Home versus group exercise training for increasing functional capacity after myocardial infarction

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ABSTRACT To evaluate the efficacy of exercise training for increasing functional capacity in the 6 months after clinically uncomplicated myocardial infarction, 198 men 52 ± 9 years of age participated in a training study. They were randomly assigned to one of four exercise protocols: 8 to 26 weeks of training at home (group 1, n = 66) or in a group program (group 2, n = 61) following treadmill testing performed 3 weeks after infarction, treadmill testing at 3 weeks without subsequent training (group 3, n = 34), and treadmill testing for the first time at 26 weeks (control, n = 37). At 26 weeks functional capacity was significantly higher in patients training at home or in a group program than that in patients without training or in control patients: 8.1 ± 1.5, 8.5 ± 1.3, 7.5 ± 1.8, and 7.0 ± 1.7 METs, respectively (p < .05 and p < .001). No significant differences in functional capacity were noted between patients training at home and those in a group program. No training-related complications occurred. Home and group training are equally effective in increasing functional capacity of low-risk patients after myocardial infarction.


EXERCISE TRAINING is commonly prescribed for the purpose of increasing functional capacity after myocardial infarction.1 No previous study has adequately addressed the possibility that clinically low-risk patients might safely undergo such exercise training at home — an option that is potentially less costly and more readily available than group programs. We have previously reported that group training significantly augments functional capacity between 3 and 11 weeks after clinically uncomplicated myocardial infarction.2 This study compares the efficacy of home and group training for augmenting functional capacity in the first 6 months after infarction.

Methods

Patients. Patients were hospitalized at Kaiser Permanente hospitals in Redwood City and Santa Clara, CA. Myocardial infarction was documented by the combination of characteristic elevation of serum creatine kinase or oxaloacetic transaminase, a history of prolonged chest pain consistent with myocardial infarction, and the appearance of new Q waves or evolutionary ST segment changes.

The patient pool consisted of 378 consecutive men 70 years old or younger. Of these, 151 were excluded because of conditions that precluded symptom-limited treadmill testing 3 weeks after infarction. These conditions included congestive heart failure, unstable angina pectoris, valvular heart disease, atrial fibrillation, bundle branch block, stroke, limiting orthopedic abnormalities, peripheral vascular disease, chronic obstructive pulmonary disease and obesity, a history of coronary artery bypass graft (CABG) surgery, reinfarction before testing, and intercurrent noncardiac illness.

The remaining 203 patients (54% of the original population) were considered eligible to undergo treadmill exercise testing 3 weeks after infarction. They were given one of four random assignments (figure 1): exercise testing 3 weeks after infarction followed by exercise training at home (group 1) or in a gym (group 2) for a duration of 8 weeks (brief training, subgroup B) or 23 weeks (extended training, subgroup A), exercise testing 3 weeks after infarction without subsequent exercise training (group 3), and treadmill testing for the first time at 26 weeks (control, group 4).

Of these 203 patients, 37 were control subjects who were not seen before exercise testing 26 weeks after infarction. Of the 166 remaining patients who underwent exercise testing at 3 weeks, four were excluded from further participation because of moderately severe exercise-induced angina. Of these, three underwent CABG surgery and one experienced nonfatal reinfarction. Another patient who was excluded because of signs of congestive heart failure during exercise testing experienced no further complications.

From the Division of Cardiology, Department of Medicine, Stanford University School of Medicine, Stanford. *With the collaboration of YMCArdis Therapy Programs in Palo Alto and San Jose, CA. Supported by grant HL18907 from the NHLBI, Bethesda, and by a grant from the PepsiCo Foundation, Purchase, NY. Address for correspondence: Nancy H. Miller, R.N., Stanford Cardiac Rehabilitation Program, 730 Welch Rd., Palo Alto, CA 94304. Received March 30, 1984; revision accepted June 28, 1984. Presented in part at the 56th Scientific Sessions of the American Heart Association, Anaheim, November 1983. **Permanente Medical Group, Inc., Redwood City, and Permanente Medical Group, Inc., Santa Clara, CA.
The remaining 161 patients undergoing treadmill exercise testing and the 37 control patients constitute the 198 patients who commenced the training study 3 weeks after infarction. All but control patients underwent treadmill testing 11 weeks after infarction and all patients underwent testing 26 weeks after infarction.

Of the 198 participants in the training study, 28 experienced cardiac events, 15 between 3 and 11 weeks and 13 between 11 and 26 weeks after infarction (table 1). The incidence of cardiac events 3 to 26 weeks after infarction was slightly higher in the control group (19%) than in patients who received no training (group 3, 12%), home training (group 1, 15%), or group training (group 2, 11%); these differences were not significant.

Ten patients dropped from the study for nonmedical reasons (refusal to participate in further exercise testing or training in eight and a move from the area in two; four left the study between 3 and 11 weeks and six between 11 and 26 weeks) (table 1). Only two of the 10 patients were lost to follow-up; of the remaining eight, one underwent CABG surgery and one experienced nonfatal reinfarction. The incidence of dropouts was significantly (p < .05) higher in patients in groups 3 and 4 than in those undergoing training (groups 1 and 2): 12%, 8%, 3%, and 2%, respectively.

The mean age of the 198 participants in the training study was 52 ± 9 years. Their occupations were professional/managerial in 56%, clerical/sales in 15%, manual labor in 15%, and retired in 14%. The site of infarction was inferior in 54%, anterior in 31%, and nontransmural in 15%. Heart size determined radiographically was normal in 85% and slightly or moderately enlarged in 15%. Lung fields determined radiographically were normal in 86% and congested in 14%. Peak creatine kinase was 1391 ± 1225 IU/liter. A history of prior infarction or angina pectoris occurring for at least 3 months before infarction was noted in 7% and 24% of patients, respectively. Demographic and medical characteristics were not significantly different between groups.

Among patients undergoing testing at 3 weeks, the proportion receiving β-blockers, oral nitrates, and antiarrhythmic medications (procainamide, quinidine, and disopyramide) was 11%, 17%, and 6%, respectively, without significant intergroup differences. At 26 weeks the proportion of patients receiving these medications was 24%, 22%, and 11%, respectively, without significant intergroup differences. On both occasions these drugs were discontinued 48 to 72 hr before testing.

**Exercise testing.** Symptom-limited treadmill testing was performed according to the combination of protocols described by Naughton et al. and was terminated by (1) limiting symptoms of chest pain, dyspnea, fatigue, or leg cramps, (2) hypotension, i.e., a fall in systolic pressure of 10 mm Hg or more from the peak value attained earlier during exercise, or (3) ventricular tachycardia, i.e., three or more consecutive premature ventricular complexes. No complications of exercise testing occurred.

**Home training.** Regimens of home and group exercise training were designed to provide a similar intensity and duration of exercise training. Home training consisted of stationary cycling for the 55 patients without exercise-induced angina at 3 weeks (whether or not they demonstrated ischemic ST segment depression) and walking for the 11 patients with exercise-induced angina at 3 weeks. Between weeks 3 and 11, patients trained for 30 min continuously 5 days per week within a range of heart rates from 70% to 85% of the peak heart rate attained on exercise testing at 3 weeks — an average of 96 to 121 beats/min. Between 11 and 26 weeks, patients trained at heart rates from 70% to 85% of the peak heart rate at 11 weeks — an average of 110 to 129 beats/min.

Patients used portable ExerSentry heart rate monitors (kindly provided by Respironics, Inc., Monroeville, PA) to assist them in remaining within their prescribed training range. Patients were also given CardioBeep portable monitors (kindly provided by Survival Technology Inc., Bethesda, MD) to transmit a bipolar MCL5 lead electrocardiogram (ECG) over the tele-

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**FIGURE 1.** Distribution of the 160 patients who remained in the training study 26 weeks after myocardial infarction. TM = treadmill; + = yes; − = no.

**TABLE 1**

Cardiac events and dropouts from exercise training study 3 to 26 weeks after infarction

<table>
<thead>
<tr>
<th>Group</th>
<th>Patients starting 3 weeks (n)</th>
<th>Nonfatal reinfarction</th>
<th>Congestive heart failure</th>
<th>Worsening angina pectoris</th>
<th>Sudden cardiac death</th>
<th>Coronary surgery</th>
<th>Total events</th>
<th>Dropouts (refusal to participate)</th>
<th>Total events and dropouts</th>
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phone to a recording unit in the program nurse’s office. At prearranged times twice weekly, the program nurse telephoned patients at home to transmit their ECGs during 1 min of exercise while the patient was within the training heart rate range and 1 min of immediate recovery from exercise. Patients who trained by walking used a 6 inch step to increase their heart rates into the training range prior to transmission of ECGs.

No episodes of ventricular tachycardia or ischemic ST segment depression exceeding 0.2 mV were noted on these telephone ECG transmissions. No patient was withdrawn from home training because of exercise-induced premature ventricular complexes or ischemic ST segment depression. The average duration of these telephone calls including the 2 min required for transmission of the ECG was approximately 5 min.

Patients reported exercise training duration and intensity and peak heart rate on logs that were mailed to the program nurse every 2 weeks and reviewed with patients during the nurse’s telephone calls. In the event that β-blockers were prescribed after treadmill testing at 3 or 11 weeks, patients were instructed to train at their previously established exercise intensity as judged by their rating of perceived exertion. A similar procedure was used for adjusting the exercise training prescription of patients undergoing group training.

Of the 40 home training sessions prescribed between 3 and 11 weeks and the 70 sessions prescribed between 11 and 26 weeks, patients completing an average of 36 (89%) and 50 (72%), respectively.

**Group training.** Two nurses or a nurse and a physician supervised 30 to 35 cardiac patients undergoing exercise training in a gymnasium. Group training consisted of three 1 hr sessions of walking/jogging per week. Patients regulated their training intensity by palpation of the radial or carotid pulse during the first 10 sec after brief cessation of walking or jogging. Of the 24 training sessions prescribed between 3 and 11 weeks and the 40 sessions prescribed between 11 and 26 weeks, patients attended an average of 20 (84%) and 28 (71%), respectively.

Patients assigned to brief home or group training were not given any specific instructions for continuing exercise training past 11 weeks. Exercise cycles and heart rate monitors were returned by patients assigned to brief home training, and paid participation in the YMCArdiac Therapy Program was terminated for patients undergoing brief group training. None of the patients in groups 1, 3, or 4 paid to participate in group training at any time 3 to 26 weeks after infarction. No complications of home or group training occurred. Patients in groups 3 and 4 reported walking an average of 45 ± 44 and 29 ± 30 min daily, respectively, 3 to 26 weeks after infarction.

**Data analysis.** Comparisons of the exercise test responses among the groups and changes occurring in the interval 3 to 26 weeks were performed by analysis of variance.

**Results**

**Treadmill exercise test responses.** Treadmill test end points at 3 weeks were as follows: angina in 13%, dyspnea and generalized fatigue in 73%, exertional hypotension in 9%, and leg cramps or fatigue in 5%. Of the 161 patients undergoing treadmill testing at 3 weeks, 47 (29%) demonstrated angina pectoris or ischemic ST segment depression exceeding 0.1 mV. Overall, half of the patients with “ischemic” ST segment depression experienced angina. The frequency of these ischemic abnormalities was not significantly different among groups 1A, 1B, 2A, 2B, and 3 (42%, 32%, 13%, 31%, and 26%, respectively).

Of 52 patients (32%) with treadmill-induced ventricular bigeminy or couplets at 3 weeks, none demonstrated ventricular tachycardia. No significant intergroup differences were noted.

The overall incidence of exercise-induced angina or ischemic ST segment depression at 26 weeks was 28% (45/160), without significant differences among groups 1A, 1B, 2A, 2B, 3, and 4 (35%, 28%, 12%, 31%, 32%, and 32%, respectively).

The incidence of treadmill ischemia was significantly (p < .03) higher in patients who experienced cardiac events or dropped out between 3 and 26 weeks than in those who completed the training study: 48% (10/21) and 43% (3/7) vs 24% (32/133). Similarly, patients with ischemic treadmill responses at 3 weeks experienced a greater incidence of cardiac events than those without ischemic responses: 21% (10/47) vs 10% (11/114) (p < .05).

Heart rate at a submaximal treadmill workload of 4 METs decreased significantly (p < .05) in all groups between 3 and 11 weeks, from 112 ± 16 to 104 ± 5 beats/min, but only slightly or not at all between 11 and 26 weeks (to 103 ± 14 beats/min; NS). Peak treadmill heart rate increased significantly (p < .05) in all groups between 3 and 11 weeks, from 138 ± 15 to 148 ± 17 beats/min, but only slightly or not at all between 11 and 26 weeks (to 150 ± 17 beats/min; NS). These changes in submaximal and peak heart rate were not significantly different between groups for either time period.

**Changes in functional capacity.** Functional capacity increased significantly between 3 and 11 weeks (p < .05) (figure 2). By 11 weeks the peak functional capacity of patients in groups 1 and 2 was higher than that of patients in group 3 (p < .05 and p < .001, respectively; figure 2). The peak functional capacity of patients in groups 1A and 2A (extended training) was higher than that of group 3 patients at 26 weeks (p < .05) and was higher in patients undergoing training than in control patients (p < .001; figure 2).

The increment in functional capacity measured between 3 and 26 weeks was not significantly greater for patients undergoing extended home or group training (groups 1A and 2A) than for patients undergoing brief home or group training (groups 1B and 2B): 2.1 ± 1.4 and 2.0 ± 1.4 METs vs 1.8 ± 1.0 and 1.7 ± 1.3 METs, respectively. The increment in functional capacity of 1.2 ± 1.3 METs in group 3 patients was significantly smaller (p < .05) than that in patients undergoing home or group training.
Discussion

Our results indicate that home training is as effective as group training for augmenting functional capacity after clinically uncomplicated myocardial infarction. These findings do not disparage the value of group training programs for this purpose.4 5 Rather, they demonstrate that group training is not the only effective means of achieving this result.

The safety of exercise training in patients with ischemic heart disease is related not only to the intensity and duration of training and to the mode of monitoring but also to patient selection. The exclusion of patients with congestive heart failure, unstable angina pectoris, and other limiting cardiac conditions largely accounts for the low rate of cardiac events observed in this study: 1% mortality, 6% combined death and reinfarction, and 14% total cardiac events, nearly half of which were CABG surgery. Of the patients considered for this study, 54% were free of these conditions and underwent randomization, of whom 198 (98%) remained in the training study after exercise testing at 3 weeks. At 11 and 26 weeks, respectively, 179 and 160 patients remained in the study, representing 47% and 42% of the entire population of 378 consecutive men.

The results also underscore the importance of exercise testing for identifying high-risk patients soon after infarction: of the five patients excluded from participation in the training study because of serious limitations to their treadmill performance, four experienced subsequent cardiac events. Moreover, no training-related cardiac events were noted, despite the fact that 37% of patients undergoing home training and 23% of patients undergoing group training demonstrated treadmill-induced ischemic ST segment depression or angina pectoris 3 weeks after infarction.

A major rationale for medically supervised group programs of exercise training for patients with ischemic heart disease is to ensure safety.6 Although the rationale is well established, the term "medically supervised" is open to interpretation. Continuous ECG monitoring does not demonstrably augment the safety afforded by visual surveillance of patients undergoing exercise training. It may also be true that visual surveillance of low-risk patients undergoing group training does not significantly augment the safety afforded by regular telephone contact with low-risk patients undergoing home training.

The brief transmissions of the ECG during home training were intended to enhance patient compliance and to detect exercise-induced ECG abnormalities that might preclude continued training. In fact, no patient was dropped from home training because of such abnormalities. It is noteworthy that patients who demonstrated ischemic ST segment depression exceeding 0.2 mV during symptom-limited treadmill testing did not exhibit this degree of ischemia on ECGs recorded during home training. Although "complex" premature ventricular complexes were often noted on the ECG transmissions, such exercise-induced ventricular ectopic activity appears to have little prognostic significance in clinically low-risk patients after infarction.

The risk of training-induced cardiac arrest is closely related to the intensity of exercise training. Hossack et al.8 noted that cardiac arrest tended to occur at heart rates exceeding the prescribed training intensity. Maintaining the heart rate within the prescribed training range is reliably accomplished by the use of portable monitors that alert patients to excessive heart rates.

The "risk exposure" of brief training in the present study (the cumulative hours during which a training-related event might have occurred) was approximately 24 hr — only one-third that of extended training. Since the peak functional capacity increased little after 11 weeks, it appears that the risk benefit of brief training is greater than that of extended training.

Despite the support and encouragement provided by fellow participants and medical supervisory staff, nearly half of patients drop out of group exercise training programs within 6 months after infarction.9 In the present study the support and encouragement provided by telephone contact with the nurse appeared to be as effective as that provided by nurses in a group program in maintaining high-level patient compliance with exercise training. The reassurance provided by the use of heart rate and ECG-transmitting monitors may also have contributed to the high level of compliance with the home training protocol.

Our results suggest that of the 600,000 Americans who survive a myocardial infarction each year, as

FIGURE 2. Changes in functional capacity 3 to 26 weeks after myocardial infarction.
many as 47% or 280,000 may be capable of safely completing 3 months of home training — nearly five times the number of postinfarction patients currently undergoing group training.

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