Land versus water exercise in patients with coronary artery disease: effects on body composition, blood lipids, and physical fitness

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Background We examined the effects of combined resistance and aerobic training on land versus combined resistance and aerobic training in water in patients with coronary artery disease.

Methods Thirty-four patients were randomly assigned to land exercise (LE, n = 12), water exercise (WE, n = 12), and control (n = 10) groups. The LE group trained 4 times per week, twice with aerobic exercise and twice with resistance training. The WE program included aquatic aerobic activities 2 times per week and resistance exercise at the same frequency carried out in water. The duration of the training programs was 4 months. Body composition measurements, blood lipids, exercise stress testing, and muscular strength were obtained at the beginning and at the end of the training period.

Results After 4 months of training, analysis of covariance revealed that body weight and sum of skinfolds were lower for WE and LE groups than for the control group. Patients who trained in water improved exercise time (+11.7% vs +8.1%) and maximum strength (+12.8% vs +12.9%) in a similar manner compared to the patients who trained on land. Total cholesterol (WE −4.4%, LE −3.3%) and triglycerides (WE −10.2%, LE −11.8%) decreased significantly for both exercise groups but not for the control group.

Conclusions Exercise programs that combine resistance and aerobic exercise performed either on land or in water can both improve exercise tolerance and muscular strength in patients with coronary artery disease. Furthermore, both programs induce similar favorable adaptations on total cholesterol, triglycerides, and body composition. (Am Heart J 2007;154:560.e1-560.e6.)

Exercise training, the major component of cardiac rehabilitation, reduces risk factors, improves functional capacity and prognosis, and enhances psychosocial well-being and quality of life in patients suffering from coronary artery disease (CAD).[1-3] Traditionally, the type of physical training that has been undertaken in cardiac rehabilitation programs was aerobic in nature, mainly walking, jogging, stationary cycling, and arm cranking.

In recent years, resistive training was also found to be a significant component in cardiac rehabilitation programs for the improvement of muscular strength and endurance,[4-6] whereas the combination of both resistance and aerobic exercise seems to induce better adaptations than aerobic training alone.[7-9] Recently, the American Heart Association recommended that resistance training be implemented in cardiac rehabilitation programs 2 times per week.[4,6]

For many decades, patients with CAD were told to avoid swimming because it was associated with undesirable cardiorespiratory alterations such as increased left ventricular volume and ventricular irritability. Furthermore, it has been reported that even comfortable swimming can elicit high $\dot{V}O_2$ and heart rate responses, especially for those patients with poor swimming skills.[10,11]

Based on recent scientific evidence, however, activities with the head out of water such as water-walking, adapted water games, and aqua-aerobic performed in thermoneutral temperatures could be a feasible alternative of physical training for low-risk patients with CAD to improve their motivation and compliance and to optimize the expected exercise-induced cardiovascular adaptations.[12-14] Water-based exercise (not swimming), as prescribed above, performed in upright position and according to the main principles of interval training is safe and elicits appropriate hemodynamic responses. Indeed, McMurray et al[15] and Fernhall et al[16] indicated that there are no differences in angina, ST depression, and

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arrhythmias between land and water exercise (WE) in patients with CAD. More recently, Schmid et al[14] reported that CAD patients with preserved left ventricular function tolerate water immersion, gymnastics, and even swimming in thermoneutral water well.

Until today, the training effects of nonswimming WE for CAD patients have received little attention. In addition, research interest in resistance-type aquatic training in this population has been scant. To the best of our knowledge, there are no studies which compare the adaptations induced after specific water-based or land exercise (LE) programs in patients with CAD. It would be interesting to examine whether the combination of both resistance and aerobic exercise is more efficient when it is performed either on land or in water. Based on the hypothesis that both land or WE programs would lead to similar adaptations, we investigated the effects of these exercise programs on body composition, blood lipids, muscular strength, and exercise tolerance to provide alternative training modes in patients with CAD.

Table I. Patient characteristics of the 2 exercise groups and the control group at the onset of the study (values presented as means ± SE and integral numbers)

	WE (n = 12)	LE (n = 12)	Control group (n = 10)
Anthropometrical characteristics			
Age (y)	53 ± 4	58 ± 3	51 ± 3
Body weight (kg)	87 ± 3	84 ± 3	79 ± 2
Sum of skinfolds (mm)	74 ± 3	58 ± 3	62 ± 4
Condition			
MI	5	3	5
CABG	3	5	2
PTCA	3	3	3
Medications			
Ítrates	6	6	4
β-Blockers	7	5	5
ÁCE inhibitors	5	6	4
Calcium-channel blockers	5	6	4
Diuretics	3	2	2
Statins	4	2	3

ACE, Angiotensin-converting enzyme; *CABG*, coronary artery bypass grafting; *MI*, myocardial infraction; *PTCA*, percutaneous transluminal coronary angioplasty.

Methods

Subjects

Thirty-four male patients (n = 34) with documented CAD (myocardial infraction, coronary artery bypass grafting, and coronary angioplasty) participated in the study. Exclusion criteria were unstable angina, high blood pressure at rest (SBP >160 mm Hg, DBP >100 mm Hg), left ventricular ejection fraction <50%, abnormal responses during exercise stress testing (ST depression >1 mm, blood pressure falling >20 mm Hg between 2 sequential measurements) and any condition precluded regular exercise. All patients were tested and underwent training while taking their usual medication without any alteration until the end of the study. In addition, none of the subjects had participated in a supervised systematic exercise program for at least 6 months before the study.

The patients were randomly divided into 3 groups: LE, WE, and control. Of the initial 34 subjects, 32 completed the study and were included in the final analysis (see the Results section). Each participant signed a written consent after being informed of all risks and benefits associated with the study; this was approved by the institutional ethics committee. Subjects were instructed not to alter their diets or alcohol habits during the study and especially during the last 3 days before blood sampling. Twenty-four hours before measurement, subjects were sustained from alcohol consumption and physical activity. During the training period, patients in both exercise groups did not perform any extra exercise outside the program (Table I).

Study design

The exercise groups enrolled in a systematic training program for 4 months performed either on land or in water at a frequency of 4 sessions per week. The LE group trained only on land (2 sessions of aerobic and 2 of resistance training), whereas the WE group trained only in water (2 sessions of aerobic and 2 of resistance training also). All exercise sessions (on land and in water) were supervised by 2 exercise physiologists. Heart rate was monitored during both strength and aerobic training with heart rate monitors (Polar-Electro, Kempele, Finland). Blood pressure was measured by a sphygmomanometer at the beginning, randomly or at subjective discomfort during exercise, and at the end of each training session. The patients in the control group did not participate in any kind of exercise program. They were asked to carry out their usual daily activities throughout the study.

Test procedures

Anthropometric profile. Measurements of body weight and skinfold thickness were taken from all patients by the same investigator. The sum of the 4 skinfold readings (triceps, subscapular, suprailiac, and thigh) using a Harpenden caliper was used as a measure of body fat.[17]

Exercise stress test. All the participants underwent a symptom-limited exercise test on the treadmill with electrocardiogram monitoring using the Bruce protocol. Heart rate was measured on a 12-lead electrocardiogram with an automatic ST-segment analysis. Blood pressure was recorded manually at rest and then at 3-minute intervals during the stress test.

Measurement of muscle strength. Muscle strength was measured with the one repetition maximum (1-RM) testing method. Strength was recorded as the maximal weight lifted in one full range of motion, and the 1-RM was determined after either 4 or 5 trials. One-minute rest followed each trial, and the resistance was increased by approximately 5 or 2.5 kg when the patient was near the maximum. Total strength was determined from the sum of 1-RM lifted on bench press, pull down, seated row, "peck-deck," leg extension, and hamstring curl.

Biochemical analysis. After an overnight fasting period (12 hours), a blood sample was drawn from an antecubital vein for measurements of total cholesterol (TC), triglycerides (TG), and high-density lipoprotein cholesterol (HDL-C). Serum triglycerides, total cholesterol, and HDL cholesterol were assayed by enzymatic colorimetric procedures (Biosystems, Barcelona, Spain). Low-density lipoprotein cholesterol (LDL-C) and very low-density

Table II. Alterations in body composition for the 3 groups after the intervention period (means ± SE)

	Body weight (kg)				Sum of skinfolds (mm)			
	Baseline		4 m		Baseline		4 m	
	Observed means	Covariate	Observed means	Adjusted means	Observed means	Covariate	Observed means	Adjusted means
WE	86.7 ± 2.9		84.9 ± 2.8	81.9 ± 0.5*	73.7 ± 3.1		68.4 ± 2.4	60.2 ± 1.4*
LE	83.7 ± 3.3	83.3	81.9 ± 3.0	81.6 ± 0.4*	57.6 ± 3.0	64.5	55.3 ± 2.7	61.5 ± 1.4*
Control	79.2 ± 2.4		80.4 ± 2.5	84.2 ± 0.5	61.9 ± 4.1		66.5 ± 4.6	68.8 ± 1.3

* $P < .05$, significant differences versus control group.

lipoprotein cholesterol (VLDL-C) were calculated using the following equations: LDL-C = [TC − (HDL-C + TG/5)] and VLDL-C = TG/5.[18]

Training on land

The LE program consisted of 2 aerobic sessions and 2 sessions of resistance training. Both aerobic and strength exercise lasted 60 minutes and included a warmup period (10 minutes), the main program (30-40 minutes) and a cool down period (10 minutes). The main aerobic program consisted of walking/running on the treadmill (15-20 minutes) and cycling on the cycle ergometer (15-20 minutes). The exercise intensity of the aerobic program was 60% to 80% of the maximal heart rate achieved during a symptom-limited grade exercise test. Resistance training consisted of 8 exercise stations performed in the following order: bench press, seated row, leg extension, pull down, peck-deck, hamstrings curl, curl-ups, and back extension. Two to three sets of 12 to 15 repetitions at 60% of 1-RM for each exercise were performed. The rest period between exercises lasted <30 seconds with periods of 5-minute rest between sets. After 2 months of training, the one repetition maximum was reassessed for each participant and resistance was adjusted accordingly.

Training in water

The WE program was conducted in a heated pool (depth 1.20 m) at water temperatures between 28°C and 30°C and consisted of 2 aerobic sessions (at 50%-70% of maximal heart rate achieved during symptom limited grade exercise test) and 2 sessions of resistance training (60%-80% of the maximal number of repetitions performed in each exercise at baseline). All sessions lasted 60 min and included a warmup period (10 minutes), the main program (30-40 minutes), and a cool down period (10 minutes). The aerobic regimen included exercises such as water walking, jogging, walking and jogging in combination with various arm movements, side-stepping, water cycling, and adapted water games (volley and basket). During resistance training, the following 8 exercises were performed: chest/upper back guide, chest back press, behind-the-back press, pivoted shoulder press (upper body) and calf lifts, supported squats, outer/inner thigh scissors, and forward and back leg glide (lower body). Each movement during resistance training was conducted using specialized equipment to increase the water resistance and the stimulus offered by the water. The progression of the training program was ensured by increasing the amount of sets, the number of repetitions, and the speed of the exercises.

Statistical analysis

All values were expressed as mean ± SE. Data were analyzed using analysis of covariance to test the differences between groups after training, with baseline scores used as covariates and the group used as the independent variable. The level of significance was set at $P < .05$.

Results

The results were based on the 32 subjects (11 in the LE, 11 in the WE, and 10 in the control group) who completed all testing and training requirements of the study. There were 2 dropouts during the course of the study: one for each exercise group for medical (orthopedic) but not cardiac reasons. There was no significant difference between mean attendance rates for the 2 exercise groups. From the 72 attainable sessions, patients trained on land completed 62.4 ± 4.6 (86%), while patients in the WE group 64.1 ± 5.3 sessions (89%). The training programs were well tolerated, and no orthopedic injuries or cardiovascular complications occurred during the exercise sessions in both groups.

Effects on body composition

At the end of the study, the patients who trained in water reduced their body mass (−1.4 kg) and sum of skinfolds (−4.3 mm) in a similar manner to those trained on land (−1.7 kg and −3.0 mm, respectively). These improvements in the exercise groups were significantly greater compared to the control group (Table II).

Effects on blood lipids

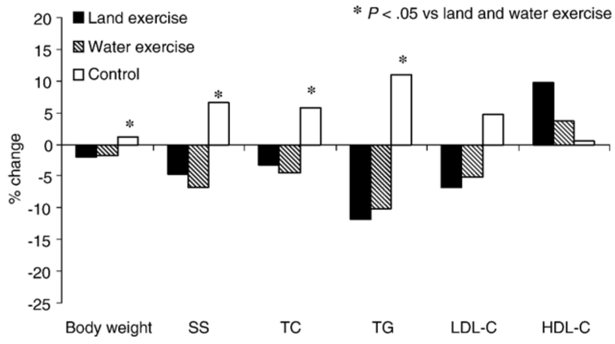
The effects of water and LE programs on the lipid profile are presented in Table III. Both exercise groups significantly reduced total cholesterol (−9.3 mg% and −7.0 mg% for WE and LE, respectively) and triglycerides (−14.5 mg% and −16.9 mg% for WE and LE, respectively), but there were no differences among groups. High-density lipoprotein levels tended to increase after training in the WE and LE groups; however, these changes were not different among patients in the 3 groups. The levels of LDL-C did not alter with any mode of exercise training.

Table III. Alterations in blood lipids (means ± SE) for the three groups after the intervention period (in mg%)

	Baseline		4 m	
	Observed means	Covariate	Observed means	Adjusted means
Total cholesterol				
WE	209.2 ± 11.9		201.0 ± 11.1	202.6 ± 7.0*
LE	220.7 ± 11.5	211.9	210.2 ± 8.8	204.9 ± 7.0*
Control	205.2 ± 5.2		220.0 ± 7.2	224.0 ± 7.4
Triglycerides				
WE	163.0 ± 16.8		144.4 ± 18.0	128.0 ± 7.8*
LE	123.6 ± 17.9	142.5	110.5 ± 14.5	125.6 ± 8.2*
Control	139.0 ± 15.6		155.2 ± 12.8	158.1 ± 8.0
HDL-C				
WE	34.5 ± 2.2		37.3 ± 1.5	38.9 ± 1.5
LE	42.2 ± 3.6	37.5	43.8 ± 3.0	41.2 ± 1.5
Control	35.6 ± 3.8		36.7 ± 2.1	37.7 ± 1.6
LDL-C				
WE	142.1 ± 11.0		135.3 ± 12.3	136.2 ± 7.7
LE	142.6 ± 9.9	143.5	133.3 ± 8.8	133.9 ± 7.6
Control	146.1 ± 6.6		152.2 ± 8.2	150.4 ± 8.0

* $P < .05$, significant differences versus control group.

Figure 1



Changes in body weight, SS, and lipid profile after 4 months of training in each group. *SS*, Sum of skinfolds.

Changes in the lipid levels were not significant in the control group (Table III and Figure 1).

Effects on hemodynamic parameters and exercise tolerance

The submaximal rate pressure product (at 6th minute of the stress test) was significantly lower ($P < .05$) for both exercise groups after training, whereas it remained unchanged in the control group (WE 19.0 ± 4.1 vs 15.7 ± 2.9 × 10^3, LE 19.6 ± 5.4 vs 16.6 ± 3.3 × 10^3, and CG 16.9 ± 1.8 vs 17.1 ± 2.3 × 10^3). Exercise time achieved during stress testing at the end of the study was significantly higher ($P < .05$) in the training groups (WE +1.3 min and LE +0.9 min) than in the control group (Table IV).

Effects on body strength

Changes in muscular strength for each of the three groups are presented in Table IV. The WE group increased their maximum strength by an average of 34.3 kg ($P <$ .05), and the LE group, by an average of 34.5 kg ($P < .05$). There was no difference in muscular strength response after training between the 2 exercise groups. Patients in the control group did not experience any significant alterations in muscular strength throughout the course of the study ($P > .05$).

Discussion

The results of the present study show that both the WE and LE programs were effective in increasing exercise time, muscular strength, body composition, and improving lipid profile in patients with CAD. All these positive alterations were significantly different from the control group. On the other hand, there were no differences between the 2 training programs. This supports our hypothesis indicating the beneficial effects of a combined resistance and aerobic training for patients with low-risk CAD, irrespective if their exercise program performed either on land or in water.

Body composition and blood lipids

Both training programs revealed positive adaptations on body composition and lipid profile (TC and TG). In particular, body weight decreased by 1.7% and 2.0%, and sum of skinfolds, by 6.7% and 4.6% for WE and LE, respectively. These changes are similar to those reported by other studies after 3 to 6 months of combined resistance and aerobic programs in cardiac patients.[19-21] Beniamini et al,[20] who used dual-energy radiographic absorptiometry in a 12-week study, showed that patients who performed combined resistance and aerobic training lost more fat and tended to gain more lean body mass than other patients who performed aerobic and flexibility exercises. All the above studies, however, were performed on land, and there is a lack of data concerning the body composition changes induced after specific water training programs in CAD patients. In a relevant study in healthy elderly women, Takeshima et al[22] reported a significant decrease (8%) in skinfold thickness 3 months after a water-based exercise. According to our study, patients with CAD can improve their body composition by exercising in water in a similar manner compared to LE.

Few studies have demonstrated the favorable effects of water-based training on blood lipids in healthy subjects.[22] Furthermore, when taking into consideration patients with CAD, data describing the efficacy of combined resistance and aerobic training programs, to improve their lipid profile, seem to be missing from the literature.

Table IV. Changes in exercise time and total muscular strength for the 3 groups after the intervention period (means ± SE)]

	Exercise time (min)				Total strength* (kg)			
	Baseline		4 m		Baseline		4 m	
	Observed means	Covariate	Observed means	Adjusted means	Observed means	Covariate	Observed means	Adjusted means
WE	11.0 ± 1.9		12.3 ± 1.8	12.4 ± 0.2†	285.5 ± 8.9		320.2 ± 10.8	302.5 ± 2.8†
LE	10.6 ± 3.1	11.1	11.5 ± 3.2	12.0 ± 0.2†	253.6 ± 13.1	268.2	287.8 ± 12.6	302.7 ± 3.0†
Control	11.8 ± 1.6		11.9 ± 1.6	11.2 ± 0.3	262.3 ± 9.5		262.7 ± 9.7	268.7 ± 2.8

*Total strength was determined from the sum of one repetition of maximum weight lifted on bench press, pull down, seated row, pec-deck, leg extension, and hamstring curl.
†$P < .05$, significant differences versus control group.

Our results indicate that a 4-month training program, which combines resistance and aerobic training performed either on land or in water, induces favorable biochemical adaptations, especially in the levels of total cholesterol (−4.4% and −3.3% for WE and LE, respectively) and triglycerides (−10.2% and −11.8% for WE and LE, respectively). This agrees with the study of Takeshima et al[22] who found a significant decrease in total cholesterol (−11%) and triglycerides (−8.5%) after a 12-week water-based exercise program in older women.

Regarding the changes in HDL-C, we observed an improvement by 3.7% for WE and 9.8% for LE. Although these alterations were not significant, they have clinical relevance. Epidemiological studies have shown that the alteration of lipid profile reduces significantly the occurrence of an expected cardiac event in the future. A 1% or 2% increase of HDL-C reduces the cardiovascular risk by 2% to 4%.[23] We recently reported significant adaptations on lipid profile (TC −9.4%, TG −18.6%, HDL −C +5.2%) after 8 months of a combined resistance and aerobic training in patients with CAD.[24]

However, the effects of exercise on lipid profile are affected not only by the training characteristics but also by other factors, including changes in body composition and food intake. Although participants were instructed not to change their dietary habits, no measure of nutritional status was performed at the beginning and at the end of the study. The adequate intensity and the high frequency of training, the high attendance rate, as well as the supervised exercise sessions were probably responsible for the positive results on blood lipids and body composition obtained in our study. However, given that dietary intake is an important factor in determining body composition and blood lipid concentrations, further research is needed to find out how nutrition and specific exercise programs may interact to affect the lipid profile of patients with CAD.

Exercise tolerance and hemodynamic function

Several studies have reported significant increases in exercise tolerance after combined resistance and aerobic training programs performed on land[9,20] but not after specific WE programs in patients with CAD. In our study, treadmill time increased in both groups after training (11.7% for WE and 8.1% for LE), suggesting that the environment of training (water or land) did not modify the expected improvement in exercise tolerance.

Both exercise groups had comparable positive changes in rate pressure product at submaximal workloads. This is very important and leads to reduced circulatory stress during the daily activities of the patients allowing them to tolerate higher workloads. The hemodynamic changes observed in our study during submaximal exercise are in accordance with the findings reported following aerobic training on land.[25] Interestingly, lower submaximal heart rate and rate pressure product have been reported in CAD patients after a 6-month resistance and aerobic exercise program but not after aerobic exercise alone.[21] Ôhe results of our study show that a combined resistance and aerobic training program for low-risk CAD patients was effective in reducing myocardial oxygen demands, whether exercise was performed on land or in water.

Muscular strength

Maintenance of muscular strength is important for cardiac patients to accomplish many daily tasks which require static or dynamic efforts. The strength improvements found in the present study for both groups (12.8% for WE and 12.9% for LE) are in agreement with those reported by other investigators after combined resistance and aerobic training programs of similar duration carried out on land.[7,8,21] In the longest follow-up study, Santa-Clara et al[9] reported significant strength increases (21.9% for upper body and 27.8% for lower body) in male cardiac patients who performed combined resistance and aerobic training for 12 months. In another study, a 10-week progressive aquatic resistance training program in healthy women resulted in significant improvement in muscle torque of the knee extensors and the flexors varied between 8% and 13%.[26] To our knowledge, there are no data concerning the effects of specific WE programs on muscular strength in patients with CAD. The present study adds further documentation on significant strength improvement after a combined resistance and aerobic training performed in water in patients with CAD.

Study limitations

Because of the small number and the low-risk status of the patients, our results could not be generalized for all patients with CAD. In addition, although we tried to control the training load between the programs, some diversity was evident in the different modes of exercise. We adjust the exercise intensity of LE versus WE and kept identical the frequency and duration of the sessions.

Conclusion

Exercise programs that combine resistance and aerobic exercise performed either on land or in water were well tolerated and improved exercise tolerance and muscular strength, inducing similar favorable adaptations on total cholesterol, triglycerides, and body composition. The findings from the present study indicate that water-based exercise may be a useful alternative for low risk patients with CAD. Additional studies are needed, however, to further define the physiological adaptations after water-based exercise in other populations of cardiac patients (eg, elderly and female patients or patients with left ventricular dysfunction).

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