High-intensity cardiac rehabilitation training of a commercial pilot who, after percutaneous coronary intervention, wanted to continue participating in a rigorous strength and conditioning program

Sanjay Shrestha, BS, Jenny Adams, PhD, Anne Lawrence, RN, and Jeffrey M. Schussler, MD

After undergoing elective percutaneous coronary intervention, a 64-year-old commercial pilot was referred to cardiac rehabilitation. His stated goals were to continue participating in a rigorous strength and conditioning program at a community workout facility and to resume working as a pilot. To help him meet those goals, we designed and implemented a regimen of high-intensity exercises, with quick transitions between a variety of tasks that are not typically included in cardiac rehabilitation programs (e.g., medicine ball throws, push-ups, dead lifts, squats, military presses, sprints, and lunges). The training was symptom limited, enabling the patient to reach extreme levels of physical exertion in a controlled, monitored setting. By studying his training data (heart rate, blood pressure, and rating of perceived exertion), we were able to give him specific recommendations for controlling his exercise intensity after graduating from our program. More than 18 months later, he continues to exercise vigorously 3 days per week and is working as a commercial pilot.

Instead of capping peak exercise intensity during cardiac rehabilitation (CR), we use a symptom-limited approach and offer customized high-intensity training for patients who have a strong desire to return to strenuous activities. We report the unconventional CR regimen of one such patient and the exercise prescription we provided for his future workouts.

CASE REPORT

A 64-year-old commercial pilot with previous hypertension saw a cardiologist because of a recent marked decrease in exercise tolerance. A longtime fitness enthusiast, the patient participated regularly in a rigorous strength and conditioning program at a community workout facility. A nuclear stress test showed an anteroseptal reversible defect. Left-sided heart catheterization revealed a left ventricular ejection fraction of 60%, normal wall motion, and severe obstructive coronary artery disease in the mid left circumflex. Placement of a drug-eluting stent in that narrowing resulted in a TIMI (thrombolysis in myocardial infarction) flow of grade 3 with no stenosis. The patient was subsequently referred to CR.

At CR enrollment, the patient's lipid levels (reported as mg/dL) were as follows: total cholesterol, 187; high-density lipoprotein cholesterol, 57; low-density lipoprotein cholesterol, 120; and triglycerides, 77. His family history was negative for premature coronary artery disease, and his physical examination was unremarkable. His body mass index was 25.7 kg/m² and his waist circumference was 39.5 inches. Medications included omeprazole, simvastatin, lisinopril, aspirin, and clopidogrel. When asked about his goals for CR, the patient indicated that he wanted to be fit so he could 1) participate confidently in the strength and conditioning program and 2) resume and maintain his job as a commercial pilot.

With the use of our facility's specificity of training equipment, we designed and implemented a regimen of high-intensity exercises that mimicked the modes and progressions of the strength and conditioning program. CR staff members provided the clinical testing and exercise training over the course of 30 sessions. Each exercise session started with a warm-up and ended with a cool-down. The patient's heart rate and rhythm were monitored by telemetry throughout each session. Blood pressure was measured before the warm-up, during peak exercise, and after the cool-down was completed. The patient reported his rating of perceived exertion (RPE; scale, 1 to 10) at peak exercise.

The first two exercise sessions were standard CR workouts that allowed the nurse to evaluate the patient's vital signs in response to exercise and to ensure that he had no adverse symptoms that would preclude continued training. We recorded

From the Department of Kinesiology, University of Texas at Arlington (Shrestha); the Cardiac Rehabilitation Department, Baylor Jack and Jane Hamilton Heart and Vascular Hospital (Adams, Lawrence, Schussler); and Texas A&M College of Medicine (Schussler). Mr. Shrestha is now with the Carter Rehabilitation and Fitness Center at Baylor All Saints Medical Center in Fort Worth.

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Corresponding author: Jenny Adams, PhD, Cardiac Rehabilitation Department, Baylor Heart and Vascular Hospital, 411 N. Washington, Suite 3100, Dallas, TX 75246 (e-mail: jennya@BaylorHealth.edu).

Figure. The patient performing (a) a box jump, (b) a kettlebell swing, and (c) a military press.

complete blood pressure data during 28 of the 30 sessions. The 3rd and 30th sessions included a metabolic treadmill stress test during which the patient's oxygen consumption data were captured by a calibrated desktop metabolic system (Fitmate MED, Cosmed USA Inc., Chicago, IL). The maximal stress test protocols included 3-minute stages at speeds of 1.7 to 5 mph and changes in grade from 0% to 20%. American College of Sports Medicine guidelines were followed to determine the end of the test (1).

The remaining 26 sessions consisted of high-intensity exercises, with quick transitions between a variety of tasks such as a medicine ball run, rope-jumping, box jumps, sit-ups, planks, kettlebell swings, medicine ball throws, push-ups, dead lifts, squats, military presses, sprints, and lunges (*Figure*). During these sessions, the patient had no arrhythmias, angina pectoris, or other adverse events that would have required the training to be stopped.

The patient's mean peak blood pressure and heart rate values during these high-intensity sessions were 202/75 mm Hg and 160 beats/minute, respectively, and his mean rating of perceived exertion was 8. His highest peak heart rate was 172 beats/minute during one high-intensity session. During another, his systolic blood pressure reached 270 mm Hg; this was one of 5 sessions in which his rate-pressure product (RPP, calculated by multiplying heart rate and systolic blood pressure) exceeded 36,000, which we use as a cautionary threshold for training intensity. His highest RPP was 45,090.

DISCUSSION

With our symptom-limited approach to CR training, the patient was able to reach extreme levels of physical exertion in

a controlled, monitored setting. A thorough review of the heart rate, blood pressure, RPP, and RPE data from his high-intensity CR sessions enabled us to identify specific exercise modes and progressions that caused his RPP to exceed 36,000. As a result, we advised him to avoid those combinations in the future, when he would be exercising without our supervision. We also recommended that he wear a heart rate monitor to control his exercise intensity after graduating from CR, as it was unlikely that he would monitor his blood pressure while exercising on his own. Upon graduation, his exercise prescription was to keep his RPP under 36,000; to meet that goal, we advised him to limit his heart rate to 160 beats/minute.

Commercial pilots are required to undergo an annual or a biannual medical examination during which they are screened for medical conditions that could impair their ability to pilot. Because their continued employment depends on maintaining good health, most pilots are motivated to maintain a healthy lifestyle (2). According to the Federal Aviation Administration's *Guide for Aviation Medical Examiners*, pilots who have undergone coronary angioplasty must perform a graded exercise stress test for at least 9 minutes (which is equal to 10 metabolic equivalents) and reach 100% of their age-predicted maximal heart rate (3). During his final stress test in CR, the patient reached not only his age-predicted maximal heart rate of 157 beats/minute but also 15 metabolic equivalents, a value that ranks him between the 95th and 100th percentiles of the physical fitness standards for men aged 56 to 65 years (4). More than a year after graduating from the CR program, he remains active as a pilot and stays in shape by performing rigorous workouts 3 days a week, with no negative cardiovascular symptoms.

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