Canadian Journal of Cardiology 35 (2019) 1353–1358

Clinical Research

Physical and Psychological Effectiveness of Cardiac Rehabilitation: Age Is Not a Limiting Factor!

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See editorial by Rouleau and Stone, pages 1272–1274 of this issue.

ABSTRACT

Background: There is little data regarding the impact of patient age on the physical and psychological effectiveness of cardiac rehabilitation (CR). The aim of the present study was therefore to compare the effects of an exercise-based CR program on physical and psychological parameters in young, old, and very old patients. We also aimed to identify the features that best predicted CR outcome.

Methods: A total of 733 patients were divided into 3 subgroups: YOUNG (< 65 years old), OLD (between 65 and 80 years old), and VERY OLD (≥ 80 years old). Physical variables such as peak workload and estimated peak VO_2 as well as psychological variables such as scores of anxiety and depression were evaluated for all patients before and after CR.

Results: Performance in all tests and scores for all questionnaires were significantly improved in all patients ($P < 0.05$). Age was

RÉSUMÉ

Contexte : Il existe peu de données sur l'incidence de l'âge du patient sur l'efficacité physique et psychologique de la réadaptation cardiaque. Par conséquent, cette étude vise à comparer les effets d'un programme de réadaptation cardiaque axé sur l'exercice sur les paramètres physiques et psychologiques chez des patients jeunes, âgés et très âgés. Nous souhaitons également déterminer les caractéristiques qui permettent le mieux de prédire les résultats de la réadaptation cardiaque.

Méthodologie : Au total, 733 patients ont été répartis dans 3 sous-groupes : le groupe JEUNE (< 65 ans), le groupe ÂGÉ (de 65 à 80 ans) et le groupe TRÈS ÂGÉ (≥ 80 ans). Des variables physiques telles que la charge de travail au pic et la consommation maximale d'oxygène estimée de même que des variables psychologiques comme les scores de l'anxiété et de la dépression ont été évaluées chez tous les patients avant et après la réadaptation cardiaque.

Cardiovascular diseases (CVD) are the main cause of death in Europe with over 4 million deaths each year.[1] Although these diseases affect more and more young people (approximately 680,000 deaths/y occurring before the age of 65 years) as a consequence of the increased sedentary lifestyle of the population, the number of people above the age of 65 years, and even more above the age of 80 years, dying from CVD is also increasingly high due to the aging of the population and the improved management of cardiac issues. Indeed, as underlined by several authors,[2,3] the biology of aging and the pathophysiology of CVD overlap, so that CVD is widespread in the increasing population of older adults. Aging is associated with several factors such as increased inflammation or oxidative stress that predispose people to CVD.[4] As a result, even before any initial cardiovascular event, elderly patients are usually less fit than their younger counterparts, and deconditioning is accelerated once CVD is established.[5] In addition, risks of complications are higher in elderly patients, leading to longer hospital stays and greater subsequent deconditioning.[6]

In this light, cardiac rehabilitation (CR) is particularly important: CR has been proposed in the 1960s as an exercise-based program for middle-aged male patients with coronaropathies.[7] But over the years, it has appeared that secondary prevention and risk factor modification were essential to limit the recurrence of cardiovascular events or secondary complications and to improve long-term prognosis.[3,8] CR has therefore evolved and it is now a complete secondary prevention program involving exercise but also risk factor modification and education, so that participation in CR programs is highly recommended in the treatment of patients with various CVD.[8,9] Substantial data from CR programs have demonstrated that it leads to great improvements in exercise capacity or cardiorespiratory fitness, reduced CVD risks, morbidity, and mortality, with its accompanying reduction in hospital costs.[10-13] In addition, CR has been shown to have positive effects on psychological stress, hence reducing mortality related to depression, as well as other psychological risk factors.[14]

Received for publication February 19, 2019. Accepted May 27, 2019.

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See page 1357 for disclosure information.

https://doi.org/10.1016/j.cjca.2019.05.038

significantly correlated with all the initial values ($P < 0.05$) but not with post-CR values. In addition, lower initial values of peak workload were associated with larger post-CR improvements irrespective of age. However, higher pre-CR anxiety and depression scores were associated with greater post-CR increases in physical performance in YOUNG and OLD patients, respectively.

Conclusions: CR induced significant improvements of physical and psychological parameters for all patient groups. More interestingly, our results suggest that patients with the greatest physical impairments at baseline would benefit the most from CR, whatever their age. However, the value of initial mental state as a predictor of post-CR improvement depends on the age of the patient.

Résultats : Une amélioration significative de la performance à toutes les épreuves et des scores à tous les questionnaires a été observée chez tous les patients ($p < 0,05$). La corrélation était significative ($p < 0,05$) entre l'âge et toutes les valeurs initiales, mais non les valeurs mesurées après la réadaptation cardiaque. De plus, les valeurs initiales les plus faibles de la charge de travail du cœur au pic ont été associées à de plus grandes améliorations après la réadaptation cardiaque sans égard à l'âge. Toutefois, les scores d'anxiété et de dépression élevés avant la réadaptation cardiaque ont été associés à une performance physique accrue après la réadaptation cardiaque chez les patients des groupes JEUNE et ÂGÉ, respectivement.

Conclusions : La réadaptation cardiaque a été associée à des améliorations significatives des paramètres physiques et psychologiques chez tous les groupes de patients. Fait encore plus intéressant, nos résultats laissent supposer que les patients présentant les déficiences physiques les plus importantes au départ bénéficieraient le plus de la réadaptation cardiaque, peu importe leur âge. Toutefois, la valeur de l'état mental initial comme facteur de prédiction de l'amélioration après la réadaptation cardiaque dépend de l'âge du patient.

All these beneficial effects have been recently summarized in several reviews having a specific focus on older adults.[2,15] However, these data often focus on patients above the age of 65 years with no distinction between old and very old patients and examine either physical or psychological outcomes (exercise capacity, quality of life, etc.). To our knowledge, few studies exist with a direct comparison of the effects of CR on physical as well as psychological parameters in young (<65 years), old (between 65 and 80 years), and very old (>80 years) adults with CVD from varying etiologies. Indeed, it would be of interest for therapists to know if patient responses to CR vary as a function of age. This would then help in correctly adjusting CR programs.

The aim of the present study was therefore to assess the influence of patient age on the physical and psychological outcomes of a classical ambulatory CR program. For this purpose, we compared CR outcomes in patients younger than 65 years (YOUNG), between 65 and 80 years (OLD), and older than 80 years (VERY OLD). We also attempted to identify the features that were best able to predict CR outcome.

Material and Methods

Population and study description

All the patients consecutively referred to CR from January 2015 to September 2017 were included in this single-centre prospective study. Altogether, 776 patients were recruited, but we excluded 43 because of early dropout from the CR program for personal or medical reasons. For analysis, the remaining 733 patients were divided into 3 subgroups: YOUNG (< 65 years old, n = 344, age 54 ± 8 years), OLD (between 65 and 80 years old, n = 347, age 71 ± 4 years), and VERY OLD (≥ 80 years old, n = 42, age 83 ± 3 years). The main characteristics of the patients are presented in Table 1. This study was approved by our local ethics committee, and informed verbal consent was obtained from all patients (trial registered as NCT03059550).

CR program

All patients were enrolled in an outpatient comprehensive CR program including 25 physical training sessions (5 sessions a week) and pluridisciplinary educational programs on cardiovascular risk factors and diseases.

Briefly, after a 5-minute warm-up, each session included three 40-minute periods of aerobic exercise performed on a treadmill, on a bicycle, and on an arm cycling ergometer. The training session was ended by a 5-minute cooling-down period. Each session was supervised by a skilled team including cardiologists, cardiovascular nurse specialists, and exercise physiologists. Exercise intensity was prescribed on an individual basis so that the patient's target training heart rate was 65% to 80% of the maximal heart rate obtained during the initial bicycle exercise test. Exercise intensity target was also based on the rating of perceived exertion, usually between 12 and 14 on Borg's scale.[16]

During the 2-month CR period, all subjects attended a pluridisciplinary educational program including physical activity, cardiovascular risk factors and diseases, smoking, and dietary counselling. Education was given both on a repeated individual basis and in group discussion.

Evaluations

Patients underwent evaluations before and at the end of the CR program. The tests used for evaluations included 2 physical tests: the cardiopulmonary exercise test and the 6-minute walk test (6-MWT).

The cardiopulmonary exercise test was performed on an upright cycle ergometer (system Marquette case 15; Marquette Electronics, Milwaukee, WI). The initial workload was 10 W with increments of 10 W at each 1-minute exercise stage. The exercise test was stopped when the patient was unable to maintain the imposed pedalling rhythm of 60 revolutions per minute, limited generally by dyspnoea and/or leg fatigue. Hence, each incremental exercise test was symptom limited. The variables analysed from this test were peak workload (PW) (measured in Watts) and heart rate (bpm). In

Table 1. Characteristics of the patients

	YOUNG	OLD	VERY OLD
N (M/F)	344 (263/81)	347 (266/81)	42 (28/14)
Age (y)	54 ± 8	71 ± 4	83 ± 3
Height (cm)	171.9 ± 8.2	169.6 ± 8.3	167.6 ± 9.0
Weight (kg)	82.2 ± 16.2	80.4 ± 15.9	74.4 ± 16.9
BMI (kg/m^2)	27.7 ± 5.6	27.7 ± 4.8	26.3 ± 5.3
CAD (n)	281	276	31
PAD (n)	31	39	4
CHF (n)	20	18	3
Valvulopathy (n)	41	63	6

BMI, body mass index; CAD, coronary artery disease; CHF, chronic heart failure; N, number of patients; OLD, patients between 65 and 80 y; PAD, peripheral artery disease; VERY OLD, patients older than 80 y; YOUNG, patients younger than 65 y.

addition, peak VO_2 was estimated for all tests using the following equation: VO_2 = (Watts max/weight) + 3.5.[17]

A 6-MWT was also performed before and after rehabilitation in several patients based on the cardiologist requirement (n = 56 YOUNG, n = 91 OLD, n = 25 VERY OLD). Briefly, this test was performed in a 50-m-long unobstructed corridor, using the protocol described by Lipkin et al.[19] Patients were asked to cover as much distance as possible in 6 minutes. Slow down and stops for resting were authorized. The total distance walked was measured in metres at the end of 6 minutes.

To evaluate psychological variables (anxiety and depression), we used the Hospital Anxiety Depression (HAD) questionnaire.[18]

Statistics

All data are expressed as mean ± standard deviation. Pre- and post-CR data between groups were compared with a 2-way analysis of variance with repeated measures. When the *P* value from analysis of variance was significant, a *Post Hoc* Newman-Keuls test was used. The correlations between pre- and post-CR variables were tested using Pearson R statistics. A significant difference was accepted when $P < 0.05$.

Results

General information

The number of prescribed rehabilitation sessions was not different between groups (24.6 ± 3.1, 25.1 ± 3.9, and 25.4 ± 3.9 for YOUNG, OLD, and VERY OLD, respectively) and adherence was excellent (98.6% ± 8.3%, 98.7% ± 7.0%, and 98.7% ± 6.2% for YOUNG, OLD, and VERY OLD, respectively).

Physical performances

As shown in Figure 1, PW (panel A) and estimated maximal VO_2 (panel B) were significantly different in all groups before rehabilitation ($P < 0.05$). The values in the VERY OLD group were lower than those in the OLD group. The latter were in turn lower than those for the YOUNG group ($P < 0.05$). These 2 parameters increased in all groups after CR ($P < 0.05$), and the improvements were not significantly different between groups

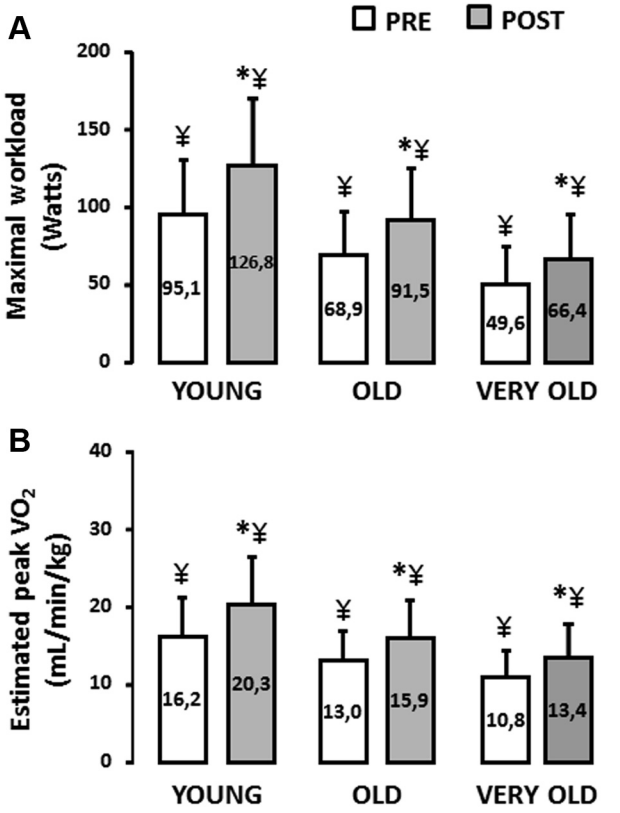

Figure 1. Peak workload (**A**) and estimated maximal VO_2 (**B**) before and after cardiac rehabilitation in YOUNG, OLD, and VERY OLD patients. Values are expressed as mean ± standard deviation. *Significantly different from PRE. ¥Significantly different from the other groups at the same time point ($P < 0.05$, Newman-Keuls *Post Hoc*).

(PW: +36.3%, +36.2%, and +40.3% in YOUNG, OLD, and VERY OLD, respectively; VO_{2peak}: +26.9%, +25.1%, and +25.8% in YOUNG, OLD, and VERY OLD, respectively).

No interaction (group × time) was observed for the distance from the 6-MWT. However, the distances covered had significantly increased for all patients after rehabilitation (+16.5%, $P < 0.05$). They were lower in OLD (436.3 ± 119.3 m) than in the YOUNG group (527.8 ± 109.5 m; $P < 0.05$). The values in the VERY OLD group were not significantly different from those measured in the OLD group (393.7 ± 139.4 m).

Questionnaires

Table 2 presents the results obtained from the HAD questionnaire before and after CR. The average anxiety score (HAD A) was higher in YOUNG than in VERY OLD patients before CR ($P < 0.05$). More patients in the YOUNG group had a score higher than 8. Values significantly decreased in all patients ($P < 0.05$) after CR, but the initial difference existing between VERY OLD and YOUNG before rehabilitation was still present after rehabilitation.

The average depression score (HAD D) was significantly reduced after rehabilitation ($P < 0.05$) without any difference between groups.

Table 2. Results to the Hospital Anxiety Depression (HAD) questionnaire before (Pre) and after (Post) rehabilitation

	YOUNG		OLD		VERY OLD	
	Pre	Post	Pre	Post	Pre	Post
HAD A	8.8 ± 3.9	7.4 ± 4.0*	8.0 ± 3.6	7.0 ± 3.4*	7.5 ± 4.0†	7.1 ± 3.4
Score HAD A ≥ 8 (n)	198	147	172	138	17	15
HAD D	5.4 ± 3.6	4.2 ± 3.5	5.3 ± 3.3	4.3 ± 3.3	5.2 ± 3.0	4.6 ± 3.2
Score HAD D ≥ 8 (n)	90	66	84	54	10	1

HAD A, score to the anxiety questionnaire; HAD D, score to the depression questionnaire; N, number of patients; OLD, patients between 65 and 80 y; VERY OLD, patients older than 80 y; YOUNG, patients younger than 65 y.

* Significantly different from Pre.

† Significantly different from YOUNG at the same time points (Newman-Keuls *Post Hoc*).

Correlations

Interestingly, correlation analyses revealed that age was significantly correlated with all pre-CR values ($P < 0.05$) but not with CR outcomes. In addition, in the subgroups that performed the 6-MWT, a significant correlation was observed between improvements in the walking test and in the PW in the VERY OLD ($r = 0.41$, $P < 0.05$). However, this was not the case in YOUNG and OLD patients.

The relationships between peak workloads before CR and their changes from baseline to the end of CR (Δ Peak Workload) are presented in Figure 2 (panels A, B, C for YOUNG, OLD, and VERY OLD subjects, respectively). The figures show that lower pre-CR values are associated with greater post-CR gains ($P < 0.05$). Similarly, lower peak VO_2 values before CR are associated with greater changes after CR in the 3 groups ($P < 0.05$).

We also observed the relationships between pre-CR psychological variables and Δ Peak Workload. Higher pre-CR anxiety scores tended to be associated with greater increases in PW but only in YOUNG patients ($P = 0.08$). Similarly, higher pre-CR depression scores were associated with greater increases in physical performance but only in OLD patients ($P < 0.05$).

Discussion

Given the limited data on the effect of age and the effectiveness of CR in patients with CVD, the present study aimed at comparing the effects of an exercise-based CR program on physical and psychological parameters in young, old, and very old patients and at identifying the predictors of CR outcome. We found that a classical ambulatory CR program significantly improved exercise capacities and psychological performances in all patients. Our results also revealed that, for all patients, initial PW and estimated VO_2 were 2 great predictors of improvements from CR, and that age is not a factor limiting CR-induced improvements.

Our findings are in keeping with previous studies of exercise-based CR showing beneficial effects on VO_{2peak}, maximum workload, and distance covered in the 6-MWT.[13] More specifically, a study comparing the effects of CR in patients below and above 65 years found lower baseline cardiorespiratory performance in the older but similar significant improvements in both groups.[20] Similar results have also been found in patients aged 75 years and above.[21] Interestingly, we found that in the VERY OLD group, the increase in distance for the 6-MWT and peak workload were positively correlated ($P < 0.05$). This result is of great interest since it suggests that for these patients, CR not only improved their maximal exercise capacity but also had a functional impact. Indeed, the 6-MWT is a submaximal test allowing the assessment of daily activities. As suggested by Schopfer et al.,[2]

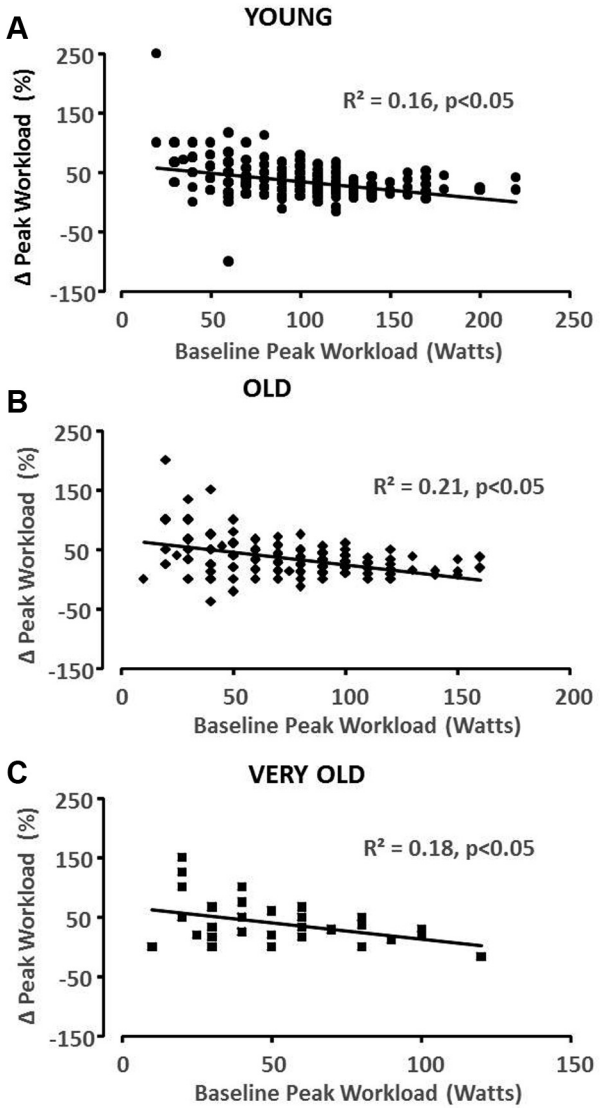

Figure 2. Scatter plots and linear correlation between peak workloads at baseline and their percentages of change from baseline (Δ Peak Workload) in YOUNG (**A**), OLD (**B**), and VERY OLD (**C**) patients. R^2 = coefficient of determination.

this would ease their lives by improving their independence, allowing them to carry groceries, navigate stairs, and maintain self-care.

Besides the effects on physical parameters, this study also analysed the impact of CR on psychological parameters and more specifically on the role of age in these variables. Indeed, there is now considerable evidence that psychosocial stress can be an important player in the pathogenesis and progression of CVD. Our results revealed that before CR, YOUNG patients had higher scores for anxiety and depression ($P < 0.05$) than VERY OLD patients. This is in line with previous data from the literature showing a very high prevalence of anxiety and depression among patients with CVD, especially younger patients.[22] As already suggested by Milani et al.,[23] we found that depressed and anxious patients had lower exercise capacities. Fortunately, CR had a very beneficial impact on these 2 parameters in all groups, although more so for depression in YOUNG patients (−23%, $P < 0.05$). However, discrepancies exist in the literature regarding the effectiveness of CR in depressed and anxious patients. Although some authors showed that patients with a high level of anxiety before CR did not show any improvement in exercise tolerance or a reduction of state anxiety,[24] others reported that depressed patients improved their exercise capacities in a similar manner and in fact increased their quality of life more than nondepressed patients.[23] Interestingly, we found that in YOUNG patients, higher anxiety score was associated with greater improvements in maximal PW after CR. Similarly, higher pre-CR depression scores were associated with greater improvements in PW after CR in OLD patients. Although it is difficult to know if there is a direct cause and effect in these relationships, these correlations seem very important to take into account, considering that psychological stress accounts for close to one-third of the total assigned risk factors for acute infarction.[25]

We also found that pre-CR values of PW and estimated peak VO_2 were strong predictors of post-CR improvement, with greater improvements occurring in those with the worst physical condition. Similar results have previously been reported for peak metabolic equivalents (METS), VO_{2peak}, distance to the 6-MWT, and 90° peak torque.[21,26] Baldasseroni et al.[21] also provided a cutoff pre-CR values below which clinically meaningful CR outcomes could be expected. If we use the same method, choosing a cutoff increase of 15% increase in performance after CR, we could say that YOUNG patients (below the age of 65), with baseline VO_{2peak} values of less than 18 mL/min/kg and PW to the cardiopulmonary exercise test of less than 105 W would be those who might benefit the most from CR. In OLD patients (between 65 and 80 years), these values would be baseline VO_{2peak} of less than 14.1 mL/min/kg and PW of less than 80 W, and hence these patients might benefit the most from CR. Lastly, in VERY OLD patients (above the age of 80 years), these values would be baseline VO_{2peak} of less than 10.5 mL/min/kg and PW of less than 65 W.

Conclusions

Despite the absence of a control group, this study demonstrates that an exercise-based CR program induced significant improvements in both physical and psychological parameters in YOUNG, OLD, and VERY OLD patients. Interestingly, our results suggest that the age of the patients is not a parameter that influences the gains made from CR. Indeed, the patients who benefit the most from CR are those with the greatest initial physical impairments irrespective of age. This demonstrates that elderly patients should not be neglected in CR programs.[27] Our study might open new perspectives for the development of CR programs specifically adapted to the characteristics of this population, taking into account features such as comorbidities and frailty.

Acknowledgements

The authors would like to express their thanks to E. Thomas for the English revision of this article.

Disclosures

The authors have no conflicts of interest to disclose.

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