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Cardiac Rehabilitation Improves Cognitive Performance in Older Adults With Cardiovascular Disease

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Participation in cardiac rehabilitation (CR) is associated with numerous benefits, including lower mortality rates, reduced systolic blood pressure and cholesterol levels, and improved health-related quality of life.[1] To date, no study has examined whether CR can also provide cognitive benefits.

Numerous studies demonstrate that cardiovascular disease (CVD) is associated with cognitive deficits long before the onset of stroke or vascular dementia.[2,3] Patients with CVD, including those participating in CR, demonstrate deficits in multiple cognitive domains, with particular difficulty in tasks involving executive function and psychomotor speed.[2,4] Although the exact mechanisms remain unknown, cerebrovascular disease and reduced integrity of white matter pathways likely contribute to the cognitive deficits observed in individuals with CVD.[3,5]

Recent studies suggest that improvements in cardiovascular fitness may result in improved cognitive performance, as healthy older adults completing an exercise program show gains in multiple cognitive domains.[6] Given that participation in CR is associated with improved cardiovascular fitness as well as reduction in risk factors that may affect cognitive functioning (eg, hypertension levels, inflammatory markers, endothelial dysfunction), it appears likely that CR may be associated with cognitive benefit.[1]

The present study sought to examine the possible cognitive benefit of CR. A small group of patients were asked to undergo brief neuropsychological assessment preparticipation and postparticipation in a 12-week CR program. Tests were chosen for their sensitivity to cognitive deficits in persons with CVD and for their limited practice effects.[7] All chosen tests tapped attention and/or psychomotor speed, domains shown to improve with gains in cardiovascular fitness in other populations.[6] On the basis of the earlier findings, we expected patients to show gains in cognitive performance following CR.

METHODS

The following methods were approved by the local institutional review board.

Participants

A total of 18 persons with documented coronary heart disease enrolled in a 12-week, hospital-based CR program were recruited (13 males and 5 females) (Table 1). Participants were required to have a total score on the Dementia Rating Scale[8] above the cutoff for dementia and have no history of neurological or severe psychiatric disorder. All medical

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information was obtained from medical records. Participants were English-speaking, with normal or corrected hearing and vision at the time of testing.

Only one participant had been hospitalized in the previous 4 months and that participant had undergone mitral valve repair, a procedure typically without neurocognitive consequences.[9] Importantly, no participant had undergone coronary artery bypass graft (CABG) in the previous 4 months, a sufficient interval for performance on the selected neuropsychological tests to return to baseline levels.[10] On average, the 8 CABG participants were 22.7 weeks postoperative at time of the initial cognitive assessment (range 16–48 weeks), and all 8 had undergone the procedure in the previous year. All 14 participants prescribed β-blocking medications remained so throughout the study period.

Instrumentation

As noted earlier, cognitive tests were chosen for their sensitivity to CVD-associated cognitive dysfunction and limited practice effects, and included the following:

Trail Making Test A[11] asks participants to connect a series of numbered circles as quickly as possible, tapping visual attention and psychomotor speed.

Grooved Pegboard[12] asks participants to place grooved metal pegs into a pegboard using just their dominant hand. This test assesses psychomotor speed with the dependent measure being time to completion.

Category Fluency – Animals[13] requires the participant to name as many different animals as possible in 60 seconds, measuring response initiation and generation.

Digit Symbol-Coding from the Wechsler Adult Intelligence Scale-III[14] asks participants to transcribe a geometric shape to its corresponding number, tapping visual speeded search and scanning abilities.

Finally, the *Beck Depression Inventory*[15] was used to measure self-reported depressive symptoms, and cardiovascular fitness was defined as peak Metabolic Equivalent (MET) on stress testing.

Procedure

After providing written informed consent, participants were administered the neuropsychological tests by a trained research team member adhering to standardized testing and scoring procedures. All participants then received standard care as part of a Phase II CR program. The program included monitored physical condition (3 times per week for 75 minutes), education on nutrition and medication use, and risk factor education with the goal of modifying behavior. Exercise training began with 10- to 15-minute intervals of activity, with a gradual increase to 30 to 45 minutes of continuous aerobic exercise. Participants also received 15 to 20 minutes of risk factor education 2 times per week, including topics such as communicating with physicians, psychological aspects of heart disease, nutrition/diet, and lifestyle changes. At completion of CR, participants completed the neuropsychological tests a second time. Medical data obtained as part of CR (eg, stress test results, medical history) were gathered at the completion of the study period.

Data Analysis

To examine cognitive benefit from CR, repeated-measures MANOVA was conducted on the raw baseline and follow-up test scores. Univariate ANOVAs were used to clarify significant omnibus tests. Repeated-measures ANOVAs were then used to determine possible change in depressive symptoms and stress test performance for participants for whom these data were

available. Finally, to help identify possible mechanisms for cognitive benefit, changes in stress test performance were correlated with change in cognitive function.

RESULTS

Cognition

Repeated-measures MANOVA demonstrated that participation in CR was associated with significant gains in cognitive performance, with $\lambda = 0.49$ ($F_{4,14} = 3.64$, $P = .03$) (Table 2). Posttests revealed significant improvement on Trail Making Test A ($F_{1,17} = 5.43$, $P = .03$] and Digit Symbol-Coding ($F_{1,17} = 5.79$, $P = .03$]. No change from baseline to follow-up emerged for Grooved Pegboard ($P = .10$) or Animal Naming ($P = .47$) performance. Although not statistically significant, the average performance on these tasks also showed improvement.

Depression

Repeated-measures ANOVA found no change in depression symptoms on the Beck Depression Inventory from baseline to follow-up ($F_{1,17} < 1$, $P = .85$).

Cardiovascular Fitness

Participants exhibited improved peak METs from baseline to follow-up ($F_{1,11} = 26.35$, $P = .001$).

Relationship Between Improved Cardiovascular Fitness and Cognition

Change in peak METs was associated with change in Grooved Pegboard performance ($r = 0.59$), although showed weaker relationships to change in Trail Making Test A ($r = 0.30$), Digit Symbol-Coding ($r = 0.26$), and Category Fluency ($r = 0.18$).

DISCUSSION

Findings from the present study suggest that the benefits of CR extend beyond improved cardiovascular health, and may provide cognitive benefit to participants. Specifically, it appears that participation in CR is associated with improvement in psychomotor speed and complex attention. Such findings further encourage participation in CR programs, as cognitive deficits are associated with greater functional impairment and poorer quality of life in this population.[2]

Improvements in cognitive performance emerged despite no change in depressive symptoms. Cognitive improvement did coincide with gains in stress test performance and these changes were related. The exact mechanism for this relationship is unclear. Cardiac rehabilitation participation is associated with beneficial effects on a number of cardiovascular factors with known relationships to cognitive performance, including hypertension and inflammatory markers.[1,16,17] It is possible that such changes result in the observed cognitive gains, although more likely explanations include the beneficial effects of better cardiovascular fitness, improved vascular health, or increased perfusion.[6] Further study is needed to determine possible mechanisms for cognitive benefits, as it may provide crucial insight into the mechanisms underlying CVD-related cognitive dysfunction.

Being a small case series, findings of the present study are limited in several ways. The earlier findings need to be replicated in a larger controlled study that includes cardiac patients matched on demographic and medical variables but not participating in CR. Matching participants on time since the onset of the event/condition is an important next step, as it will allow researchers to disentangle the possible cognitive benefits of CR from

spontaneous gains. A controlled study will also help confirm that the observed cognitive benefit is the result of cardiovascular gains rather than practice effects. Although the neuropsychological tests employed have little or no practice effects,[7] this notion could be confirmed through a controlled study.

Despite these limitations, the present study provides 2 important findings to the existing literature. First, it offers preliminary evidence that CR has beneficial effects on cognition in older adults with CVD, a known contributor to functional impairment and reduced quality of life. Second, it suggests that conducting serial neuropsychological and cardiac assessments may provide key insight into the mechanisms of CVD-associated cognitive dysfunction.

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Table 1

DEMOGRAPHIC AND MEDICAL COMPOSITION OF CARDIAC REHABILIATION PATIENTS

	Mean	SD	Range	Frequency*, %
Demographic				
Age, y	68.11	7.72	53–79	
Education, y	14.94	3.02	8–20	
Dementia	137.94	4.33	130–144	
Rating Scale total score				
Medical history				
Myocardial infarction				67
Heart failure				28
Coronary artery bypass				44
Valve repair or replacement				8
Hypertension				72
Diabetes				17
Depression				11

* Denotes the percentage of participants with these conditions listed in their medical history at the completion of the study period.

Table 2

COGNITION, DEPRESSION, EJECTION FRACTION, AND PEAK METs PRE–CARDIAC REHABILITATION AND POST–CARDIAC REHABILITATION

Measure	Mean (SD)		*P**
	Baseline	12-Week	
Trail Making Test A	40.50 (14.56)	34.44 (12.04)	.03
Grooved Pegboard—Dominant	86.17 (13.99)	82.78 (16.80)	.10
WAIS-III Digit Symbol-Coding	55.89 (14.07)	60.89 (11.15)	.03
Category Fluency – Animals	19.61 (4.49)	20.33 (5.11)	.47
Beck Depression Inventory	5.67 (5.21)	5.83 (4.97)	.85
Stress Test Peak Training METs	5.19 (1.99)	7.40 (2.01)	<.01

* Denotes level of univariate significance.