

Comparison of cardiac rehabilitation outcomes in individuals with respiratory, cardiac or no comorbidities: A retrospective review

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OBJECTIVE: To describe the prevalence and impact of respiratory comorbidities on patients undergoing cardiac rehabilitation (CR).

METHODS: A retrospective review of a CR database (1999 to 2004) of patients with ischemic heart disease with ≥ 10 pack per year (ppy) smoking history and respiratory comorbidities (RC), non-respiratory comorbidities (NRC) and no comorbidities (NC) was performed. Primary outcomes at zero, six and 12 months included peak oxygen uptake (VO_{2peak}), maximum workload, resting heart rate, ventilatory anaerobic threshold and anthropometrics. Analyses were performed on individuals who completed the program, adjusting for age, sex and baseline VO_{2peak} .

RESULTS: Of 5922 patients, 1247 had ≥ 10 ppy smoking history: 77 (6.2%) had RC; 957 (76.7%) had NRC; and 213 (17.1%) had NC. The program completion rate for each group was similar for the RC (46.8%), NRC (55.8%) and NC groups (57.3%) ($P=0.26$). The RC group had the lowest baseline fitness levels ($P<0.002$). For VO_{2peak} , there were significant differences among groups ($P=0.02$) and improvements over program duration ($P<0.0001$). There were no significant differences in other outcomes.

CONCLUSIONS: There was a low prevalence of patients with comorbid chronic obstructive pulmonary disease in CR when based on physician referral documentation. This is likely underestimated and/or reflects a referral bias. Diagnostic testing at CR entry would provide a more accurate measure of the prevalence and severity of disease. CR participation resulted in significant and similar improvements in most key CR outcomes in all groups including similar completion rate. A CR model was effective for patients with coexisting RCs. Strategies to improve access and diagnosis should be explored.

Key Words: *Aerobic exercise; Cardiac rehabilitation; Comorbidities; COPD; Smokers*

Cardiovascular and chronic respiratory disease are leading causes of morbidity and mortality in the United States and worldwide (1). In 2008, cardiovascular disease (CVD) caused 17 million deaths worldwide (48% of all noncommunicable diseases), and chronic obstructive pulmonary disease (COPD) and asthma caused 4.2 million deaths. These noncommunicable diseases, according to the World Bank/WHO, will rank in the top three of burdened diseases worldwide by 2020 (1,2).

CVD and respiratory disease share many comorbid characteristics including multimorbidity (≥ 2 conditions) as a common feature (3). The prevalence of multimorbidity increases with age and results in poor health outcomes (4,5), stressing the importance of effective health care interventions for this population (1). The specific prevalence of respiratory comorbidity (eg, COPD, asthma) in cardiac disease has varied in the literature: 9% to 39% in patients with acute or nonacute cardiac morbidities (eg, acute myocardial infarction, cardiac surgery) (6-9). The method by which respiratory disease was defined in these studies and the cohort investigated may have contributed to this high level of variability in prevalence.

La comparaison des résultats de la réadaptation cardiaque chez les personnes ayant des comorbidités respiratoires ou cardiaques ou n'ayant aucune comorbidité : une analyse rétrospective

OBJECTIF : Décrire la prévalence et les effets des comorbidités respiratoires sur les patients en réadaptation cardiaque (RC).

MÉTHODOLOGIE : Les chercheurs ont réalisé l'analyse rétrospective d'une base de données de RC (de 1999 à 2004) dont ils ont extrait les patients atteints d'une maladie cardiaque ischémique ayant des antécédents de tabagisme d'au moins dix paquets par année (ppa) et des comorbidités respiratoires (CR), des comorbidités non respiratoires (CNR) ou aucune comorbidité (AC). Les résultats primaires en début d'étude, au sixième et au douzième mois incluaient la consommation maximale d'oxygène (VO_{2max}), la charge de travail maximale, la fréquence cardiaque au repos, le seuil anaérobie ventilatoire et les données anthropométriques. Les chercheurs ont effectué des analyses chez les personnes qui ont terminé le programme, après rajustement selon l'âge, le sexe et la VO_{2max} en début d'étude.

RÉSULTATS : Des 5 922 patients, 1 247 avaient des antécédents de tabagisme d'au moins 10 ppa : 77 (6,2 %) avaient des CR, 957 (76,7 %) des CNR, et 213 (17,1 %) AC. Le taux d'achèvement du programme était similaire dans les groupes ayant des CR (46,8 %), des CNR (55,8 %) et AC (57,3 %) ($P=0,26$). Le groupe ayant des CR présentait le taux de forme physique le plus faible en début d'étude ($P<0,002$). Les différences entre les groupes étaient significatives pour ce qui est de la VO_{2max} ($P=0,02$) et de l'amélioration pendant la durée du programme ($P<0,0001$). Les autres résultats ne présentaient aucune différence significative.

CONCLUSIONS : Peu de patients atteints d'une maladie pulmonaire obstructive chronique comorbide allaient en RC selon les documents d'orientation des médecins. Ce nombre est probablement sous-estimé ou reflète un biais d'orientation. Les tests diagnostiques à l'arrivée en RC fourniraient une mesure plus précise de la prévalence et de la gravité de la maladie. Dans tous les groupes, la participation à la RC s'associait à des améliorations significatives et similaires à l'égard de la plupart des principaux résultats liés aux RC au sein des groupes, y compris un taux d'achèvement similaire. Un modèle de RC était efficace pour les patients présentant des CR. Il faudra chercher des stratégies pour améliorer l'accès et le diagnostic.

Cardiac rehabilitation and pulmonary rehabilitation are common interventions for CVD and COPD (10,11). The population of patients who enter these programs share many characteristics: a common intrathoracic location of the pathology; the frequent coexistence of cardiac and pulmonary disease; and shared symptoms, such as dyspnea, fatigue, psychological disturbances, deconditioning and exercise intolerance (12-14). In addition, they share common rehabilitation goals and outcomes including improvement in exercise tolerance, which can reduce future morbidity and disability, as well as enhance quality of life (10,13,15). Although the principles of both pulmonary and cardiac rehabilitation are similar, the patients who enter these programs are functionally diverse (16). In many cardiac rehabilitation patients (without heart failure), the chief functional limitation and cause of exercise intolerance is deconditioning and, in some patients, CVD rate-limiting angina or ischemia (13-17). In many pulmonary rehabilitation patients, functional limitations are more extensive: work inefficiency due to impairment in lung mechanics; inspiratory muscle fatigue; ineffective gas exchange;

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TABLE 1
Baseline characteristics of subgroups that completed the Toronto Rehabilitation Institute Cardiac Rehabilitation and Secondary Prevention Program (Toronto, Ontario), January 1999 to May 2004

Characteristic	Comorbidities			P
	Respiratory (n=36)	Non-respiratory (n=534)	None (n=122)	
Female sex	8 (22.2)	58 (10.9)	5 (4.1)	0.004
Age, years	67.2±10.1	61.1±10.1	60.5±8.3	0.001
Smoking status				0.78
Quit	33 (91.7)	484 (90.6)	113 (92.6)	
Current	3 (8.3)	50 (9.4)	9 (7.4)	
Pack per year smoked	48.3 (32.4)	37.0 (27.1)	36.3 (29.9)	0.06
Occupational status				0.0002
Employed	5 (14.3)	211 (39.5)	52 (42.6)	
Retired	22 (62.9)	198 (37.1)	39 (32.0)	
Disability pension	4 (11.4)	9 (1.7)	2 (1.6)	
Sick leave	2 (5.7)	96 (18.0)	24 (19.7)	
Unemployed	2 (5.7)	17 (3.2)	3 (2.5)	
Body mass index, kg/m ²	27.3±3.6	28.4±4.2	28.2±3.9	0.48
Waist circumference, cm	95.2±10.9	98.4±11.7	99.3±10.8	0.18
Body fat percentage	24.6±8.0	23.7±5.8	23.3±8.5	0.72
Resting heart rate, beats/min	70.5±13.1	67.2±12.6	66.7±12.2	0.28
Resting systolic blood pressure, mmHg	145.0±18.7	139.8±21.9	138.8±20.7	0.31
Resting diastolic blood pressure, mmHg	77.5±11.6	75.7±12.2	75.5±11.3	0.68
Maximum heart rate, beats/min	115.9±22	119.0±21.7	121.4±22.0	0.36
Maximum systolic blood pressure, mmHg	190.2±27.3	187.1±27.5	186.8±26.0	0.80
Maximum diastolic blood pressure, mmHg	83.6±12.7	83.7±12.9	83.0±12.1	0.83
Maximum workload, W	99.9±38.7	124.6±39.6	133.8±37.8	0.00004
Peak oxygen uptake (VO _{2peak}), mL/kg/min	16.0±3.8	18.3±4.9	19.2±5.2	0.002
Ventilatory anaerobic threshold, mL/kg/min	11.4±2.3	12.3±2.7	12.6±2.8	0.08
Angina	1 (2.9)	19 (3.6)	1 (0.8)	0.56
Symptoms during cardiopulmonary exercise test	8 (23.5)	160 (30.0)	38 (31.1)	0.85
Exercise at home	31 (91.2)	384 (72.0)	89 (73.0)	0.29
Primary diagnosis				0.0002
Coronary artery bypass graft surgery	15 (41.7)	213 (39.9)	73 (59.8)	
Percutaneous coronary intervention	2 (5.6)	97 (18.2)	9 (7.4)	
Myocardial infarction	11 (30.6)	158 (29.6)	23 (18.9)	
Ischemic heart disease (no intervention)	8 (22.2)	66 (12.4)	17 (13.9)	
Medications				
Respiratory	18 (50.0)	279 (52.2)	69 (56.6)	0.65
β-blockers	14 (38.9)	424 (79.4)	96 (78.7)	<0.0001
Lipid-lowering agent	26 (72.2)	407 (76.2)	98 (80.3)	0.17
Platelet inhibitor	34 (94.4)	488 (91.4)	109 (89.3)	0.60
Anti-anxiolytics	6 (16.7)	67 (12.5)	20 (16.4)	0.45
Wait time to program entry, days	51.4±40.6	42.2±21.6	41.7±22.2	0.06

Data presented as n (%) or mean ± SD unless otherwise indicated. Bolded values indicate statistical significance (ie, P<0.05)

right ventricular dysfunction; alterations in peripheral muscle metabolism; acute exacerbations; and malnutrition (13,18,19). These greater limitations may place patients with respiratory comorbidities enrolled in a cardiac rehabilitation program at a disadvantage compared with those without airflow limitations.

There is currently little information regarding the prevalence and impact of respiratory comorbidities on patients who have completed a cardiac rehabilitation program. In their retrospective review, King et al (8) noted a decreased likelihood of cardiac rehabilitation attendance in patients with a history of COPD or asthma. In a cohort study, Savage et al (20) found that chronic lung disease was one of the comorbidities that significantly predicted no improvement in peak oxygen uptake that occurred in 20% of 385 cardiac rehabilitation patients. Identifying the characteristics of cardiac rehabilitation patients with respiratory comorbidities, and the impact of this comorbidity on key outcomes, is the first step toward adapting rehabilitation needs and improving care.

The present article describes the characteristics and effects of exercise training for individuals with respiratory comorbidities and

enrolled in a traditional cardiac rehabilitation program. The specific objective was to compare the prevalence, demographic, aerobic and functional characteristics, and risk factor profile of individuals with: respiratory comorbidities (RCs); nonrespiratory comorbidities (NRCs); and no comorbidities (NCs) using a retrospective database review. All individuals included in the present study participated in the Cardiovascular Prevention and Rehabilitation Program at the Toronto Rehabilitation Institute/University Health Network (Toronto, Ontario) and had a ≥10 pack per year (ppy) smoking history. We hypothesized that the prevalence of respiratory comorbidities would be low in the cardiac rehabilitation program. This subgroup would also have lower cardiovascular fitness compared with the subgroups without RCs, but exhibit similar improvements after completing the program; providing support for the enrollment of these patients into standard cardiac rehabilitation programs. This is important considering the poor availability of pulmonary rehabilitation programs for individuals with chronic respiratory disease (21,22).

METHODS

Study design

The present study was a retrospective review of a database found in the Cardiac Rehabilitation and Secondary Prevention Program at Toronto Rehabilitation Institute. The program admits 1800 patients annually, with the majority of admissions for percutaneous coronary intervention, coronary artery bypass graft (CABG) surgery and myocardial infarction. Data were extracted from all available cases from January 1999 to May 2004. The present study was approved by the Toronto Rehabilitation Research Ethics Board.

Patients

The entire cohort of cardiac rehabilitation patients from January 1999 to May 2004 was initially reviewed. Only patients with a primary cardiac diagnosis and a ≥ 10 pack per year (ppy) smoking history were analyzed comparing the following three groups: RC, NRC and NC. Identifying comorbidities was based on physician referral information; formal pulmonary function testing was not conducted. Although there is no consensus or standardized ppy smoking history associated with COPD to increase the likelihood of identifying true cases, both the label of 'COPD' (or other chronic respiratory disease such as interstitial lung disease or asthma) based on physician referral and a smoking history of at least 10 ppy (23,24), was required. Physician referrals were used to identify COPD because other standard measures (25) of diagnoses, such as spirometry and clinical assessment (including dyspnea), were not collected as part of the program.

Cardiac rehabilitation intervention

Participants were referred to the cardiac rehabilitation program by their family physicians, surgeon or other health care provider. The program was led by an interprofessional team of physicians, physiotherapists, nurses, kinesiologists, psychologists and dietitians. Each participant was assigned to a case manager. Participants attended 90 min classes once per week for six to 12 months, and monthly classes for four to 12 months. Cardiopulmonary exercise tests (CPETs) were conducted in all participants at baseline, six and 12 months, except in those who prematurely discontinued the program. Classes included aerobic training, resistance training, education sessions, as well as psychosocial and dietary counselling. One exercise session was conducted in the facility each week, with the balance of the exercise being completed in the home/community. Exercise sessions, both at the facility and home/community, were tracked via diaries. The initial walking prescription was set at a distance of approximately 1.6 km per day and an intensity equivalent to the ventilatory anaerobic threshold (VAT) and/or 60% to 80% oxygen uptake (VO_{2peak}). Prescriptions were progressed every two weeks, increasing distance to a maximum of 6.4 km and then increasing intensity to a maximum of 80% of VO_{2peak} (maximum duration of 60 min). Thereafter, training intensity was adjusted to maintain a pace equivalent to 80% of VO_{2peak} . Resistance training exercises were initiated eight weeks after aerobic training and included lower body, upper body and trunk-stabilizing exercises. Participants were advised to gradually progress from 10 to 15 repetitions and then to increase resistance by 5 kg, or one exercise band level and reduce the number of repetitions to 10.

Outcomes

Baseline variables were compared among the three groups and included age, sex, smoking history, presence of angina, occupational status, whether the patient completed the program (completed all diagnostic testing at baseline, six and 12 months, and attended classes over 12 months), anthropometrics (body mass index [BMI], waist circumference, body fat percentage) and cardiorespiratory status at rest and during CPET (heart rate [HR], blood pressure [BP], workload, oxygen uptake [VO_{2peak}], VAT and presence of symptoms).

The following variables were compared among groups and over three different time points (baseline, immediately after discharge [six

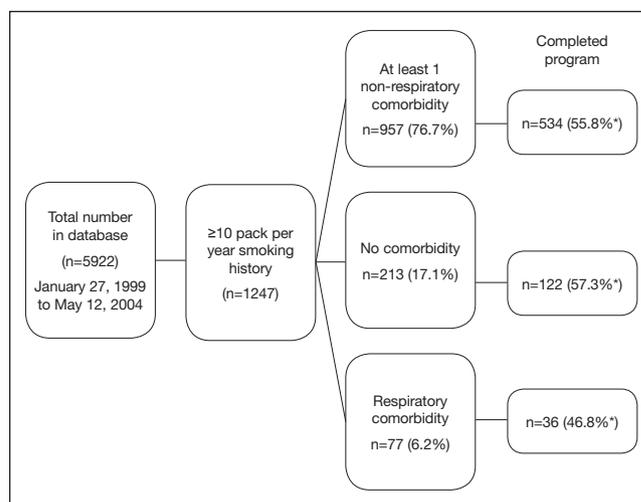


Figure 1 Flow diagram of 5922 patient records from the Toronto Rehabilitation Institute Cardiac Rehabilitation and Secondary Prevention Program (Toronto, Ontario) database from January 27, 1999 to May 12, 2004. *Percentage based on sample size of non-respiratory comorbidity (n=957), no comorbidity (n=213) and respiratory comorbidity (n=77) subgroups

months] and 12 months after the program): anthropometrics (BMI, waist circumference, body fat percentage), cardiorespiratory status at rest and during cardiopulmonary exercise testing (HR, BP, workload, VO_{2peak} , VAT and presence of symptoms).

Measurements

Body fat percentage was assessed using bioelectrical impedance for patients referred after 1999 (Tanita TBF-300A, Japan) and, before this, by skin fold measurements (26). Waist circumference was measured at the narrowest part of the torso between the iliac crest and xiphoid process, or at the level of the iliac crest after normal exhalation (27). CPET was performed on either an upright cycle ergometer (Ergoselect 200P, Germany) or a treadmill (same modality pre- and post-training) depending on patient balance and comfort. On the cycle, workload was increased by either 8.3 Watts or 16.7 Watts every minute, maintaining a pedalling rate of 60 rpm. On the treadmill, the Bruce or Modified Bruce protocol was selected (27). Gas samples were collected via calibrated metabolic cart (SensorMedics Vmax Encore, USA) with continuous monitoring of 12-lead electrocardiography (ECG) (Marquette Case 80, GE Healthcare, USA) and BP. The test was terminated at peak volitional effort (unable to maintain treadmill speed or pedalling rate) if a physiological maximum was achieved, or if the patient exhibited adverse clinical signs or symptoms. VAT was determined using a combination of the V-slope and ventilatory equivalents methods (28,29) by agreement between the supervising physician and technologist.

Data analysis

Descriptive statistics (mean \pm SD, frequencies and counts) were used to describe all groups. A one-way ANOVA (continuous) and χ^2 test (categorical) were used to compare baseline characteristics among groups. To evaluate the effects of the cardiac rehabilitation intervention, mixed factorial ANOVA (continuous variables) and logistic regression (categorical variables) was used for the between-subject, between-group and within-subject effects at each time point (zero, six and 12 months), adjusted for age, sex and baseline VO_{2peak} . Pairwise post hoc tests were performed for the cardiac rehabilitation intervention outcomes if there were significant findings (with Bonferroni adjustment). An alpha level ≤ 0.05 was considered to be statistically significant (SAS version 9.3 [SAS, USA] and SPSS version 20 [IBM Corporation, USA]).

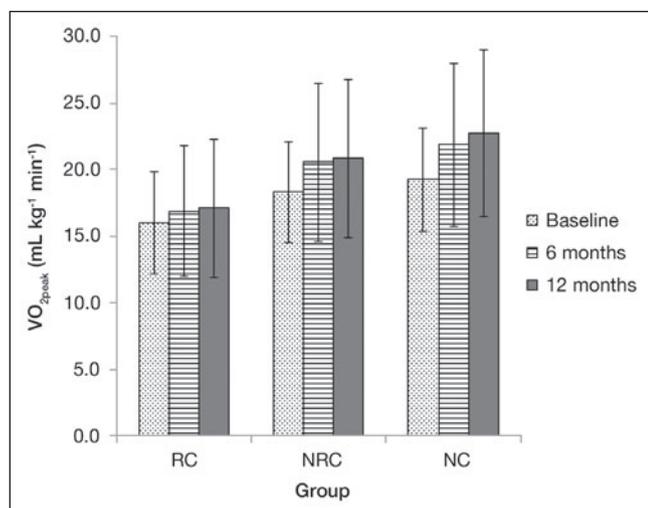


Figure 2 Peak oxygen uptake (VO_{2peak}) in the three comparison groups over time. Error bars represent standard deviation. There were significant differences among groups ($P=0.02$) (adjusted for age and sex): Non-respiratory comorbidity (NRC) VO_{2peak} significantly greater than the respiratory comorbidity (RC) group ($P=0.05$). There were significant improvements over time ($P<0.0001$) (adjusted for age and sex): VO_{2peak} significantly greater at six and 12 months versus baseline (both $P<0.0001$). There was no significant group \times time interaction. NC No comorbidity

RESULTS

There were a total of 5922 patients in the database from January 1999 to May 2004, in whom 266 (4.5%) had respiratory comorbidities (only COPD, no other chronic respiratory diseases were identified). The number of patients with ischemic heart disease and a smoking history of >10 ppy was 1247 (and the focus for the present analysis). Of this smoking cohort, 77 (6.2%) had an RC; 957 (76.7%) had at least one NRC and; 213 (17.1%) had no NC. NRCs included diabetes, cardiac conduction deficits (eg, atrial fibrillation), cancer, cardiomyopathy, congestive heart failure, cerebrovascular disease, hypertension, peripheral vascular disease, pericarditis and thyroid abnormalities. The proportion of patients from this smoking cohort who completed the program did not significantly differ among groups: RC ($n=36$ [46.8%]); NRC ($n=534$ [55.8%]); and NC ($n=122$ [57.3%]) ($P=0.26$) (Figure 1).

Baseline characteristics of comparative groups

The RC group was older compared with the other two groups (mean \pm SD) of 67.2 ± 10.1 years of age versus 61.2 ± 10.1 NRC and 60.5 ± 8.3 NC ($P=0.001$), and had more female patients (eight of 36 [22%] versus 58 of 534 [11%] NRC and five of 122 [4%] NC; $P=0.004$). The RC group had the lowest fitness levels at baseline compared with the other two groups: VO_{2peak} 16.0 ± 3.8 mL/kg/min versus 18.3 ± 4.9 NRC and 19.2 ± 5.2 mL/kg/min NC ($P=0.002$). Table 1 summarizes details regarding other significantly different outcomes among the three subgroups at baseline.

Cardiac rehabilitation outcomes for comparative groups

For VO_{2peak} , there were significant differences among groups, adjusted for age and sex ($P=0.02$). The NC group (over all three time points) had significantly greater VO_{2peak} (21.3 ± 6.0 mL/kg/min) compared with the RC group (16.7 ± 3.8 mL/kg/min). There were also significant improvements over time ($P=0.0002$), adjusted for age and sex. Overall (ie, all groups together) VO_{2peak} was significantly greater at six (20.6 ± 5.9 mL/kg/min) and 12 months (21.0 ± 6.2 mL/kg/min) versus baseline (18.3 ± 4.9 mL/kg/min) (both $P<0.0001$). There was no significant group \times time interaction (Table 2, Figure 2).

There were no significant differences among the three groups over time (adjusted for age, sex and baseline VO_{2peak}) for: VAT, resting HR, resting systolic or diastolic BP, BMI, waist circumference, body fat

percentage, angina or symptoms during exercise (leg fatigue or shortness of breath) (Table 2).

DISCUSSION

In the present retrospective review of a cardiac rehabilitation program database, there was an overall 4.5% prevalence of respiratory comorbidities (presumed COPD). For all groups, there were significant improvements in VO_{2peak} over the 12-month program. The respiratory group had significantly worse VO_{2peak} compared with the NC group. There were no differences among the groups in the other outcomes. Patients enrolled in a cardiac rehabilitation program significantly improved their fitness level over time, despite the presence or absence of comorbidities (when considering age, sex and baseline VO_{2peak}).

The prevalence of COPD was low. This was likely underestimated because diagnoses were based on physician referrals. Systematic spirometry and clinical assessment (that includes assessment of dyspnea) at entry to cardiac rehabilitation, according to standard criteria, such as Global Initiative for Obstructive Lung Disease (GOLD) (25), would have yielded a more accurate number and provided a breakdown of different severity levels (7,9,30). Studies using spirometry and clinical symptoms have shown the highest levels of prevalence. Fuster et al (7) and Soriano et al (9) used clinical assessment and the GOLD (1) spirometric criteria for COPD. Fuster et al (7) found 39% of patients undergoing CABG ($n=1412$) had COPD. Soriano et al (9) compared the prevalence of airflow limitation in three nonsurgical groups: patients with CVD ($n=52$), no CVD ($n=450$) and hospitalized CVD ($n=119$). Prevalence was estimated at 17.5%, 19.2% and 33.6%, respectively ($P<0.05$). Soriano et al (9) found airflow limitation was underdiagnosed and, therefore, highly undertreated. In contrast, King et al (8) and Cooper et al (6) used documented history in retrospective chart reviews. King et al (3) estimated that 9% of patients following acute myocardial infarction, percutaneous transluminal coronary angioplasty and/or CABG ($n=1254$) possessed respiratory comorbidities; Cooper et al (4) estimated 18% in patients receiving isolated CABG ($n=104,880$). Pulmonary function testing is rarely performed at baseline or at the end of cardiac rehabilitation programs (31-34). Incorporating lung screening may definitively identify airflow limitation and help individualize program needs accordingly. We cannot rule out the possibility that fewer patients with a complex medical history are less likely to be referred to cardiac rehabilitation.

Patients with RCs had the poorest fitness level compared with those with NRCs or NCs. In addition, patients with NRCs often had poorer outcomes compared with those with NCs. COPD, among other comorbidities (peripheral vascular disease, renal disease and diabetes mellitus), has been shown to have the greatest impact on short-term and long-term mortality of patients undergoing CABG surgery (7,35,36). Pathogenic mechanisms explaining why respiratory comorbidities have the greatest burden on outcomes is likely multifactorial: systemic and lung inflammation; hypoxia (alveolar and tissue); hypercapnic acidosis; endothelial dysfunction/vessel wall abnormalities; and polycythemia (14,37).

Despite the burden of respiratory disease, we found the relative improvements in aerobic capacity (ie, VO_{2peak}) after cardiac rehabilitation and the number of patients who completed the program similar for all three groups despite the lowest fitness level at baseline (VO_{2peak}). Similar results have been shown in other studies investigating the efficacy of cardiac rehabilitation in patients with a differing number of medical comorbidities (38); diabetes versus no diabetes (39); with and without stroke (40,41); and with and without chronic kidney disease (42). Rehabilitation benefited the RC and other comorbid groups by increasing their functional and fitness levels, and potentially reducing their risk for death (43).

There is increasing comorbid disease burden among cardiac patients, and an aging population and improved operative survival will expand the number of patients living with prognostically significant comorbidities. A cardiac rehabilitation model may be effective for patients with COPD or a pulmonary rehabilitation model for patients

TABLE 2
Comparison of body composition, resting and maximal exercise test outcomes for three groups at baseline, six and 12 months (respiratory comorbidity [RC, n=36]; non-respiratory comorbidity [NRC, n=534]; no comorbidity [NC, n=122])

Characteristic	Time, months			Mean (all groups)	P		
	0	6	12		Group	Time	Group x time
Peak oxygen uptake (VO_{2peak}), mL/kg/min							
RC	15.9±3.9	17.0±3.9	17.1±3.9	16.7±3.8	0.02*	<0.0001**	0.20
NRC	18.2±4.9	20.5±5.9	20.8±6.2	19.9±5.8			
NC	19.4±5.1	22.1±5.9	22.6±6.2	21.3±6.0			
Mean (all time periods)	18.3±4.9	20.6±5.9	21.0±6.2				
Maximum workload, W							
RC	100.5±39.2	113.0±38.7	111.6±37.4	107.9±38.0	0.11	<0.0001**	0.78
NRC	121.6±36.2	137.8±41.2	140.5±45.4	134.1±43.2			
NC	131.4±32.5	147.8±35.8	151.1±39.7	143.5±38.8			
Mean (all time groups)	122.2±36.2	138.2±40.8	140.8±44.7				
Ventilatory anaerobic threshold, mL/kg/min							
RC	11.8±2.0	12.0±2.3	12.2±1.8	11.8±2.1	0.18	0.12	0.26
NRC	12.3±2.6	13.8±3.4	14.1±3.6	13.3±3.5			
NC	12.6±2.8	14.3±3.7	14.8±4.6	13.9±3.9			
Mean (all time groups)	12.4±2.6	13.8±3.5	14.2±3.8				
Resting heart rate, beats/min							
RC	70.2±13.2	65.2±9.4	65.7±10.3	67.3±11.2	0.36	0.68	0.80
NRC	67.3±12.6	64.2±11.2	65.0±11.8	65.4±11.9			
NC	66.6±12.2	63.3±10.3	63.7±11.2	64.6±11.3			
Mean (all time groups)	67.3±12.6	64.1±11.0	64.8±11.6				
Resting systolic blood pressure, mmHg							
RC	144.9±19.0	140.9±16.9	145.1±15.2	143.6±16.9	0.84	0.81	0.28
NRC	139.7±21.9	140.5±20.6	141.6±20.0	140.6±20.9			
NC	138.9±20.8	140.2±19.0	138.6±17.4	139.1±19.2			
Mean (all time groups)	139.8±21.6	140.5±20.1	141.2±19.3				
Resting diastolic blood pressure, mmHg							
RC	77.2±11.6	72.1±10.8	76.0±9.6	75.0±10.8	0.96	0.85	0.32
NRC	75.7±12.2	74.4±11.8	76.2±11.1	75.5±11.9			
NC	75.6±11.3	75.5±12.1	76.1±10.3	75.7±11.2			
Mean (all time groups)	75.8±12.0	74.5±11.8	76.1±10.9				
Body mass index, kg/m ²							
RC	27.0±3.3	27.5±3.1	27.6±3.2	27.5±3.4	0.49	0.12	0.54
NRC	28.2±4.1	28.3±4.2	28.6±4.6	28.3±4.4			
NC	28.3±3.9	28.3±4.2	28.5±4.2	28.3±4.1			
Mean (all time groups)	28.1±4.0	28.2±4.2	28.6±4.5				
Waist circumference, cm							
RC	94.2±9.8	95.3±9.8	95.7±9.5	95.8±10.4	0.53	0.15	0.50
NRC	98.4±11.6	98.1±11.3	98.6±11.6	98.4±11.6			
NC	99.5±10.8	98.9±10.7	99.5±10.6	99.2±10.7			
Mean (all time groups)	98.4±11.4	98.1±11.1	98.7±11.3				
Body fat percentage							
RC	25.6±7.3	25.2±4.8	27.2±7.0	25.3±7.7	0.53	0.36	0.36
NRC	27.4±7.9	26.9±7.2	27.9±8.2	24.4±6.2			
NC	33.7±19.8	28.7±2.8	28.9±4.0	24.4±7.2			
Mean (all time groups)	28.2±10.4	27.1±6.6	28.0±7.6				
Angina							
RC	1 (2.9)	0 (0)	0 (0)	1 (2.8)	0.41	0.99	0.63
NRC	19 (3.6)	10 (1.9)	9 (1.7)	36 (6.7)			
NC	1 (0.8)	1 (0.8)	3 (2.5)	5 (4.1)			
Mean (all time groups)	21 (3.0)	11 (1.6)	12 (1.7)				
Symptoms*** during cardiopulmonary exercise test							
RC	8 (22.2)	5 (13.9)	4 (11.1)	17 (47.2)	0.36	0.52	0.07
NRC	160 (30.0)	80 (15.0)	13 (2.4)	253 (47.4)			
NC	38 (31.1)	22 (18.0)	4 (3.3)	64 (52.4)			
Mean (all time groups)	206 (29.8)	107 (15.5)	21 (3.0)				

Data presented as mean ± SD or n (%) unless otherwise indicated. All analyses adjusted for age, sex and baseline VO_{2peak} (except VO_{2peak} , which was adjusted only for age and sex). *Statistically significant (bold) pairwise post-hoc tests (Bonferroni adjustment) at P=0.05 level: NC>RC; **Statistically significant (bold) pairwise post-hoc tests (Bonferroni adjustment) at P=0.05 level: six-month > baseline; 12 month > baseline; ***Leg fatigue or shortness of breath

with CVD. Currently, the accessibility of cardiac and pulmonary rehabilitation programs fall below need (21,22,44,45). Pack et al (45) surveyed cardiac rehabilitation program directors in the American Association of Cardiovascular and Pulmonary Rehabilitation database and found only 28% of eligible patients utilized cardiac rehabilitation programs. They suggested modest expansion of all programs operating at capacity would meet, at most, 47% of eligible patients in the United States. Although cardiac rehabilitation utilization is low compared with the number of individuals who need it, pulmonary rehabilitation fares significantly worse. In a systematic review comparing pulmonary rehabilitation programs internationally, Desveaux et al (22) found that the availability of pulmonary rehabilitation services accommodated $\leq 1.2\%$ of individuals with COPD. In a recent survey of Canadian pulmonary rehabilitation programs, Camp et al (21) found that only 0.4% of all Canadians with COPD (0.8% with moderate to severe) have access to these programs. Having both cardiac and respiratory programs available may increase rehabilitation accessibility for these patients. One potential solution may be to have cardiac and pulmonary rehabilitation programs in one institution or location, such as at Duke Regional Hospital (Durham, North Carolina, USA <www.dukeregional.org/services/cardiac-and-pulmonary-rehabilitation/cardiac-and-pulmonary-rehabilitation/servicepage_view>). Although the two programs at this hospital operate separately, they are likely to be more cost effective and efficient because they share common infrastructure and, presumably, have cross-trained health care professionals. Similar programs can be found in Canada. An alternative rehabilitation model is one that combines COPD and heart failure patients in one program. Evans et al (46,47) completed a study of an exercise rehabilitation program for patients with congestive heart failure and COPD. This combined training program was not only feasible but also significantly improved functional and health status for both groups. Future research may include evaluating combination or adapted rehabilitation training programs for cardiac and respiratory patients and determining the type of COPD patient (eg, severity level) who may benefit.

Limitations

There were a few limitations to our study, the first of which was those common to retrospective cohort designs (48). Identification of respiratory and other comorbidities were based on physician referrals, and may have underestimated specific diagnoses. In addition, we could not delineate the severity of the individuals with COPD. Significant differences in baseline characteristics (ppv, occupational status, respiratory medication, β -blockers, BMI and waist circumference) and external factors beyond the database may have contributed to the results. Second, the present study described outcomes from one cardiac rehabilitation and secondary prevention program in Toronto, Ontario; therefore, the results may not be generalizable to areas with different cultures, practices and policies. Finally, significant results from the numerous post hoc analyses performed may have occurred due to random chance.

CONCLUSIONS

The prevalence of patients with COPD in a cardiac rehabilitation program was low, and likely due to the method for which diagnosis was made (physician referrals). It is recommended that spirometry and clinical assessment according to standard criteria be used to yield more accurate diagnoses and enable individualized programming. Patients with RCs had the poorest fitness level compared with those with NRCs or NCs. However, all groups improved after cardiac rehabilitation and the number of patients who completed the program were similar. Cardiac rehabilitation and pulmonary rehabilitation program accessibility is limited for the CVD and COPD populations. Individuals with COPD may benefit from cardiac rehabilitation programs; individuals with CVD may benefit from pulmonary rehabilitation programs. Adaptation and/or combinations may optimize their accessibility.

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