3±1.1	0.276
MMSE score	27.9±2.0	27.8±2.3	0.882	27.7±2.2	28.3±2.0	0.103	27.9±2.1	27.7±2.2	0.580
GDS score	3.3±2.9	3.1±3.0	0.628	3.1±2.6	3.8±3.4	0.188	3.6±3.2	2.9±2.6	0.175
BMI	25.9±3.8	26.1±2.9	0.724	25.6±3.7	26.5±3.8	0.184	26.3±3.8	25.3±2.3	0.050
Ejection fraction	53.8±8.9	53.3±8.7	0.727	54.3±8.4	51.9±9.7	0.129	54.0±8.4	53.1±9.3	0.513
eGFR(CKDepi cc/min)	<u>63.5±16.7</u>	<u>59.7±19.3</u>	<u>0.208</u>	<u>62.9±16.7</u>	<u>61.0±19.6</u>	<u>0.550</u>	<u>63.5±16.7</u>	<u>63.8±18.5</u>	<u>0.320</u>
Females	33(30.8)	13(27.7)	0.691	28(24.3)	19(42.2)	0.026	23(28.0)	24(31.2)	0.667
Diagnosis			0.171			0.212			0.141
ACS (126)	83.1	72.3		80.4	75.5		81.7	75.3	
CABG (23)	11.4	23.4		12.6	17.8		11.0	18.2	
VALV (11)	6.5	4.3		7.0	6.7		7.3	6.5	
Hypertension	76.6	83.0	0.377	79.1	71.1	0.279	72.0	81.8	0.141
Obesity	13.1	14.9	0.763	13.0	15.6	0.678	17.1	9.1	0.137
Diabetes	22.4	29.8	0.329	29.6	11.1	0.015	30.5	18.2	0.071
Sedentary	15.9	10.6	0.391	11.3	24.4	0.036	13.4	15.6	0.697
Dislipidemia	38.3	48.9	0.218	38.3	44.4	0.473	46.3	33.8	0.106
Depression	16.8	17.0	0.976	13.0	28.9	0.018	22.0	13.0	0.138
Smoking	29.0	14.9	0.062	25.2	24.4	0.919	22.0	28.6	0.336
COPD	<u>12.1</u>	<u>6.5</u>	<u>0.280</u>	<u>10.4</u>	<u>11.1</u>	<u>0.904</u>	<u>12.2</u>	<u>9.1</u>	<u>0.527</u>
Antiplatelets	90.7	87.2	0.522	90.4	86.7	0.487	78.4	93.5	0.097
ACE/ARB	91.6	87.2	0.401	89.6	91.1	0.769	90.2	89.6	0.894
Betablockers	78.5	83.0	0.524	81.7	75.6	0.379	78.0	81.8	0.554
Statins	86.9	89.4	0.671	88.7	84.4	0.465	82.9	92.2	0.078

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434 **Table 4**

Independent variables	$\Delta \text{VO}_2\text{peak} \leq 5\%$		$\Delta \text{VO}_2\text{peak} >15\%$	
	Wald χ^2 R	OR (95%CI)	Wald χ^2 R	OR (95%CI)
Age	6.55	1.12 (1.03-1.23) §	1.39	0.95 (0.87-1.04)
Female gender	2.43	0.53 (0.24-1.18)	1.27	1.60 (0.71-3.60)
Baseline VO_2peak	14.45	1.24 (1.11-1.39) ¶	6.59	0.86 (0.77-0.97) ¶
Statins	3.94	2.87 (1.01-8.13) #

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Independent variables	6 WT $\leq 5\%$		6 WT $>15\%$	
	Wald χ^2 R	OR (95%CI)	Wald χ^2 R	OR (95%CI)
Age	7.13	1.13 (1.03-1.23) §	3.08	0.92 (0.83-1.01)
Female gender	0.52	0.74 (0.33-1.68)	0.28	0.80 (0.35-1.86)
Baseline 6WT	8.96	1.01 (1.00-1.01) §	13.65	0.99 (0.99-1.00) ¶
Depression	1.18	1.75 (0.64-4.85)	1.35	0.57 (0.22-1.47)
Sedentary Lifestyle	0.01	0.98 (0.34-2.83)

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Independent variables	PT 90° $\leq 5\%$		PT 90° $>15\%$	
	Wald χ^2 R	OR (95%CI)	Wald χ^2 R	OR (95%CI)
Age	1.36	1.06 (0.96-1.17)	0.01	1.00 (0.92-1.09)
Female gender	1.94	0.51 (0.19-1.32)	2.75	2.06 (0.88-4.85)
Basal PT 90°	14.31	1.04 (1.02-1.06) ¶	15.58	0.96 (0.94-0.98) ¶
Charlson index	6.32	0.75 (0.60-0.93) #
BADL	4.49	2.60 (1.07-6.27) #
BMI	0.51	0.96 (0.87-1.07)

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p<0.05

§ p <0.01

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