Exercise-Based Cardiac Rehabilitation for Very Old Patients (≥75 Years)

FOCUS ON PHYSICAL FUNCTION

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■ Older patients have high rates of physical function impairment and disability following a cardiac event. Exercise training has been shown to favorably affect such limitations, as well as cardiovascular risk factors, symptoms, and mortality postcoronary event in middle-aged patients. Aerobic capacity, body strength, quality of life, and physical function are improved with exercise-based cardiac rehabilitation (CR) in patients older than 65 years. However, there have been relatively few studies of the effects of exercise-based CR on physical function recovery in the very old patients (≥75 years), despite the continuous growth of this segment of the population. After hospitalization for a cardiac event, postacute inpatient CR serves as a bridge between acute care and independent home living for the most disabled older patients. It plays an important role in the physical recovery process, particularly after cardiac surgery. Exercise-based outpatient (phase II) CR, starting early after hospital discharge, is safe in very old patients and studies demonstrate that these patients derive similar benefits from CR, compared with younger patients, regarding physical function improvement. Older patients, however, are less likely than younger cardiac patients to participate in outpatient CR programs. There is a need to find protocols that could increase the referral and participation rates of the frailer and older cardiac patient to exercise-based CR.

K E Y W O R D S

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exercise training

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It is estimated that by 2030, 1 in 5 Americans will be older than 65 years.[1] As a consequence, the number of older patients with cardiovascular disease (CVD) is expected to increase. From 1979 to 2004, the number of inpatient discharges with CVD as the primary diagnosis increased 30%, and hospital discharges for heart failure increased 175% during the same period.[2,3] Elderly patients with CVD have very high rates of disability, recurrent coronary events, and health resources use.[4–7,8] For noninstitutionalized elderly patients with CVD, disability rates are particularly high in women, patients with more advanced age, and individuals with chronic angina pectoris or heart failure.[6,9,10] CVD is the most common primary diagnosis at admission of nursing home residents 65 years or older.[3,11]

There is a pressing need to develop strategies to reduce the societal burden of disability due to coronary artery disease (CAD) and other CVD in the elderly population. Exercise training has been shown to favorably affect cardiovascular risk factors, symptoms, exercise tolerance, and CAD mortality postcoronary event in middle-aged patients.[12–19] In older cardiac patients, a primary goal of exercise-based cardiac rehabilitation (CR) is to reduce disability and lengthen disability-free survival following a coronary event.

Aerobic capacity, body strength, quality of life (QOL), as well as both perceived and measured physical function, are improved with exercise-based CR in patients older than 65 years.[20–36] The effect of exercise-based CR in the very old patients (≥75 years) has been less well studied. The purpose of this review is to analyze the impact of exercise-based CR in the very old population, with an emphasis on physical function and disability.

DETERMINANTS OF PHYSICAL FUNCTION AND DISABILITY IN OLDER CORONARY PATIENTS

Physical function relates to the ability of an individual to perform physical tasks necessary for activities of daily life. Disability, the consequence of disease or pathology, has been referred to as impairment in the normal functioning of an individual.[37,38] The 4 major types of disability are physical, emotional, mental, and social.[38] The Framingham Disability Study analyzed the relationship between specific CAD manifestations such as angina and heart failure and physical disability in 2,576 community-dwelling older individuals (Table 1).[9] A greater percentage of women reported being disabled than men. In all gender and age strata, disability was more prevalent in individuals with CAD than in individuals free of CAD. The most disabled group was older women (≥70 years old) with CAD, particularly those with angina or heart failure.

Table 1 • PREVALENCE OF DISABILITY BY AGE AND CARDIOVASCULAR DISEASE STATUS IN THE FRAMINGHAM DISABILITY STUDY[a]

	55 to 69 y		70 to 88 y	
	n	%	*n*	%
No CAD or CHF				
Women	829	25	471	49
Men	574	9	275	27
CAD				
Women	81	64	109	79
Men	121	49	92	49
Angina pectoris				
Women	67	67	83	84
Men	81	57	59	56
CHF				
Women	15	80	25	88
Men	7	43	14	57

Abbreviations: CAD, coronary artery disease; CHF, chronic heart failure.
[a]Adapted from Pinsky JL, Jette AM, Branch LG, et al. The Framingham Disability Study: Relationship of various coronary heart disease manifestations to disability in older patients living in the community. *Am J Public Health.* 80:1363–1368.

In a subsequent study of 1,001 elderly individuals, it was found that women with angina were at significantly higher risk for reduced functional capacity than men with angina or women with other heart disease, mirroring the results of the Framingham Disability Study.[39] Finally, the Medical Outcomes Study, a survey of 9,385 older adults, analyzed the impact of various chronic diseases on functional status and well-being. It was found that heart disease had the greatest overall impact when compared with other chronic diseases.[40]

Peak aerobic capacity and depression score were shown to be independent predictors of self-reported physical function in a study with patients older than 65 years with chronic CAD.[6] Furthermore, in this study, women had lower physical function than men, which was consistent with other studies.[9,41] On the other hand, body mass index, revascularization status, and ejection fraction did not predict physical function. Of note, the lower physical function scores in women compared with men were not due to differences in age, depression score, measures of left ventricular function, or frequency of comorbidities. Factors most likely contributing to lower physical function among women were lower measures of peak aerobic capacity and strength in women compared with men. Perceptual factors may also have played an important role in the lower physical function scores, because women were more likely than men to describe that they limited activities to be "safe for their heart."

PHYSICAL FUNCTION ASSESSMENT IN OLDER CARDIAC REHABILITATION PATIENTS

Exercise testing, self-reported physical function questionnaires, and physical performance testing have all been used to assess physical function and disability in older individuals with CAD. Each modality of functional evaluation possesses advantages and disadvantages.

Exercise Testing

Exercise testing is valuable for diagnosis, risk stratification, and exercise prescription. It is also useful to evaluate the results of an exercise-training program. Exercise performance can also be used as a rough predictor of self-reported physical function and ability to perform daily activities in elderly individuals with CAD.[6,32,42] However, it does not always correlate with the degree of participation in daily household activities. In a study of 100 men aged 35 to 77 years, participation in many household activities bore no relationship to exercise capacity measured on the treadmill.[43] Patients' own perceptions of their limitation for physical activities was determined by cardiac symptoms and concerns for safety.

The most common form of exercise testing in older CR participants (≥65 years) consists of progressive exercise on a treadmill or a cycle ergometer to exhaustion or symptoms.[6,20,21,23–31,34–36,42,44–52] Although treadmill exercise is the generally preferred modality in America, cycle ergometry, used more commonly in Europe, may be ideal in subjects with gait or balance instability.[53] Aerobic capacity can be measured directly with collection of expired gas and determination of peak oxygen uptake (peak VO_2), expressed in milliliters (mL) · kilogram $(kg)^{-1}$ · minute $(min)^{-1}$. It can also be estimated from the highest treadmill work achieved and is then expressed in metabolic equivalents of task (METS). The American College of Sports Medicine equation for the estimation of oxygen uptake is: 1 MET = 3.5 mL of $O_2 \cdot kg^{-1} \cdot min^{-1}$.[53,54] However, in the setting of CR, peak VO_2 was overestimated by about 40% with this equation in a population of mostly middle-aged patients.[55] This equation also overestimated aerobic capacity in elderly (from 12% to 31%) and younger CR patients (from 23% to 51%) compared with precise measurements of peak VO_2.[49] When accurate and reproducible objective assessment of aerobic capacity is needed, such as in research studies, peak VO_2 is usually measured directly.

Self-Reported Physical Function Questionnaires

Most of the current information on physical function in elderly CR (≥65 years) patients derives from self-reported physical function questionnaires.[9,26,32–34,46,49,56,57] The most frequently used questionnaire is the physical function component of the Medical Outcomes Study 36-Item Short-Form Health Survey (SF-36).[26,32,33,46,49,56,57] The SF-36 is a reliable measure of health-related QOL, and it has been extensively studied and validated in different clinical populations.[40,58–62] It consists of 36 items divided into 8 subscales that measure different health concepts or domains: vitality, role physical, role emotional, physical function, mental health, general health, bodily pain, and social functioning. Two summary scores (physical and mental) are calculated from the 8 subscale scores.

The physical component summary score includes perception of ability to engage in different levels of physical activity, ability to carry out roles, pain, and general health. It is scored from 0 to 100, with higher scores indicating better physical function.[59,62] In older CR patients (≥65 years), the SF-36 physical function score is correlated with aerobic capacity and body strength.[6,63]

Physical Performance Testing

Physical performance testing objectively measures performance of daily activity in a laboratory setting. Only a few studies have used comprehensive physical performance tests to assess physical function and disability in elderly patients (≥65 years) with CAD.[32,33,52] The Continuous-Scale Physical Functional Performance Test (CS-PFP) was designed and validated for the measurement of physical function across a wide range of functional levels.[32,33,61,62,64] It is highly correlated with peak VO_2 and strength testing in elderly patients with CAD, and it is sensitive to change induced by exercise.[32,33,64] However, there is not always a close association between the CS-PFP and self-reported physical function measured by the SF-36 questionnaire suggesting that both instruments assess different concepts.[32] This test is based on execution of 16-structured common household tasks, sequentially performed, at near maximal effort (Table 2). All tasks are quantified by a combination of time, distance, and weight carried. Each task is scored 0 to 100, on the basis of data gathered from older adults with a broad range of individual functional abilities.[61] The test yields a total score (0–100) that is the average of the following 5 separate physical domains scores: upper body strength, lower body strength, flexibility, balance, and coordination. A shorter version of the CS-PFP has also been developed; the Physical Functional Performance–10 Test

Table 2 • TASKS OF THE CONTINUOUS-SCALE PHYSICAL FUNCTIONAL PERFORMANCE TEST (CS-PFP) AND THE PHYSICAL FUNCTIONAL PERFORMANCE-10 TEST (PFP-10)

Tasks	CS-PFP	PFP-10
Carrying a weighted pan a distance of 1 m	+	+
Pouring water from a jug into a cup	+	−
Putting on and removing a jacket	+	+
Placing a sponge on and removing it from an adjustable shelf	+	+
Floor sweeping with broom and dustpan	+	+
Transferring clothes from washer to dryer and from dryer to basket	+	+
Opening and passing through a fire door	+	−
Making a bed	+	−
Vacuuming	+	−
Placing a strap over a shoe	+	−
Picking up 4 scarves from the floor	+	+
Carrying weighted bags up and down a simulated bus stop	+	−
Carrying groceries 70 m	+	+
Sitting on and standing up from the floor	+	+
Climbing stairs	+	+
6-min walking	+	+

(Table 2). It yields measurements that are reliable, valid, and sensitive to change, and can be confidently substituted for the CS-PFP.[65]

The 6-minute walk test, which is also part of the CS-PFP, measures the maximal distance that a patient can walk in a period of 6 minutes and has been used to evaluate functional status in elderly patients with CAD.[66,67] Its properties are well-established.[68] Reference equations have been derived from healthy adults matched for age, gender, height, and weight.[69] Moreover, standardized protocols of administration have been published.[70,71]

Most patients with CAD do not achieve maximal exercise capacity with the 6-minute walk test.[70] However, most activities of daily living are performed at submaximal levels of exertion and, therefore, the 6-minute walk test may be more reflective of activities of daily living than progressive symptom-limited exercise tests.[70] This test is simple to administer and well tolerated. It requires a 100-ft hallway but no exercise equipment or advanced staff training. It can be performed by most patients, even the frail elderly; however, it cannot be performed as easily by people with lower extremity dysfunction or severe obesity.[70,72]

CARDIAC REHABILITATION IN VERY OLD PATIENTS (≥75 YEARS) AND PHYSICAL FUNCTION IMPROVEMENT

Postacute Inpatient Cardiac Rehabilitation

Although standard phase I CR encourages early mobilization and activity progression after admission for a cardiac event, older patients often have a slower and more complicated recovery, particularly after heart surgery. As a result, patients frequently are not able to return directly to home without intensive physical and medical rehabilitation. Therefore, they are often referred to a medical rehabilitation facility for postacute inpatient CR, also termed transitional CR or phase 1B CR.[73,74] Postacute inpatient CR is offered in the setting of a comprehensive medical rehabilitation program. This type of CR represents a bridge between acute inpatient (phase I) and outpatient (phase II) CR programs for autonomous patients. Its primary purpose is restoration of functional independence.[73]

Studies of postacute inpatient CR in the medical literature are sparse. An analysis of 1,620 patients who underwent cardiac surgery at Brigham and Women's hospital from July 2000 to June 2001 revealed that 56% of patients were older than 65 years and that nearly half of them needed transitional CR after surgery in comparison with only 9% of younger patients.[75] These results are concordant with a study published in 2006, which demonstrated that patients older than 65 years had an adjusted odds ratio of 9.4 of being transferred to transitional CR after cardiac surgery in comparison with patients younger than 55 years.[73] Risk factors, other than age, for the need of transitional CR after cardiac surgery are female gender, lack of social support, lower hemoglobin level, and longer hospital length of stay after surgery.[73,75] Comorbid conditions such as chronic obstructive pulmonary disease, functional class before surgery, preoperative use of intra-aortic balloon pump, and aortic valve replacement also predict use in univariate analyses.[73] In 2006, of 530 patients at our institution who had cardiac surgery (coronary artery bypass and/or valve surgery), 130 (24.5%) were 75 years or more. Of the older patients, 22 (17%) were transferred from the surgical unit to a medical rehabilitation facility. All of these 22 patients were subsequently discharged home.

Benefits of Postacute Inpatient Cardiac Rehabilitation

Kong et al evaluated a consecutive sample of 44 patients who underwent cardiac surgery (coronary artery bypass and/or valve surgery) and who were subsequently admitted to postacute inpatient CR (Table 3).[76] Their mean age was 71 years and 45% were women. Patients had to be stable medically, to be able to tolerate 3 or more hours of therapy daily, and to have a potential for functional gains. Functional status of each patient was evaluated on admission and at discharge with the Functional Independence Measure (FIM) instrument, an 18-item observer-rated instrument, widely used in the setting of medical rehabilitation.[77,78] It is scored from 18 (total dependence) to 126 (complete independence) and assesses transfers, locomotion, self-care, and sphincter management, which altogether compose a motor subtotal, as well as communication and social cognition, which form a cognitive subtotal.

The mean length of stay in postacute inpatient CR was 12 days. There was a significant increase in the FIM score from admission to discharge in the population studied, predominantly in the motor category. The predictors of a higher discharge FIM score in multivariate analysis were higher admission score and longer length of stay in the acute care facility. The predictors of discharge disposition were not evaluated, but more than 90% of all patients returned directly home after discharge. This small study illustrates the important functional gains that can be made during inpatient postacute CR by selected individuals not functionally ready to go directly home after a cardiac surgery.

Table 3 • BENEFITS OF POSTACUTE INPATIENT CARDIAC REHABILITATION

Study	Patients	LOS[a]	Main Results
Kong et al (1996)[76]	*N* = 44 (postcardiac surgery) Mean age = 71 Women = 45%	12 days	Increased discharge mean total FIM score vs admission (97 vs 76, $P < .001$); increased discharge mean motor FIM score vs admission (66 vs 46, $P < .001$); no change in cognitive FIM score Best predictors of discharge total FIM score were higher admission FIM score and longer LOS in the acute care facility
Sansone et al (2002)[74]	*N* = 143 (cardiac surgery, post-MI, or heart failure) Mean age = 70 Women = 40%	17 days	Increased discharge mean total FIM score versus admission (113 vs 90, $P < .0001$) Best predictors of discharge total FIM score were lower age, higher admission FIM score, and primary diagnosis of cardiac surgery Best predictors of discharge disposition to home were higher discharge total FIM score, higher admission total FIM score, and a shorter LOS in the inpatient CR program
Lichtman et al (2007)[79]	*N* = 121 (cardiac surgery, post-MI, or heart failure) Mean age = 76 Women = 54%	14 days	Increased discharge mean total FIM score vs admission (115 vs 88, $P < .001$); increased discharge mean motor FIM score vs admission (82 vs 56, $P < .001$); increased discharge mean cognitive FIM score vs admission (33 vs 32, $P < .001$) Increased discharge mean SF-36 score vs admission (57 vs 43, $P < .001$) Preserved 3-month and 1-year function (total, motor, and cognitive FIM) vs discharge Increased 3-month and 1-year mean SF-36 scores vs discharge All patients discharged home

Abbreviations: CR, cardiac rehabilitation; FIM, Functional Independence Measure; LOS, length of stay; MI, myocardial infarction; SF-36, 36-Item Short-Form Health Survey.
[a]In postacute inpatient cardiac rehabilitation facility.

In a retrospective analysis, Sansone et al sought to identify the predictors of functional gains during transitional CR.[74] They studied 143 patients postcardiac event (cardiac surgery, myocardial infarction, or heart failure) who were admitted to phase 1B CR from January 1998 to June 1999 (Table 3). Median age of study patients was 70 years; 40% were women. The FIM was used to assess functional status of participants in this study. The median duration of postacute inpatient CR was 17 days. There was a significant increase in the overall FIM score at discharge as compared to baseline. Most patients (76%) were discharged home, 11% were transferred to nursing facilities, and the remainder were discharged to other institutions. Length-of-stay in phase 1B CR was inversely correlated with admission and discharge FIM scores. Younger age, a primary diagnosis of cardiac surgery, and higher admission FIM score, were independent predictors of higher discharge FIM score. The independent predictors of home discharge were higher admission and discharge FIM scores and shorter length of stay in the program. Age was not a significant predictor of discharge disposition.

Finally, Lichtman et al performed a study with 121 patients transferred to postacute inpatient CR following admission for cardiac surgery, myocardial infarction, or heart failure, from 2000 to 2003 (Table 3).[79] Mean age of patients was 76 years and 54% were women. In addition to using the FIM for evaluation of functional independence, the authors assessed QOL by means of the SF-36 questionnaire. Mean length of stay in the rehabilitation unit was 14 days. There was a significant improvement between admission and discharge total FIM scores as well as between admission and discharge motor and cognitive FIM scores and SF-36 scores. Long-term follow-up information was available for 70 patients and results demonstrated that improvement in all aspects of FIM score were preserved at 3 months and 1 year. Also, QOL continued to improve over 3 months and remained stable at 1 year. Of note, all patients were discharged home from postacute inpatient CR. This study demonstrates that the benefits of postacute inpatient CR in terms of functional improvement and improvement in QOL persist at 3 months and 1 year. It also suggests that such programs might be useful in increasing the number of frail elderly patients discharged home following hospitalization for a cardiac event.

Thus, postacute inpatient CR appears to be a valuable intervention in selected older patients following hospitalization for a cardiac event. Adequately controlled studies with assessment of functional status by conventional means at predefined intervals postdischarge are, however, essential in the evaluation of long-term results and relevance of such programs for the older cardiac population.

Exercise-Based Outpatient (Phase II) Cardiac Rehabilitation

Exercise-based outpatient CR is recognized as an essential component in the contemporary management of patients with heart disease, including the elderly.[80] Phase II CR has been shown to have beneficial effects on cardiovascular risk factors, exercise tolerance, psychological well-being and health-related QOL, and CAD morbidity and mortality in young and middle-aged patients.[12–36] Exercise-based CR has also been shown to be more cost-effective than most other post-myocardial infarction treatment interventions.[81] Moreover, the safety of exercise-based CR is well recognized following an acute cardiac event and patients are now encouraged to begin exercise-based outpatient CR as soon as possible postdischarge.[54,71,82,83] Only limited data are, however, available for the very old patients, that is, those in their eighth or ninth decade.

Benefits of Exercise-Based Cardiac Rehabilitation in Very Old Patients Compared to Younger Patients

Several studies have demonstrated that older patients derive similar and sometimes greater relative improvements in exercise tolerance and self-reported physical function in comparison with younger patients after exercise-based CR. In a study of 45 phase II CR patients (33% women), baseline and follow-up aerobic capacity were compared between "older old" ($\geq$70 years) and "younger old" ($<$70 years) patients.[45] Baseline peak $\dot{V}O_2$ was lower in older patients with a tendency toward a greater relative improvement after exercise-based CR in these patients (Table 4).

In a subsequent study by Balady et al, 778 consecutive phase II CR patients (28% women) were evaluated for baseline and post-CR exercise tolerance (Table 4).[47] Subjects were separated into the following 3 groups: $<$65 years, 65 to 75 years, and $>$75 years. At baseline, there was a significant decline in exercise tolerance with increasing age. Exercise tolerance was also significantly lower for women than for men in the 2 younger groups but not in the older group (data not shown). After exercise training, there were similar relative improvements in exercise tolerance from baseline for each age and gender group. Training response was thus unaffected by advanced age. Of note, among patients with baseline exercise tolerance $<$5 METS, exercise tolerance rose from 4.1 to 8.3 METS ($P <$ .001). Multivariate analysis demonstrated that the greatest change in exercise tolerance with CR was found in patients with an initial peak METS level $<$5.

A study by Lavie et al compared 54 consecutive patients 75 years or older (28% women) with 229 patients younger than 60 years (15% women), who completed a phase II CR program (Table 4).[46] Although this study showed that exercise tolerance was lower for the very elderly at baseline, the benefits of exercise-based CR were similar in the very elderly, with a 39% increase in exercise tolerance compared with 31% increase in the younger participants. Moreover, despite somewhat lower baseline values, exercise-based CR was as effective in the very old vis-a-vis total QOL (SF-36) score and each component of QOL, including physical function, depression, anxiety, somatization, and hostility. Physical function, in particular, increased by 27% in older patients in comparison with 20% in patients younger than 60 years.

Another study by the same authors, using a similar design, compared the effects of phase II CR on aerobic capacity and QOL (SF-36) in 57 consecutive patients older than 70 years (26% women) and 125 patients younger than 55 years (15% women) (Table 4).[49] In this study, baseline peak $\dot{V}O_2$ was lower in the very elderly, and older patients also had a slightly lower relative improvement in peak $\dot{V}O_2$ with exercise training, although increases in peak $\dot{V}O_2$ were significant in both groups. Nevertheless, despite somewhat lower baseline values, the elderly had greater improvements in QOL and physical function scores.

Benefits of Exercise-Based Cardiac Rehabilitation for Patients in Their Ninth Decade of Life

Vonder Muhll et al conducted a study with 53 patients 80 years or older (28% women) who attended at least 1 session of a phase II CR program (Table 5).[50] They demonstrated a 20% increase in functional capacity with exercise-based CR in this very elderly cohort without any serious adverse events. Moreover, women achieved similar relative improvements compared with men. Sandu-Marinescu et al, in a

Table 4 • BENEFITS OF EXERCISE-BASED CARDIAC REHABILITATION IN VERY OLD PATIENTS COMPARED WITH YOUNGER PATIENTS

Study	Patients	Results
Ades et al (1993)[45]	N = 45 (<70 y; n = 29, ≥70 y; n = 16) Women = 33%	Lower baseline peak VO_2 (mL/kg/min) in older vs younger patients (15.9 vs 21.5, $P < .05$) Greater relative improvement after CR in older vs younger patients (21% vs 10%, $P < .16$)
Balady et al (1996)[47]	N = 778 (<65 y; n = 492, 65–75 y; n = 241, >75 y; n = 45) Women = 28%	Decreased baseline exercise tolerance (METS) with increasing age (<65 y, 8.9 vs 65–75 y, 6.6 vs >75 y, 5.7, $P < .001$) Similar relative improvement after CR for each age and gender groups (< 65 y: men, 36% and women, 41%, both $P < .001$ from baseline; 65–75 y: men, 36% and women, 50%, both $P < .001$ from baseline; >75 y: men, 36%, $P < .01$ from baseline and women, 32%, P = NS from baseline)
Lavie et al (1996)[46]	N = 283 (<60 y; n = 229, ≥75 y; n = 54) Women = 25% (<60 y; 15% ≥75 y; 28%)	Lower baseline exercise tolerance (METS) in older vs younger patients (4.4 vs 7.6, $P < .0001$) Greater relative improvement in exercise tolerance after CR in older vs younger patients (39% vs 31%, $P = .06$, both $P < .001$ from baseline) Lower baseline QOL (SF-36) and SF-36 physical function scores in older vs younger patients Greater relative improvement in QOL (20% vs 14%, $P < .05$) and physical function (27% vs 20%, P = NS) (all $P < .0001$ from baseline) scores after CR in older patients vs younger patients
Lavie et al (2000)[49]	N = 182 (<55 y; n = 125, >70 y; n = 57) Women = 18% (<55 y; 15% >70 y; 26%)	Lower baseline peak VO_2 (mL/kg/min) in older vs younger patients (14.7 vs 18.1, $P < .01$) Lower relative improvement in peak VO_2 after CR in older vs younger patients (13% vs 18%, $P < .01$) (both $P < .0001$ from baseline) Lower baseline QOL (SF-36) and SF-36 physical function scores in older vs younger patients Greater relative improvement in QOL (20% vs 14%, $P = .03$) and SF-36 physical function (27% vs 20%, $P = .02$) (all $P < .0001$ from baseline) scores after CR in older vs younger patients

Abbreviations: CR, cardiac rehabilitation; METS, metabolic equivalents of task; QOL, quality of life; SF-36, 36-Item Short-Form Health Survey; VO_2 indicates oxygen uptake.

subsequent study with 34 patients older than 80 years (68% women), found a significant increase from baseline in the 6-minute walk distance after exercise-based CR (Table 5).[66]

Benefits of Exercise-Based Cardiac Rehabilitation in Very Old Patients

Randomized Controlled Study

The preceding studies addressed the relative benefits of exercise-based CR in very old patients (≥eighth decade) compared with younger patients. None of these studies, however, were designed to truly assess the benefits of exercise-based CR in the very old patients in a controlled fashion.

Marchionni et al designed and carried out the only randomized-control exercise-based CR trial in very old patients, the CR-AGE study, which randomized 270 low-risk postmyocardial infarction patients (32% women) to hospital-based CR, home-based CR, or no CR (control group) (Table 6).[51] An age- and gender-stratified factorial design was used, with 3 predefined age groups: middle-aged (45–65 years), old

Table 5 • BENEFITS OF EXERCISE-BASED CARDIAC REHABILITATION FOR PATIENTS IN THEIR NINTH DECADE OF LIFE

Study	Patients	Results
Vonder Muhll et al (2002)[50]	N = 53 (all ≥ 80 y) Women = 28%	Increased exercise tolerance (METS) from baseline with CR (5.5 vs 6.6, $P < .05$)
Sandu-Marinescu et al (2005)[66]	N = 34 (all ≥ 80 y) Women = 68%	Increased 6-min walk distance (m) from baseline with CR (174 vs 242, $P < .001$)

Abbreviations: CR, cardiac rehabilitation; METS, metabolic equivalents of task.

Table 6 • BENEFITS OF EXERCISE-BASED CARDIAC REHABILITATION IN VERY OLD PATIENTS: RANDOMIZED CONTROLLED STUDY

Study	Patients	Results
Marchionni et al (2003)[51]	*N* = 270 (45–65 y = 90, 66–75 y = 90, 75 y = 90) Each age strata divided in 3 groups: H-B CR (*n* = 30) Hos-B CR (*n* = 30) Control (*n* = 30) Women = 32%	Greater exercise tolerance (TWC) from baseline at 2 mo in both CR interventions (H-B CR and Hos-B CR), in all age strata Exercise tolerance remained greater at 6 and 12 mo in H-B CR but not in Hos-B CR Similar exercise tolerance from baseline at 2 mo in control group Improved QOL in middle-aged and old patients at 2, 6, and 12 mo, in all treatment groups Improved QOL in very old patients at 2, 6, and 12 mo with both CR interventions (H-B CR and Hos-B CR), but not in the control group

Abbreviations: CR, cardiac rehabilitation; H-B, home-based; Hos-B, hospital-based; QOL, quality of life; TWC, total work capacity.

(66–75 years), and very old (>75 years). Major exclusion criteria were left ventricular ejection fraction below 35%, severe cognitive impairment or physical disability, and contraindications to vigorous physical activity. At baseline, exercise tolerance, assessed by a symptom-limited exercise test on a cycle ergometer, was lower in older patients, but similar within each age group by treatment assignment. After 2 months of the CR intervention, exercise capacity was higher within each age group, whereas in control patients it was unchanged. At 6 and 12 months postintervention, with hospital-based CR, exercise tolerance remained significantly higher than baseline only in middle-aged patients. However, with home-based CR, exercise tolerance remained higher than baseline in all age groups up to 12 months follow-up. This was attributed to the fact that home-based CR patients acquired better skills to maintain their exercise program in a nonsupervised setting. Health-related QOL, assessed by a validated Italian questionnaire, improved significantly over the entire study follow-up in middle-aged and old patients, whereas in the very old patients QOL improved significantly in both CR groups but not in the control group. In this trial, there were no adverse events related to exercise, even in the home-based CR group.

Therefore, hospital-based or home-based phase II CR programs, compared with no CR, confer benefits, at least in the short term, in patients of all ages including the very elderly. Home-based CR programs might be of even greater benefit in the long term in very old cardiac patients at low risk. However, even if exercise-based CR is beneficial in improving exercise capacity and the sense of a better QOL, additional controlled studies are needed to assess with more objective performance tests, such as the CS-PFP test (or its shorter version), the effect of exercise-based CR on performance of activities of daily living and physical function in the very old patients.

CARDIAC REHABILITATION REFERRAL AND ATTENDANCE IN VERY OLD PATIENTS (≥75 YEARS)

Older patients, particularly those 75 years or older, are less likely to be referred to CR.[84–89] Older women are also less likely than older men to receive a strong recommendation to enter CR by their physicians.[90] In the elderly, the most powerful predictor of CR participation is the strength of the physician's recommendation for participation.[91,92] Longer transportation time to CR facility, denial of illness severity, and history of depression are also associated with poor CR participation in the elderly.[91] However, participation rates in elderly and younger patients can be increased greatly with appropriate patient education and referral assistance by telephone.[93,94] Computer-aided automatic referral has also been demonstrated to increase the CR participation to a great extent; about 2 times more than usual referral.[95–98] Indeed, in the context of automatic referral, usual predisposing factors of nonattendance to CR programs, such as age and gender, no longer predict patient enrollment to CR programs. [96]

CONCLUSIONS

Older cardiac patients have high rates of physical function impairment and disability. There have been relatively few studies of the effects of CR on physical function recovery after an acute cardiac event in patients' age of 75 or greater. Postacute inpatient CR seems to play an important role in physical function recovery of frail and older patients, particularly after cardiac surgery. It facilitates recuperation to the minimum level of autonomy required for independent home living. Adequately controlled studies examining short- and long-term functional status of patients after discharge from postacute inpatient CR, however, are lacking. Therefore, an objective evaluation of the usefulness of such programs for frail and older cardiac patients is indicated. Furthermore, to optimize long-term outcomes, continuity of care between postacute inpatient CR and outpatient (phase II) CR should be fostered.

Exercise-based outpatient CR appears to be safe in very old patients and studies demonstrate that the magnitude of the training response, regarding physical function improvement, is similar to younger patients. Yet, there has been relatively little study on whether phase II CR prevents or reverses disability in the very old. Properly controlled studies are needed to objectively assess the benefits of exercise-based CR on performance of daily activities in the very old.

Finally, older cardiac patients are much less likely to be referred to CR than younger patients. Factors that can increase their referral and participation rates, such as automatic referral, should be further explored. Protocols that could broaden availability of CR to the frailest patients, such as programs with home visits, or home-based programs, should also be considered.

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