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ORIGINAL RESEARCH

Community-Based Training–Detraining Intervention in Older Women: A Five-Year Follow-Up Study

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This five-year follow-up nonrandomized controlled study evaluated community-based training and detraining on body composition and functional ability in older women. Forty-two volunteers (64.3 ± 5.1 years) were divided into four groups: aerobic training, strength training, combined aerobic and strength, and control. Body composition and physical fitness were measured at baseline, after nine months of training and after three months of detraining every year. After five years of training, body fat decreased, and fat free mass, strength, and chair test performance increased ($p < .05$) in all training groups. Training-induced favorable adaptations were reversed during detraining but, eventually, training groups presented better values than the control group even after detraining. Thus, nine months of annual training, during a five-year period, induced favorable adaptations on body composition, muscular strength, and functional ability in older women. Three months of detraining, however, changed the favorable adaptations and underlined the need for uninterrupted exercise throughout life.

Keywords: aging, exercise training, body composition, functional ability, physical fitness

Increased physical activity and regular exercise positively affect daily performance in older adults (Chou, Hwang, & Wu, 2012; Karavirta et al., 2011; Toto et al., 2012) and may prevent the age-related protein degradation of skeletal muscle (Dickinson, Volpi, & Rasmussen, 2013). They can also delay the reduction of muscle mass (Manini et al., 2009), and slow down the progression of muscle atrophy when combined with dietary intervention (Burd, Gorissen, & van Loon, 2013). Furthermore, controlling body fat mass through exercise reduces the risks of inflammation, metabolic syndrome, arterial stiffness, and glucose intolerance, which affect functional ability and quality of life (Peterson, Sen, & Gordon, 2011). Aerobic endurance can be achieved through aerobic training, while muscle strength can be improved through resistance training (Stenholm et al., 2012).

Aerobic training in older individuals increases maximal oxygen consumption, oxidative enzyme activity, and muscle capillarization, while resistance training increases muscle mass and improves muscular strength (Bird, Hill, Ball, Hetherington, & Williams, 2011; Huang, Shi, Davis-Brezette, & Osness, 2005; Jubrias, Esselman, Price, Cress, & Conley, 2001; Kalapotharakos et al., 2005). Furthermore, the combination of aerobic exercise and strength training was found to improve both cardiorespiratory and muscular fitness (Kalapotharakos et al., 2005; Karavirta et al., 2011). It appears, therefore, that a program combining strength and aerobic exercise could prove to be beneficial to older individuals.

It is well known that most of the favorable training-induced adaptations require time to be accomplished and gradually disappear upon the cessation of the program (Fatouros et al., 2005; Ivey et al., 2000; Kalapotharakos, Smilios, Parlavantzas, & Tokmakidis, 2007; Tokmakidis, Kalapotharakos, Smilios, & Parlavantzas, 2009). Therefore, the duration of exercise programs is vital. No data exists, however, on long-term effects of training programs based on a year-by-year follow-up study. To our knowledge, most research intervention studies lasted eight months or less (Avila, Gutierres, Sheehy, Lofgren, & Delmonico, 2010; Williams et al., 2011; Zhuang, Huang, Wu, & Zhang, 2014), while others had a 12–23-month follow-up (Bird et al., 2011; Opdenacker, Boen, Coorevits, & Delecluse, 2008; Opdenacker, Delecluse, & Boen, 2011). More time is required, however, to examine the hypothesis that exercise training may resist or delay the age-related physiological decline, and this can be achieved better in a community-based setting.

Long-term community-based programs are feasible and could provide data on physical fitness and health-related adaptations. For example, studies have shown that exercise has been associated with decreased mortality in cancer patients who participated in a five-year community-based program (Haas, Kimmel, Hermanns, & Deal, 2012). In addition, the partial or complete loss of training-induced adaptations as a consequence of training cessation is documented in older individuals (Ivey et al., 2000; Kalapotharakos et al., 2007; Tokmakidis et al., 2009) as well as in patients with coronary artery disease (Tokmakidis & Volaklis, 2003). Nonetheless, an interruption of training is sometimes inevitable, especially in community-based programs. Therefore, a long-term follow-up study, including training and detraining periods of five years, seems to be an appropriate design that provides adequate time to reveal valuable information on specific training, detraining, and retraining adaptations on functional ability and body composition.

The purpose of the current study was to examine the effects of three different community-based exercise training programs (multicomponent aerobic, strength training, and their combination) on body composition and functional ability during a five-year follow-up in older women. The annual plan of these community-based training programs consisted of nine months of training and three months of detraining. Thus, the impact of exercise cessation (detraining effects), as well as the extent of the regained adaptations after training resumption (retraining effects), were assessed during the long-term intervention period. To eliminate interference, the setting of each program was conducted in a different region of the city.

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Methods

Subjects

Participants were recruited from different regions of Thessaloniki, Greece, through advertising in local newspapers, posters, and print materials. Although 118 women expressed their interest to participate in the program, after being notified, only 80 volunteers appeared in the first meeting (Figure 1). Demographic and medical questionnaires were administered at the beginning of the study.

Inclusion criteria were: age ≥ 60 years and no involvement in regular exercise programs in the previous 12 months. Exclusion criteria included: high blood pressure (systolic blood pressure ≥ 160 mmHg and/or diastolic blood pressure ≥ 100 mmHg) and/or any cardiovascular and health problem that precluded regular exercise. Nine women did not meet the inclusion criteria: aged below 60 years, high blood pressure (systolic blood pressure ≥ 160 mmHg and/or diastolic blood pressure ≥ 100 mmHg), and/or any cardiovascular and health problem that precluded regular exercise. Four women declined to participate (unable to follow the schedule) and four were excluded for personal reasons. Sixty-three women were initially enrolled in the study (N = 63), but the pretest was completed only by 50 (N = 50) women (five stopped without any notification, five did not appear for the measurements, and three had difficulties with

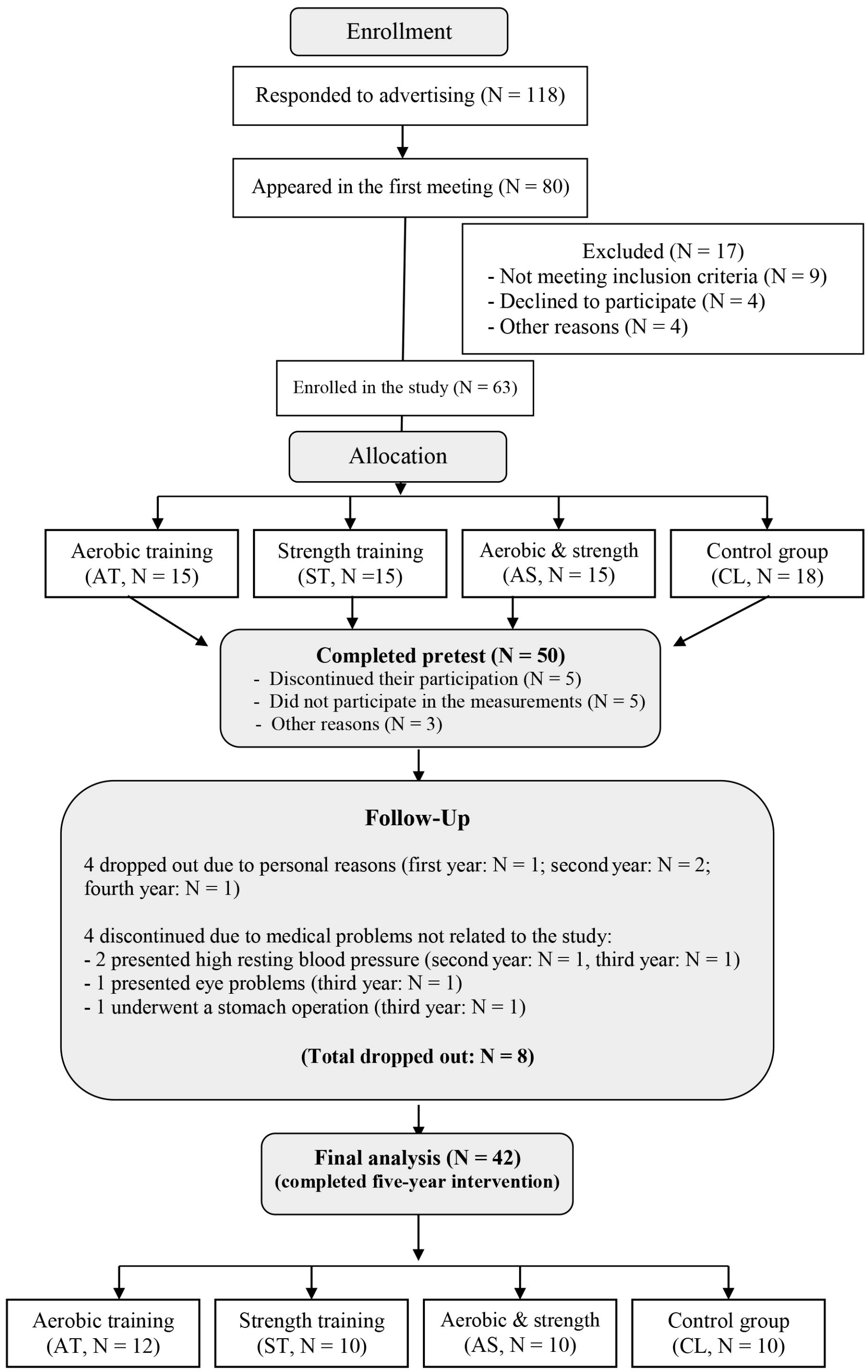

Figure 1 — Flow diagram of the study.

following the schedule). During the course of the study, eight women discontinued the intervention (Figure 1). Finally, 42 women, aged 64.3 ± 5.1 years, completed the five-year follow-up study.

The design of our study is a nonrandomized control intervention. The subjects were divided into four groups according to the region they lived in and followed three different training programs, with one control group: aerobic training (AT, $N = 12$), strength training (ST, $N = 10$), combined aerobic and strength training (AS, $N = 10$), and a control group (CL, $N = 10$). The anthropometrical characteristics of the subjects are presented in Table 1. All participants signed a written consent form after being informed of all risks and benefits associated with the study. The Research Ethics Committee of the university approved the study.

Training Intervention

The exercise training groups followed a supervised five-year community-based training intervention. Each year consisted of nine months of systematic training and three months of detraining. During the training periods, the women exercised three times per week with each session lasting 45 min. The sessions of all intervention programs included a warm-up (10 min), the main activity (30 min), and a cool down (5 min). The warm-up (stretching and vigorous walking) and the cool-down exercises (stretching) were the same for all groups. Heart rate was monitored regularly throughout training with heart-rate monitors (Polar-Electro S810, Kempele, Finland) for safety reasons and to have feedback on the proper training intensity.

Except for the first year where baseline was obtained, all subjects were tested twice per year as follows (Figure 2): (1) First year: baseline data collection and beginning of the program (September 2006), nine-month training (data collection June 2007), three-month detraining (data collection September 2007); (2) second year: nine-month training (data collection June 2008), three-month detraining (data collection September 2008); (3) third year: nine-month training (data collection June 2009), three-month detraining (data collection September 2009); (4) fourth year: nine-month training (data collection June 2010), three-month detraining (data collection September 2010); (5) fifth year: nine-month training (data collection June 2011, end of program).

The participants of the training groups did not perform any extra exercise or physical activity outside the program during the training period. In addition, after the completion of the exercise intervention programs, subjects in the exercise groups were instructed to carry out their usual daily activities throughout detraining and avoid any type of systematic exercise for the next three months. The women of the control group did not participate in any systematic exercise program and were asked to carry out their daily activities throughout the study.

Aerobic Training. The multicomponent AT program consisted of aerobic dance exercise, aerobic dance with fit-balls, and step training for 25 min, as well as abdominal and lower back strength exercises for 5 min. During the first two months, each training session included only floor aerobic exercises without an apparatus. Aerobic exercise with fit-balls was added during the third and fourth months, and step training was added after the fifth month. The height of the steps

Table 1 Anthropometric and Demographic Characteristics of the Different Exercise Groups and the Control Group at Baseline (Mean ± *SD*)

	Total (*N* = 42)	AT (*N* = 12)	ST (*N* = 10)	AS (*N* = 10)	CL (*N* = 10)
Anthropometric Characteristics					
Age (years)	64.3 ± 5.1	63.8 ± 5.6	62.1 ± 4.1	65.6 ± 4.9	66.2 ± 5.1
Age (range)	60–78	60–78	60–73	60–74	61–75
Body mass (kg)	76.8 ± 10.5	79.1 ± 9.9	77.16 ± 12.5	75.46 ± 9.5	75.3 ± 11.2
Height (cm)	160 ± 0.05	159 ± 0.07	159 ± 0.04	159 ± 0.07	160 ± 0.04
Body mass index (kg/m^2)	30.1 ± 4.4	31.09 ± 3.47	30.29 ± 5.4	29.73 ± 3.6	29.3 ± 5.3
Waist-to-hip ratio	0.85 ± 0.04	0.86 ± 0.06	0.85 ± 0.03	0.86 ± 0.04	0.83 ± 0.07
Body fat (%)	43.5 ± 4.7	44.55 ± 4.01	44.1 ± 5.1	42.8 ± 4.86	42.4 ± 5.47
Free fat mass (kg)	56.4 ± 4.7	55.44 ± 4.01	55.8 ± 5.1	57.1 ± 4.86	57.5 ± 5.45
Demographic Characteristics					
Type of residence					
Detached house	97.6%	91.7%	100%	100%	100%
Block of flats	2.4%	8.3%	–	–	–
Marital status					
Married	83.3%	83.3%	90%	80%	80%
Widowed	11.9%	8.3%	10%	20%	10%
Divorced and/or separated	4.8%	8.3%	–	–	10%
Education					
Level I (0–9 years of school)	95.2%	83.3%	100%	100%	100%
Level II (10–12 years of school)	–	–	–	–	–
Level III (> 12 years of school)	4.85%	16.7%	–	–	–
Financial status					
Moderate (< €500)	–	–	–	–	–
Good (€500–1,000)	75%	75%	60%	70%	100%
Very good (> €1,000)	25%	25%	40%	30%	–
Alcohol consumption	26.2%	25%	10%	40%	30%
Current smoking	11.9%	8.3%	30%	–	10%

Abbreviations: AT = aerobic training; ST = strength training; AS = combined aerobic and strength training; CL = control group.

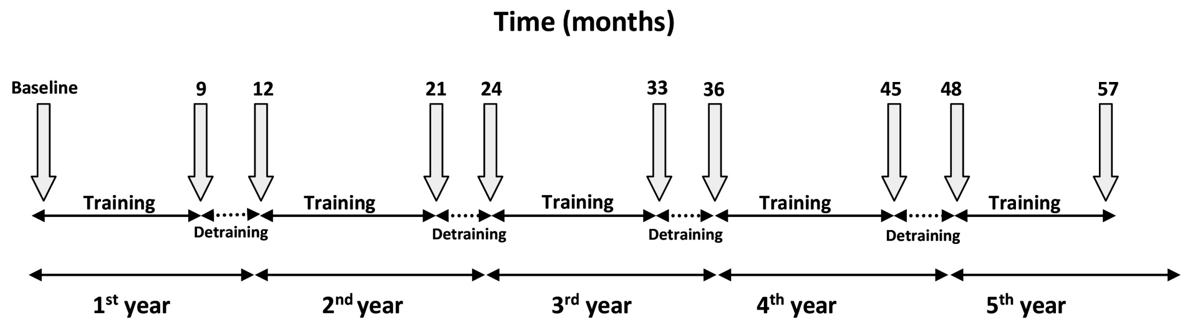

Figure 2 — Experimental design of the study (arrows denote the time points of measurement).

(10–15 cm) was adjusted according to the individual capabilities of the participants. After the aerobic session, participants performed three different abdominal and dorsal raise exercises (2–3 sets of 15–20 repetitions with 30 s rest). From the start until the end of each annual training period, exercise intensity increased gradually using a combination of exercises with more complicated steps. Exercise intensity during the training period ranged from 60% to 75% of the predicted maximum heart rate (maximum heart rate = 220 – age). It should be noted that although some strength exercises (abdominal and dorsal) were applied, more emphasis was given on aerobic exercise.

Strength Training. The multicomponent ST program included various exercises using body weight, exercise bands, gym sticks, and dumbbells. The annual training approach consisted of exercises using body weight the first month, bands the second month, 1-kg gym sticks the third month, and dumbbell exercises (1–2 kg for the upper limbs and 0.5–1 kg for the lower limbs) during the fourth through ninth months. During each training session, the participants performed six exercises (2–3 sets of 10–15 repetitions) for the upper body (e.g., modified push-ups, bicep curls, tricep extensions, lateral raises, overhead presses, modified peck-deck) and four exercises for the lower body (e.g., squats, lunges, hip extensions, toe raises). Thereafter, participants performed three different abdominal and dorsal raise exercises, similar to those described previously in the AT program (2–3 sets of 15–20 repetitions with 30 s rest).

Combined Aerobic and Strength Training. The AS program included a combination of aerobic and muscular strength training exercises. During the main activity, the participants performed 15 min of aerobic exercise with or without fitness balls and then three exercises for the upper body and three exercises for the lower using body weight, 1-kg gym sticks, and dumbbells (1–2 kg for the upper limbs and 0.5–1 kg for the lower limbs) for the next 15 min. The exercises and the portable apparatus used were alternated from session to session. At the end of each training session, the participants performed three different abdominal and dorsal raise exercises (2–3 sets of 15–20 repetitions with 30 s rest). The progress of the combined AS training program throughout each training period was similar to the one described previously for the AT and ST groups.

Measurements

Anthropometric Characteristics. Standing height was measured to the nearest 1.0 cm using a stadiometer (model 220; Seca, Hamburg, Germany). Body mass was measured to the nearest 0.1 kg using an electronic digital scale (model 770; Seca, Hamburg, Germany) with the subjects wearing light clothing. Body mass index (BMI) was calculated from weight (kg) divided by height squared (m^2).

A flexible tape was used to measure waist circumference midway between the lower rib margin and the iliac crest and hip circumference at the widest point of the buttocks. The circumferences were measured to the nearest 1 mm in standing position. The waist circumference was divided by the hip circumference to determine the waist-to-hip ratio (WHR).

Body composition was measured using bioelectrical impedance (Bodystat 1500; Bodystat, Douglas, Isle of Man, United Kingdom) to determine percentage body fat (BF) and fat free mass (FFM). Measurements were performed on the right side while the subject was supine and with the limbs slightly apart from the trunk. Two electrodes were placed on the dorsal surfaces of the right hand and foot, across the distal ends of the metacarpals and metatarsals, respectively, and two electrodes between the radius and ulna, on the wrist between the medial and lateral styloid process and on the ankle between the medial and lateral malleoli. The same examiner performed all measurements in the morning. The subjects were given instructions to undertake the measurement in a state of normal hydration (no exercise or alcohol/caffeine consumption in the preceding 12 hr and no eating or drinking in the preceding 4–5 hr were allowed). The machine reliability was set within 0.2% of a standard resistor (500 ohms) (Meeuwsen, Horgan, & Elia, 2010) and the intraobserver precision was < 1% under the standard conditions (Ghosh, Meister, Cowen, Hannan, & Ferguson, 1997) that were used in the current study.

Physical Fitness and Functional Ability Tests. Specific measurements (curl-ups, modified shoulder press, chair stand test, modified step test) were used to evaluate muscular fitness. Curl-ups and the shoulder press were used to evaluate upper body functional ability, whereas the chair stand and step test were applied for lower body functional ability. Before testing, the participants were familiarized with all testing procedures.

Curl-Up Test. The endurance of the abdominal muscles was assessed with the curl-up test. The participants laid on the mat with the knees bent, feet flat on the floor, and hands resting on the thighs. During the curl-up performance, hands slid up to the thighs until the fingertips touched the knee caps and then returned to the starting position. The feet touched the floor throughout the execution of the test. The curl-up test was performed as fast as possible for 30 s, and the number of repetitions was recorded (Faulkner, Springs, & McQuarrie, 1989).

Modified Shoulder Press. During the modified shoulder press, the participant sat on a chair, grasped a 1-kg bar with an overhand grip with hands about shoulder-width apart, and brought the bar across the upper chest. Then, the subjects lifted the bar vertically and back to the starting position as many times as possible for 30 s. The number of repetitions was recorded to evaluate the mobility of the arms using a multijoint movement.

Chair Stand Test. The chair stand test was used to assess the functional ability of the lower limbs. The participants sat as far back as possible in the chair seat and kept their feet firmly planted on the floor approximately hip width apart with the back of their lower legs away from the chair. The knees were bent at a 90° angle and the arms were crossed over the chest. The subjects stood up and sat down, returning to the correct starting position. This action was repeated as quickly as possible for 30 s and the number of repetitions was recorded (Jones, Rikli, & Beam, 1999).

Modified Step Test. A modified step test was applied to measure the functional endurance strength of the lower limbs (Danneskiold-Samsøe et al., 1984). Each subject stepped up and down on the platform (height 30 cm) as fast as possible for 30 s. The number of successful attempts was recorded and used in the analysis.

Statistical Analysis

All data were analyzed using the SPSS version 10.0 for Windows (IBM Inc., Chicago, IL). A one-way analysis of variance with repeated measures was used for each variable to examine differences between time points in each group. The Holm-Bonferroni correction was used to control type I error. Two-way (group × time point) multivariate analysis of covariance (MANCOVAs), using initial values as covariate, were applied for the analysis of anthropometric characteristics and the functional ability variables, followed by two-way (group × time point) univariate ANCOVAs to determine the differences between groups at each time point. The slope of linear regressions applied during each training and detraining period was used to determine the rate of change in the measured variables during each period. Thereafter, two-way multivariate analysis of variance (MANOVA) was applied for the analysis of the anthropometric characteristics and the functional ability variables followed by univariate two-way analysis of variance (group × training period) with repeated measures in the second factor to determine the differences between the groups and the training periods in the rate of change. Whenever appropriate, the Tukey post hoc test was applied to locate the differences between the means. The accepted level of significance was set at $p < .05$. The effect sizes were calculated using Cohen's *d* (*d* = difference between means ÷ pooled *SD*) for pairwise comparisons. The small, medium, and large effects were reflected in Cohen's *d* values greater than 0.2, 0.5, and 0.8, respectively (Cohen, 1988).

Results

In the current study, 118 women were willing to participate by responding to the advertised invitation. Although 80 appeared in the first meeting, a total of 63 fulfilled the criteria and were divided into four groups according to the area of residence, and a total of 42 completed the five-year follow up (Figure 1). No significant differences were observed among groups when assessing baseline demographic variables, anthropometric characteristics (Table 1), and functional ability tests. The exercise program was safe and well-accepted by the participants, with an adequate rate of attendance (ranging from 83% to 88%) and with no complaints about exercise intensity. The results presented in Figure 3, Figure 4, and Figure 5 illustrate adjusted means following the ANCOVA analysis and depict the statistical differences among groups during the program. Table 2 and Table 3 present the data (mean ± *SD*) and statistical differences among different time points within each group throughout the five-year follow-up.

Anthropometric Characteristics

The MANCOVA analysis, using anthropometric characteristics, revealed a significant ($p = .002$) interaction effect between the factors of group and time point. Similarly, a significant interaction effect was observed with the MANOVA on the rate of changes of the variables during training ($p = .001$) and detraining ($p = .026$).

Body Fat. Between baseline and the five-year follow up, percentage of BF in the ST group decreased from 44.1–40.1% (*d*: –0.88, $p < .05$) and from 44.5–42.3% in the AT group (*d*: –0.55), whereas it increased in the control group (*d*: 0.54, $p < .05$) from 42.4–45.4% (Table 2). The AT and ST groups had lower ($p < .05$) BF fat than the CL group after the first training year and throughout the study (AT vs. CL *d*: 0.04 to –0.68; ST vs. CL *d*: –0.09 to –1.19). In addition, the ST group had lower BF from the other two training groups after the second training year and until the end of the study (ST vs. AT *d*: 0.04 to –0.68; ST vs. AS *d*: –0.09 to –1.19) (Figure 3ii).

The rate of decrease or increase of BF percentage was not different ($p > .05$) during training and detraining in the exercise groups. No systematic differences were observed among groups in rate of BF change during training and detraining ($p > .05$; Table 4).

Fat Free Mass. FFM increased from 55.8 to 59.8 kg ($p < .05$, *d*: 0.88) in the ST group and from 55.4 to 57.6 kg in the AT group ($p < .05$, *d*: 0.55), while there was a progressive but not significant decrease from 57.5 to 53.3 kg in the control group (*d*: –0.77) during the five-year period (Table 2). The ST group had higher FFM than the CL group after the second year of training and until the end of the follow-up (*d*: 0.28–1.49). Furthermore, the CL group had a lower FFM from all training groups after the fourth year of training (*d*: 0.23–1.49; Figure 3iii).

No significant differences ($p > .05$) were found in the rate of change of FFM during training and detraining. In addition, no systematic differences were found among groups in the rate of change of FFM ($p > .05$; Table 4).

Body Mass Index. BMI did not change significantly during the five-year period for the training groups (AT *d*: –0.33; ST *d*: –0.27; AS *d*: –0.12; Table 2), while it increased from 29.3 to 31.3 kg/m^2 in the CL group (*d*: 0.35, $p < .05$). The CL group had higher BMI than all training groups after the second year of training and until the end of the five-year follow-up period (AT vs. CL *d*: 0.13 to –0.3; ST vs. CL *d*: –0.2 to –0.48; AS vs. CL *d*: –0.05 to –0.41). Furthermore, the BMI of the ST group was lower ($p < .05$) than the AS group after the second training period and remained lower until the end of the study (*d*: –0.18 to –0.09; Figure 3i).

No significant differences ($p > .05$) were found in the rate of change of BMI among the training periods or the detraining periods in all groups. The rate of change in the CL group during the training periods was positive, and differed ($p < .05$) in most periods from that observed in the exercise groups where it was negative. No differences were found among groups in the rate of change of BMI during the detraining periods ($p > .05$; Table 4).

Waist-to-Hip Ratio. A marginal (but not significant) decrease was observed in WHR during the five-year period for the training groups (AT *d*: –0.29; ST *d*: –0.33; AS *d*: –0.24). On the contrary, WHR increased significantly from 0.83 to 0.86 in the CL group (*d*: 0.43, $p = .02$). The AT and the AS groups had lower WHR values ($p < .05$) than the CL group throughout the follow-up period (AT

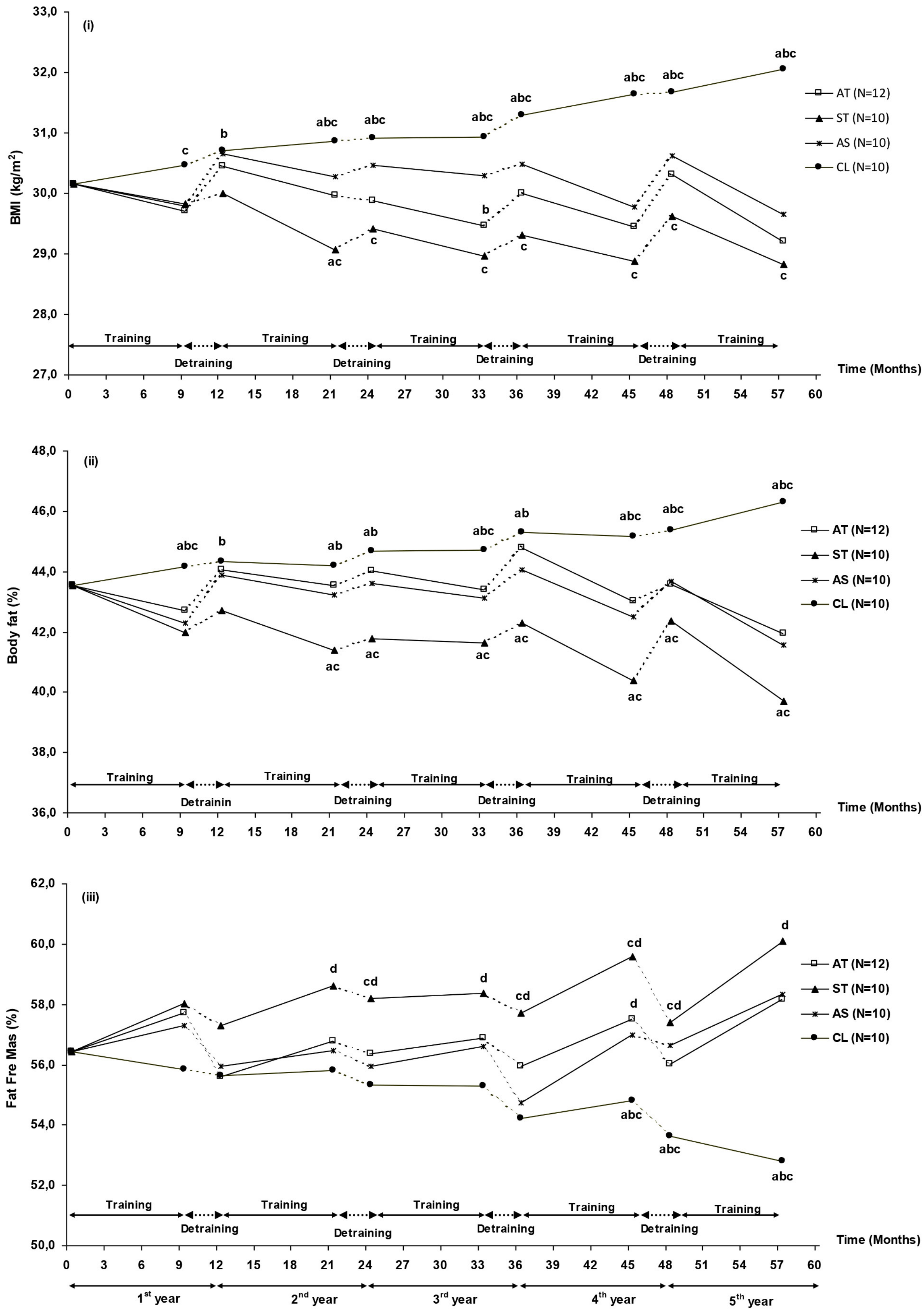

Figure 3 — Adjusted means of body mass index (BMI) (i), body fat (ii), and fat free mass (iii), using the initial values in each variable as covariate, over the five-year intervention period and between-group differences at each time point. Note: Error bars are omitted for clarity. AT = aerobic training; ST = strength training; AS = combined aerobic and strength training; CL = control group. a = $p < .05$ from AT group; b = $p < .05$ from ST group; c = $p < .05$ from AS group; d = $p < .05$ from CL group.

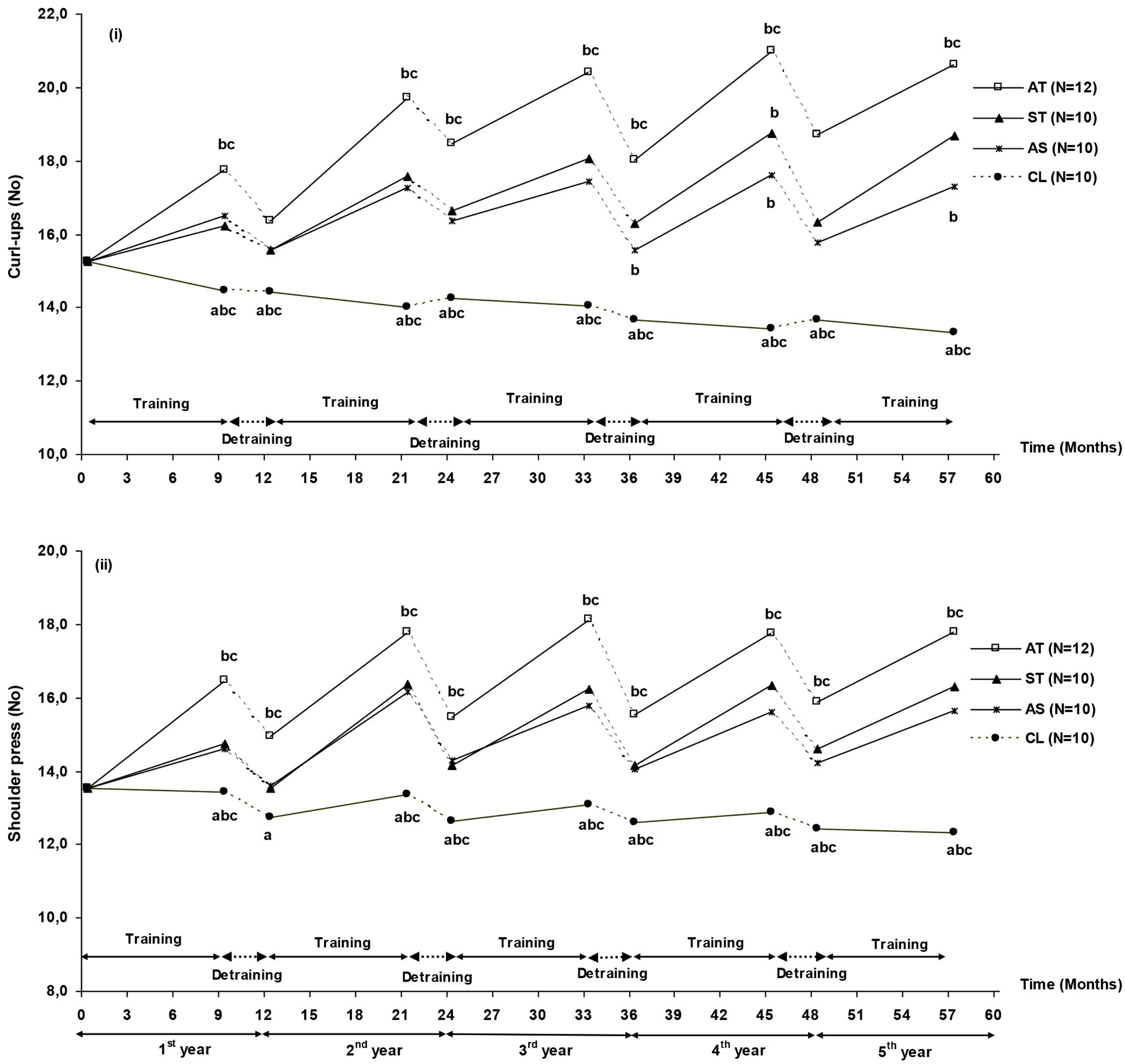

Figure 4 — Adjusted means of curls-ups (i) and shoulder press (ii), using the initial values in each variable as covariate, over the five-year intervention period and between-group differences at each time point. Note: Error bars are omitted for clarity. AT = aerobic training; ST = strength training; AS = combined aerobic and strength training; CL = control group. a = $p < .05$ from AT group; b = p < .05 from ST group; c = $p < .05$ from AS group; d = $p < .05$ from CL group.

vs. CL *d*: 0.45 to –0.25); AS vs. CL *d*: 0.6 to –0.08). The ST group showed lower values ($p < .05$) than the CL group after each training period (*d*: 0.23 to –0.49; Table 2).

The rate of change of WHR was not different ($p > .05$) among the training or the detraining periods for all groups. No systematic differences were observed among groups in WHR rate of change during training and detraining ($p > .05$; Table 4).

Physical Fitness and Functional Ability

The MANCOVA analysis used the values of fitness and functional ability and showed a significant ($p = .002$) interaction effect between the factors of group and time point. Moreover, a significant interaction effect was observed with the MANOVA analysis on the rates of change of performance during training ($p = .001$) and detraining ($p = .028$).

Curl-Ups. The number of curl-ups in 30 s increased from 14.3 to 20.0 repetitions five years later in the AT group ($p < .05$, *d*: 1.66). The ST group improved performance after each training period and reached a value of 17.9 repetitions at the end compared with 10.2 repetitions at baseline (*d*: 1.42). The AS group did not show significant improvement although it increased the number of repetitions performed after each training period (*d*: 0.51). The CL group showed a progressive decrease in the curl-ups test during the five-year follow-up period from 16.6 repetitions at baseline to

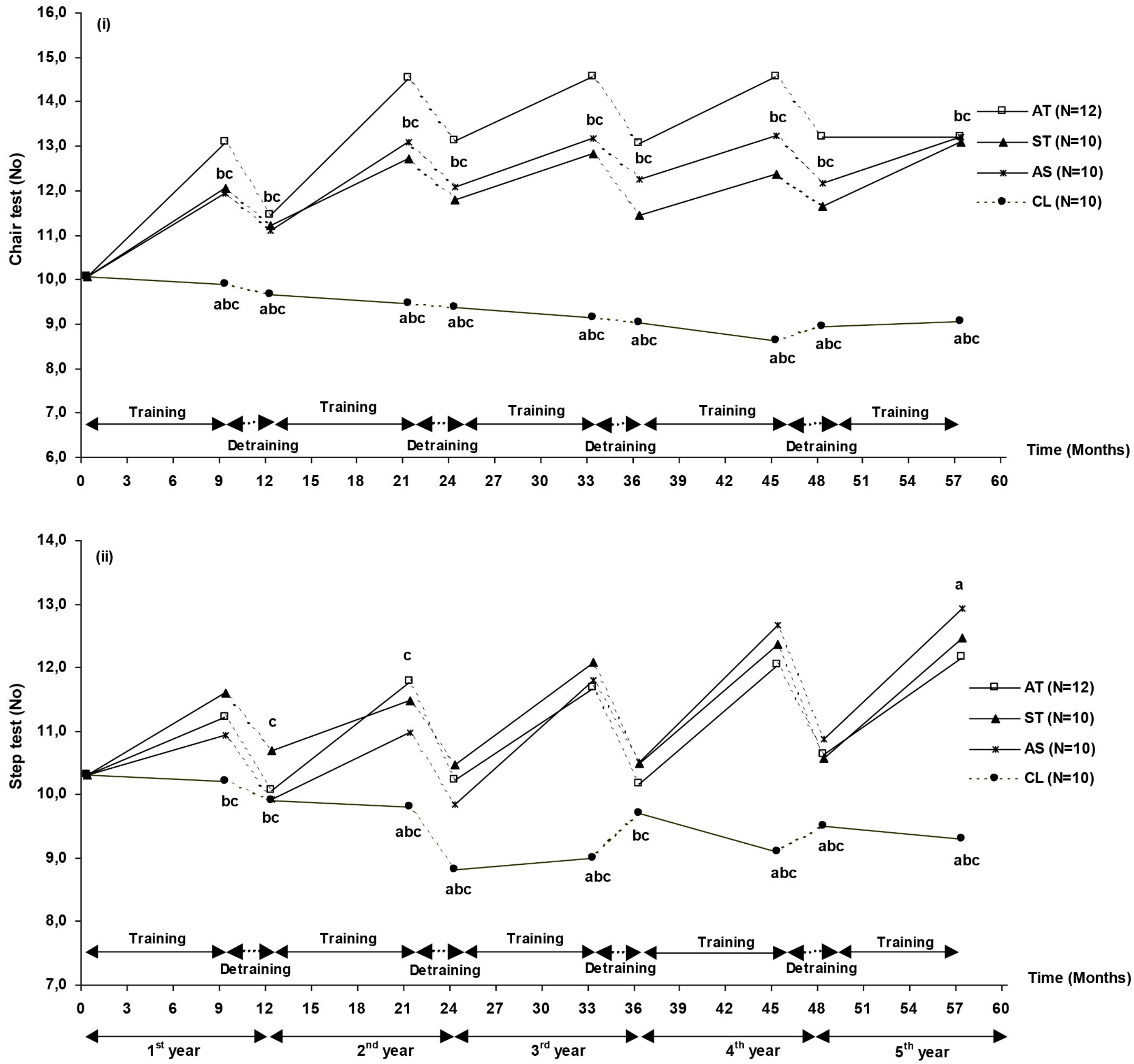

Figure 5 — Adjusted means of the chair test (i) and step test (ii), using the initial values in each variable as covariate, over the five-year intervention period and between-group differences at each time point. Note: Error bars are omitted for clarity. AT = aerobic training; ST = strength training; AS = combined aerobic and strength training; CL = control group. a = $p < .05$ from AT group; b = $p < .05$ from ST group; c = p < .05 from AS group; d = $p < .05$ from CL group.

14.1 repetitions at the end (*d*: –0.81; Table 3). All training groups performed better in the curl-ups test after the first training year and during the whole five-year follow-up period than the CL group (AT vs. CL *d*: 0.38 to 2.29; ST vs. CL *d*: –0.17 to 1.31; AS vs. CL *d*: 0.65 to 1.35). Furthermore, the AT group was better during the study period than the ST (*d*: 0.13 to 0.73) and the AS (*d*: –0.53 to 0.75) groups (Figure 4i).

No systematic differences ($p > .05$) were found in the rate of change of curl-up repetitions among the training or the detraining periods in all groups. The rate of change in the CL group during the training periods was negative and differed ($p < .05$) in all periods from the rate of change observed in the training groups where it was positive. During the third and the fourth detraining periods, the rate of decrease in curl-up performance was lower in the CL group compared with the training groups ($p < .05$; Table 5).

Modified Shoulder Press. The AT group improved performance in the shoulder press test from 13 repetitions to 17.5 repetitions ($p < .05$, *d*: 2.21) and showed consistently higher values compared with baseline, even after the detraining periods. The ST group improved performance from 14.2 to 16.6 repetitions (*d*: 1.09), and the AS group from 12.8 to 15.3 repetitions (*d*: 0.93). Both groups performed better at the end of the study compared with baseline by 16.9% and 19.53%, respectively. The CL group showed a progressive decrease

Table 2 Results of Body Composition After Training, Detraining, and Retraining (Mean ± *SD*)

		First Year		Second Year		Third Year		Fourth Year		Fifth Year
	Baseline	Training 9 Months	Detraining 12 Months	Training 21 Months	Detraining 24 Months	Training 33 Months	Detraining 36 Months	Training 45 Months	Detraining 48 Months	Training 57 Months
Body mass (kg)										
AT (*N* = 12)	79.1 ± 2.8	77.9 ± 2.9	79.7 ± 3.0	78.3 ± 2.8	78.4 ± 2.5	77.0 ± 2.4	78.4 ± 2.6	76.8 ± 2.4	79.3 ± 2.6	76.4 ± 2.7
ST (*N* = 10)	77.1 ± 3.9	76.3 ± 3.8	76.8 ± 3.4	74.5 ± 3.2	75.6 ± 3.1	74.1 ± 3.2	75.1 ± 3.1	74.0 ± 3.2	75.9 ± 3.1	73.8 ± 3.1
AS (*N* = 10)	75.4 ± 3.0	74.5 ± 3.0	76.8 ± 3.0[b]	76.0 ± 3.2	76.6 ± 3.1	76.0 ± 3.0	76.5 ± 3.2[c]	74.8 ± 3.2	76.7 ± 3.2[h]	74.2 ± 3.0
CL (*N* = 10)	75.3 ± 3.5	76.1 ± 3.5	76.8 ± 3.5[a]	77.4 ± 3.6[a]	77.7 ± 3.7[a]	77.7 ± 3.6[a,b]	78.6 ± 3.7[a,c]	79.5 ± 3.7[a,b,d,f]	80.1 ± 3.6[a,c,e,g]	80.5 ± 3.7[a,b,d,f]
BMI (kg/m^2)										
AT (*N* = 12)	31.0 ± 1.0	30.6 ± 1.0	31.3 ± 1.0	30.7 ± 0.8	30.6 ± 0.7	30.2 ± 0.7	30.7 ± 0.8	30.2 ± 0.8	31.0 ± 0.8	29.9 ± 0.8
ST (*N* = 10)	30.2 ± 1.7	29.9 ± 1.6	30.1 ± 1.4	29.1 ± 1.2	29.5 ± 1.1	29.0 ± 1.1	29.4 ± 1.2	28.9 ± 1.2	29.7 ± 1.1	28.9 ± 1.1
AS (*N* = 10)	29.7 ± 1.1	29.3 ± 1.1	30.2 ± 1.1[b]	29.9 ± 1.1	30.1 ± 1.1	29.9 ± 1.1	30.1 ± 1.1	29.4 ± 1.1	30.2 ± 1.1[h]	29.2 ± 1.1[i]
CL (*N* = 10)	29.3 ± 1.6	29.6 ± 1.67	29.9 ± 1.6[a]	30.1 ± 1.6[a]	30.2 ± 1.6[a]	30.2 ± 1.7[a,b]	30.6 ± 1.7[a,c]	30.9 ± 1.7[a,b,d,f]	30.9 ± 1.7[a,c,e]	31.3 ± 1.7[a,b,d,f]
Waist-hip ratio										
AT (*N* = 12)	0.86 ± 0.01	0.84 ± 0.01[a]	0.85 ± 0.01	0.85 ± 0.01	0.85 ± 0.01	0.84 ± 0.01	0.86 ± 0.01	0.85 ± 0.01	0.86 ± 0.01	0.84 ± 0.01[a]
ST (*N* = 10)	0.85 ± 0.01	0.85 ± 0.01	0.85 ± 0.01	0.84 ± 0.01	0.85 ± 0.01	0.85 ± 0.01	0.85 ± 0.00	0.84 ± 0.01	0.85 ± 0.01	0.83 ± 0.00[i]
AS (*N* = 10)	0.86 ± 0.01	0.86 ± 0.01	0.87 ± 0.01	0.86 ± 0.01	0.86 ± 0.01	0.86 ± 0.01	0.86 ± 0.01	0.85 ± 0.01	0.86 ± 0.01	0.85 ± 0.01
CL (*N* = 10)	0.83 ± 0.01	0.84 ± 0.01	0.84 ± 0.01	0.84 ± 0.01	0.84 ± 0.01	0.85 ± 0.01[a]	0.85 ± 0.01[a]	0.85 ± 0.01[a]	0.85 ± 0.01[a,c]	0.86 ± 0.01[a,b,d]
Body fat (%)										
AT (*N* = 12)	44.5 ± 1.1	43.2 ± 1.3	45.2 ± 1.0[b]	44.0 ± 1.1	44.4 ± 1.0	43.9 ± 0.9	44.9 ± 1.1	43.2 ± 1.0	44.4 ± 0.9	42.3 ± 1.0[a,i]
ST (*N* = 10)	44.1 ± 1.6	42.5 ± 1.5	43.2 ± 1.2	41.8 ± 1.1[a]	42.2 ± 1.0	42.1 ± 1.0[a]	42.7 ± 1.1	40.8 ± 1.0[a]	42.8 ± 1.0	40.1 ± 0.9[a,i]
AS (*N* = 10)	42.8 ± 1.5	42.0 ± 1.4	43.4 ± 1.5	42.9 ± 1.6	43.4 ± 1.5	42.8 ± 1.6	45.2 ± 2.1	42.4 ± 1.4[g]	43.0 ± 1.4	41.4 ± 1.5
CL (*N* = 10)	42.4 ± 1.7	43.0 ± 1.6	43.4 ± 1.6	43.2 ± 1.7	43.7 ± 1.6[a]	43.8 ± 1.6	44.3 ± 1.6[a]	44.3 ± 1.5[a,b]	44.5 ± 1.5[a,c]	45.4 ± 1.5[a,b,d,f,h]
FFM (kg)										
AT (*N* = 12)	55.4 ± 1.1	56.7 ± 1.3	54.7 ± 1.0[b]	55.9 ± 1.1	55.5 ± 1.0	56.0 ± 0.9	55.1 ± 1.1	56.7 ± 1.0	55.5 ± 0.9	57.6 ± 1.0[a,i]
ST (*N* = 10)	55.8 ± 1.6	57.4 ± 1.5	56.8 ± 1.2	58.1 ± 1.1[a]	57.7 ± 1.0	57.8 ± 1.0[a]	57.2 ± 1.1	59.1 ± 1.0[a]	57.1 ± 1.0[h]	59.8 ± 0.9[a,b,i]
AS (*N* = 10)	57.1 ± 1.5	57.9 ± 1.4	56.5 ± 1.5	57.0 ± 1.6	56.5 ± 1.5	57.1 ± 1.6	54.7 ± 2.1	57.5 ± 1.4[g]	56.9 ± 1.4	58.6 ± 1.5
CL (*N* = 10)	57.5 ± 1.7	56.9 ± 1.6	56.6 ± 1.6	56.7 ± 1.7	56.2 ± 1.6	56.1 ± 1.6	55.6 ± 1.6	55.6 ± 1.5	54.1 ± 1.6	53.3 ± 1.5

Abbreviations: AT = aerobic training; ST = strength training; AS = combined aerobic and strength training; CL = control group; BMI = body mass index; FFM = fat free mass.

$p < .05$ significant differences: [a] baseline; [b] 9 months; [c] 12 months; [d] 21 months; [e] 24 months; [f] 33 months; [g] 36 months; [h] 45 months; [I] 48 months; [j] 57 months.

Table 3 Results of Muscle Strength and Functional Ability After Training, Detraining, and Retraining (Mean ± *SD*)

		First Year		Second Year		Third Year		Fourth Year		Fifth Year
	Baseline	Training 9 Months	Detraining 12 Months	Training 21 Months	Detraining 24 Months	Training 33 Months	Detraining 36 Months	Training 45 Months	Detraining 48 Months	Training 57 Months
Curl-ups (No)										
AT (*N* = 12)	14.3 ± 1.1	17 ± 1.1[a]	15.6 ± 0.8[a,b]	19 ± 1.1[ab]	17.8 ± 0.9[a]	19.8 ± 0.9[a,b,e]	17.4 ± 0.7[a,f]	20.4 ± 0.8[a,b,d,g]	18.0 ± 0.8[a,h]	20.0 ± 0.7[a,b,i]
ST (*N* = 10)	13.9 ± 0.6	15.1 ± 0.9	14.5 ± 0.8	16.5 ± 1.0[a,c]	15.7 ± 0.6	17.2 ± 0.9[a,b]	15.4 ± 0.6	17.9 ± 0.8[a,b,g]	15.4 ± 0.8[h]	17.9 ± 0.9[a,b,i]
AS (*N* = 10)	16.3 ± 0.9	17.4 ± 0.8	16.4 ± 0.8	18.1 ± 0.8	17.1 ± 0.7	18.1 ± 0.8	16.3 ± 0.8	18.3 ± 1.0[a,g]	16.5 ± 0.7	17.9 ± 0.9
CL (*N* = 10)	16.6 ± 1.0	15.6 ± 0.8	15.5 ± 0.9	15.1 ± 0.9[a]	15.2 ± 0.8[a]	14.9 ± 0.7[a]	14.6 ± 0.8[a]	14.3 ± 0.8[a,b]	14.6 ± 0.8[a]	14.1 ± 0.7[a,j]
Step test (No)										
AT (*N* = 12)	10.7 ± 0.4	11.5 ± 0.3[a]	10.4 ± 0.3[b]	12.0 ± 0.2[a,c]	10.5 ± 0.3[d]	12 ± 0.3[a,e]	10.5 ± 0.3[f]	12.3 ± 0.3[a,b,g]	10.9 ± 0.3[h]	12.4 ± 0.2[a,b,i]
ST (*N* = 10)	10.2 ± 0.3	11.5 ± 0.3[a]	10.6 ± 0.3	11.4 ± 0.4[a]	10.4 ± 0.3[d]	12 ± 0.4[a,e]	10.4 ± 0.3[f]	12.3 ± 0.3[a,g]	10.5 ± 0.3[h]	12.4 ± 0.3[a,d,i]
AS (*N* = 10)	9.9 ± 0.5	10.6 ± 0.6	9.6 ± 0.5	10.7 ± 0.5	9.6 ± 0.3	11.5 ± 0.4[a,e]	10.2 ± 0.5[a,b,d,g]	12.4 ± 0.4	10.6 ± 0.5[h]	12.7 ± 0.6[a,b,d,i]
CL (*N* = 10)	10.3 ± 0.4	10.2 ± 0.3	9.9 ± 0.3	9.8 ± 0.4	8.8 ± 0.4[a,c,d]	9 ± 0.4	9.7 ± 0.4	9.1 ± 0.3[a,b]	9.5 ± 0.3	9.3 ± 0.2[a,b]
Chair test (No)										
AT (*N* = 12)	9.6 ± 0.4	11.6 ± 0.7[a]	10.8 ± 0.6	12.8 ± 0.9[a,c]	11.8 ± 0.6[a]	12.9 ± 0.9[a,b]	12 ± 0.7[a]	13 ± 0.8[a,b]	11.9 ± 0.6[a]	12.9 ± 0.9[a,b]
ST (*N* = 10)	10.5 ± 0.5	12.4 ± 0.4[a]	11.5 ± 0.3	13 ± 0.6[a]	12.1 ± 0.6	13.1 ± 0.7[a]	11.7 ± 0.7	12.6 ± 1.0[a]	11.9 ± 0.6	13.4 ± 0.6[a]
AS (*N* = 10)	10.2 ± 0.5	13.2 ± 0.5[a]	11.5 ± 0.5[a,b]	14.6 ± 0.5[a,b,c]	13.2 ± 0.5[a,c,d]	14.6 ± 0.5[a,b,f]	13.1 ± 0.4[a,c,f]	14.6 ± 0.5[a,b,g]	13.3 ± 0.5[a,c,h]	14.5 ± 0.5[a,b,i]
CL (*N* = 10)	9.8 ± 0.2	9.7 ± 0.1	9.5 ± 0.1	9.3 ± 0.1	9.2 ± 0.2	9 ± 0.2	8.9 ± 0.2[a]	8.5 ± 0.2[a,b]	8.8 ± 0.2[a]	8.9 ± 0.2[a]
Shoulder press (No)										
AT (*N* = 12)	13.0 ± 0.5	16.0 ± 0.6[a]	14.5 ± 0.4[a,b]	17.5 ± 0.5[a,b,c]	15.1 ± 0.5[a,d]	17.9 ± 0.5[a,b,e]	15.3 ± 0.4[a,f]	17.5 ± 0.5[a,b,g]	15.6 ± 0.4[a,c,h]	17.5 ± 0.5[a,b,i]
ST (*N* = 10)	14.2 ± 0.3	15.3 ± 0.5	14.1 ± 0.2	16.8 ± 0.6[a,c]	14.6 ± 0.3[d]	16.6 ± 0.6[a,e]	14.5 ± 0.4[f]	16.6 ± 0.8[a,g]	14.9 ± 0.6	16.6 ± 0.8[a]
AS (*N* = 10)	12.8 ± 0.7	14 ± 0.7	13 ± 0.8	15.7 ± 0.7[a,c]	13.8 ± 0.6[d]	15.4 ± 0.7[a]	13.7 ± 0.5	15.3 ± 0.8[a]	13.9 ± 0.6	15.3 ± 0.8[a]
CL (*N* = 10)	14.1 ± 0.6	13.9 ± 0.5	13.2 ± 0.5	13.7 ± 0.8	13 ± 0.5	13.4 ± 0.7	12.9 ± 0.5	13.1 ± 0.6	12.7 ± 0.5	12.6 ± 0.7[a]

Abbreviations: AT = aerobic training; ST = strength training; AS = combined aerobic and strength training; CL = control group.

$p < .05$ significant differences: [a] baseline; [b] 9 months; [c] 12 months; [d] 21 months; [e] 24 months; [f] 33 months; [g] 36 months; [h] 45 months; [I] 48 months; [j] 57 months.

Table 4 Rate of Changes per Month in Anthropometric Characteristics During Each Training and Detraining Phase (Mean ± *SD*)

	Training					Detraining			
	First Year	Second Year	Third Year	Fourth Year	Fifth Year	First Year	Second Year	Third Year	Fourth Year
Body mass (kg/month)									
AT (*N* = 12)	–0.13 ± 0.14	–0.15 ± 0.32	–0.15 ± 0.14	–0.17 ± 0.15	–0.32 ± 0.16	0.59 ± 0.47[#]	0.01 ± 0.60[#]	0.46 ± 0.64	0.81 ± 0.58[d]
ST (*N* = 10)	–0.09 ± 0.12	–0.25 ± 0.34	–0.16 ± 0.12	–0.12 ± 0.09	–0.23 ± 0.05	0.17 ± 0.95[c]	0.38 ± 0.25	0.31 ± 0.31	0.62 ± 0.46
AS (*N* = 10)	–0.09 ± 0.10	–0.08 ± 0.14	–0.05 ± 0.09	–0.19 ± 0.15	–0.27 ± 0.21	0.74 ± 0.33[#]	0.18 ± 0.25[#]	0.15 ± 0.48	0.66 ± 0.48[#]
CL (*N* = 10)	0.08 ± 0.06[a,b,c]	0.06 ± 0.10[a,b,c]	–0.001 ± 0.11	0.09 ± 0.07[a,b,c]	0.04 ± 0.13[a,b,c]	0.24 ± 0.30	0.09 ± 0.20	0.30 ± 0.32	0.21 ± 0.36
BMI ([kg/m^2]/month)									
AT (*N* = 12)	–0.052 ± 0.05	–0.06 ± 0.12	–0.04 ± 0.05	–0.06 ± 0.05	–0.12 ± 0.05	0.23 ± 0.17	–0.04 ± 0.24	0.18 ± 0.24	0.28 ± 0.21
ST (*N* = 10)	-0.03 ± 0.05	–0.10 ± 0.14	–0.04 ± 0.04	–0.04 ± 0.03	–0.08 ± 0.02	0.05 ± 0.39	0.11 ± 0.10	0.11 ± 0.12	0.24 ± 0.18
AS (*N* = 10)	-0.04 ± 0.04	–0.03 ± 0.04	–0.01 ± 0.03	–0.08 ± 0.05	–0.10 ± 0.08	0.29 ± 0.13	0.07 ± 0.08	0.06 ± 0.18	0.28 ± 0.19
CL (*N* = 10)	0.03 ± 0.02[a,c]	0.02 ± 0.04[a,b]	0.001 ± 0.04	0.03 ± 0.03[a,b,c]	0.04 ± 0.03[a,b,c]	0.09 ± 0.12	0.03 ± 0.05	0.11 ± 0.13	0.01 ± 0.08
Waist hip ratio (cm/month)									
AT (*N* = 12)	–0.0021 ± 0.0028[b,d]	–0.0005 ± 0.0019	–0.0009 ± 0.0009	–0.0015 ± 0.0011	–0.0018 ± 0.0007	0.0044 ± 0.0050	0.0008 ± 0.0038	0.0053 ± 0.0041[d]	0.0039 ± 0.0031
ST (*N* = 10)	0.0004 ± 0.0011[a]	–0.0011 ± 0.0015	–0.0002 ± 0.0015	–0.0014 ± 0.0013	–0.0020 ± 0.0014	0.0013 ± 0.0028[a]	0.0020 ± 0.0059	0.0003 ± 0.0048	0.0053 ± 0.0053[d]
AS (*N* = 10)	–0.0002 ± 0.0005[d]	–0.0007 ± 0.0017	–0.0002 ± 0.0011	–0.0013 ± 0.0009	–0.0009 ± 0.0014	0.0013 ± 0.0023[a]	0.0003 ± 0.0046	0.0013 ± 0.0045	0.0033 ± 0.0031
CL (*N* = 10)	0.0008 ± 0.0012	0.0002 ± 0.0007	0.0008 ± 0.0007	0.0003 ± 0.0005[b]	0.0003 ± 0.0005	0.0000 ± 0.0035[a]	0.0000 ± 0.0022	–0.0003 ± 0.0019	0.0007 ± 0.0014
Body fat (%/month)									
AT (*N* = 12)	–0.14 ± 0.11	–0.13 ± 0.18	–0.06 ± 0.14	–0.18 ± 0.10	–0.23 ± 0.12	0.66 ± 0.76	0.12 ± 0.43	0.33 ± 0.47	0.39 ± 0.49
ST (*N* = 10)	–0.18 ± 0.19	–0.15 ± 0.15	–0.02 ± 0.16	–0.21 ± 0.14	–0.29 ± 0.10	0.21 ± 0.49	0.13 ± 0.57	0.22 ± 0.38	0.64 ± 0.44
AS (*N* = 10)	–0.09 ± 0.09	–0.06 ± 0.10	–0.07 ± 0.11	–0.30 ± 0.45	–0.18 ± 0.21	0.48 ± 0.37	0.18 ± 0.56	0.79 ± 1.65	0.19 ± 0.31
CL (*N* = 10)	0.07 ± 0.05[a,b]	–0.02 ± 0.09	0.00 ± 0.07	–0.01 ± 0.13	0.10 ± 0.05	0.11 ± 0.16	0.18 ± 0.45	0.18 ± 0.25	0.07 ± 0.29
Fat free mass (kg/month)									
AT (*N* = 12)	0.14 ± 0.11	–0.66 ± 0.76	0.13 ± 0.18	–0.12 ± 0.43	0.06 ± 0.14	–0.33 ± 0.47	0.18 ± 0.10	–0.39 ± 0.49	0.23 ± 0.12
ST (*N* = 10)	0.18 ± 0.19	–0.21 ± 0.49	0.15 ± 0.15	–0.13 ± 0.57	0.02 ± 0.16	–0.22 ± 0.38	0.21 ± 0.14	–0.66 ± 0.42	0.30 ± 0.10
AS (*N* = 10)	0.09 ± 0.09	–0.48 ± 0.37	0.06 ± 0.10	–0.18 ± 0.56	0.07 ± 0.11	–0.79 ± 1.65	0.30 ± 0.45	–0.19 ± 0.31	0.19 ± 0.22
CL (*N* = 10)	–0.07 ± 0.05[a,b]	–0.11 ± 0.16	0.02 ± 0.09	–0.18 ± 0.45	0.00 ± 0.07[a,b,c]	–0.18 ± 0.25	0.01 ± 0.13	–0.04 ± 1.12	–0.11 ± 0.10

Abbreviations: AT = aerobic training; ST = strength training; AS = combined aerobic and strength training; CL = control group; BMI = body mass index.

[#] $p < .05$ from previous point; [a] $p < .05$ from AT group; [b] $p < .05$ from ST group; [c] $p < .05$ from AS group; [d] $p < .05$ from CL group.

Table 5 Rate of Changes per Month in Functional Performance Tests During Each Training and Detraining Phase (Mean ± *SD*)

	Training					Detraining			
	First Year	Second Year	Third Year	Fourth Year	Fifth Year	First Year	Second Year	Third Year	Fourth Year
Curl-ups (no/month)									
AT (*N* = 12)	0.30 ± 0.14[#]	0.37 ± 0.13	0.22 ± 0.08[#]	0.33 ± 0.07	0.22 ± 0.08	–0.44 ± 0.43[#,d]	–0.39 ± 0.34[d]	–0.81 ± 0.33	–0.78 ± 0.16
ST (*N* = 10)	0.13 ± 0.21[#]	0.22 ± 0.23	0.17 ± 0.17	0.28 ± 0.12	0.28 ± 0.11	–0.20 ± 0.39	–0.27 ± 0.78	–0.60 ± 0.44	–0.83 ± 0.36
AS (*N* = 10)	0.12 ± 0.25	0.19 ± 0.15	0.11 ± 0.16	0.22 ± 0.18	0.16 ± 0.15	–0.33 ± 0.22	–0.33 ± 0.27	–0.60 ± 0.41	–0.60 ± 0.54
CL (*N* = 10)	–0.11 ± 0.16[a,b,c]	–0.04 ± 0.06[a,b,c]	–0.03 ± 0.09[a,b,c]	–0.03 ± 0.05[a,b,c]	–0.06 ± 0.08[a,b,c]	–0.03 ± 0.29	0.03 ± 0.19	–0.10 ± 0.16[a,b,c]	0.10 ± 0.16[a,b,c]
Step test (no/month)									
AT (*N* = 12)	0.09 ± 0.06[b,c]	0.19 ± 0.05[b,c]	0.17 ± 0.07[#]	0.20 ± 0.04	0.17 ± 0.10	–0.39 ± 0.19	–0.53 ± 0.22	–0.50 ± 0.30	–0.47 ± 0.22
ST (*N* = 10)	0.14 ± 0.12	0.09 ± 0.11	0.18 ± 0.08	0.21 ± 0.08	0.21 ± 0.06	–0.30 ± 0.19	–0.33 ± 0.27	–0.53 ± 0.17	–0.60 ± 0.26
AS (*N* = 10)	0.08 ± 0.11	0.12 ± 0.08	0.21 ± 0.06	0.24 ± 0.09	0.23 ± 0.19	–0.33 ± 0.27	–0.37 ± 0.33	-0.43 ± 0.22	–0.60 ± 0.31
CL (*N* = 10)	–0.01 ± 0.08[a,b,c]	–0.01 ± 0.06[a,b,c]	0.02 ± 0.09[a,b,c]	–0.07 ± 0.09[a,b,c]	–0.02 ± 0.07[a,b,c]	–0.10 ± 0.16[a]	–0.33 ± 0.22	0.23 ± 0.16[a,b,c]	0.13 ± 0.23[a,b,c]
Chair test (no/month)									
AT (*N* = 12)	0.33 ± 0.13	0.34 ± 0.13	0.16 ± 0.10[#]	0.17 ± 0.07	0.14 ± 0.10	–0.56 ± 0.38	–0.47 ± 0.26	–0.50 ± 0.17	–0.44 ± 0.30
ST (*N* = 10)	0.21 ± 0.21[#]	0.17 ± 0.18	0.11 ± 0.09	0.10 ± 0.18	0.17 ± 0.08	–0.30 ± 0.40	–0.30 ± 0.40	–0.47 ± 0.17	–0.23 ± 0.55
AS (*N* = 10)	0.22 ± 0.15	0.22 ± 0.17	0.12 ± 0.13	0.11 ± 0.09	0.11 ± 0.16	–0.27 ± 0.34	–0.33 ± 0.42	–0.30 ± 0.33	–0.37 ± 0.37
CL (*N* = 10)	–0.01 ± 0.10[a,b,c]	–0.02 ± 0.05[a,b,c]	–0.02 ± 0.07[a,b,c]	–0.04 ± 0.06[a,b,c]	0.01 ± 0.10[a,b]	–0.07 ± 0.14[a,b,c]	–0.03 ± 0.19[a]	–0.03 ± 0.11[a,b]	0.10 ± 0.27[a,c]
Shoulder press (no/month)									
AT (*N* = 12)	0.33 ± 0.11[#]	0.32 ± 0.15	0.31 ± 0.08	0.25 ± 0.07	0.21 ± 0.06	–0.50 ± 0.30[#]	–0.78 ± 0.22[#]	–0.86 ± 0.22	–0.64 ± 0.17
ST (*N* = 10)	0.12 ± 0.16[#]	0.30 ± 0.20	0.22 ± 0.14	0.23 ± 0.18	0.19 ± 0.16	–0.40 ± 0.41[#]	–0.73 ± 0.38	–0.70 ± 0.33	–0.57 ± 0.47
AS (*N* = 10)	0.13 ± 0.18[#]	0.30 ± 0.23[#]	0.18 ± 0.16[#]	0.18 ± 0.17	0.16 ± 0.15	–0.33 ± 0.31[#]	–0.63 ± 0.46	–0.57 ± 0.39	–0.47 ± 0.45
CL (*N* = 10)	–0.02 ± 0.09[a,b,c]	0.06 ± 0.15[a,b,c]	0.04 ± 0.11[a,b,c]	0.02 ± 0.09[a,b,c]	–0.01 ± 0.10[a,b,c]	–0.23 ± 0.22[a,b,c]	–0.23 ± 0.35[a,b,c]	–0.17 ± 0.24[a,b,c]	–0.13 ± 0.32[a,b,c]

Abbreviations: AT = aerobic training; ST = strength training; AS = combined aerobic and strength training; CL = control group.

[#] $p < .05$ from previous point; [a] $p < .05$ from AT group; [b] $p < .05$ from ST group; [c] $p < .05$ from AS group; [d] $p < .05$ from CL group.

from 14.1 to 12.6 repetitions (*d*: –0.61, *p* = .06) during the study in shoulder press performance, and the number of repetitions performed at the end of the study was lower by 10.64% compared with baseline (Table 3). All training groups performed a higher number of repetitions in the shoulder press test after the first training year and during the five-year follow-up period than the CL group (AT vs. CL *d*: 1.01–2.17; ST vs. CL *d*: 0.58–1.45; AS vs. CL *d*: 0.05–1.00). Furthermore, the AT group was better than the ST (*d*: 0.36–0.41) and the AS (*d*: 0.69–0.97) groups during the study period (Figure 4ii).

The rate of change of shoulder press performance did not show systematic differences ($p > .05$) during training and detraining of all groups. The rate of increase in shoulder test performance in the training groups was higher ($p < .05$) compared with the CL group, but the rate of decrease in performance during the detraining periods was also higher in the training groups ($p < .05$; Table 5).

Chair Stand Test. All training groups increased ($p < .05$) the number of repetitions performed during the chair test until the second year of training and retained this increased level until the end of the five-year follow-up period (AT: from 9.6 to 12.9 repetitions, 34.4%, *d*: 2.13; ST: from 10.5 to 13.4 repetitions, 27.6%, *d*: 1.47; AS: from 10.2 to 14.5 repetitions, 42.2%, *d*: 1.31). The CL group performance progressively decreased from 9.8 to 8.9 repetitions and was lower ($p < .05$) in the last two years of the study compared with baseline (*d*: –1.12). All training groups had higher scores in the chair test than the CL group throughout the five-year follow-up period (AT vs. CL *d*: 1.39–3.67; ST vs. CL *d*: 1.55–2.75; AS vs. CL *d*: 0.81–2.19). Furthermore, the AS group presented higher values as compared with the other training groups (AS vs. ST *d*: –0.12 to 0.53; AS vs. AT *d*: 0.38 to 0.70; $p < .05$; Figure 5i).

The rate of change in the performance of the chair stand test did not show any differences ($p > .05$) during training and detraining in all groups. The rate of increase in chair stand performance in the training groups was higher ($p < .05$) compared with the CL group in all training periods. On the other hand, the rate of decrease in performance during detraining was, in most cases, higher in the training groups ($p < .05$; Table 5).

Step Test. The AT group improved ($p < .05$) the number of steps performed from 10.7 to 12.4 (15.5%; *d*: 1.30), the ST group improved from 10.2 to 12.4 (21.6%, *d*: 1.98), and the AS group improved from 9.9 to 12.7 (28.3%, *d*: 1.42) after the last training period compared with baseline. However, during each detraining period, step test performance decreased ($p < .05$) to baseline values. The number of steps performed progressively decreased in the CL group, from 10.3 to 9.3, and were lower by 9.7% by the end of the study (*d*: –0.82). After the second year of training and until the end of the study, all training groups performed a higher number of repetitions during the step test than the CL group (AT vs. CL *d*: 0.43–3.22; ST vs. CL *d*: 0.61–3.28; AS vs. CL *d*: 0.19–2.11). No systematic differences were observed among the three training groups (Figure 5ii).

The rate of change in the performance of the step test did not show any differences ($p > .05$) during training and detraining in all groups. The rate of increase in step test performance in the exercise groups was higher ($p < .05$) compared with the CL group in all training periods. On the other hand, the rate of decrease in performance was also higher in the exercise groups at the third and the fourth detraining periods ($p < .05$; Table 5).

Discussion

The results of the current study indicated that all training programs applied (AT, ST, AS) led to beneficial adaptations on body composition and functional ability. Aerobic training (AT) and the combination of aerobic and strength (AS) seemed to be better in functional ability, while strength training (ST) revealed better results in body composition. After a five-year supervised community-based intervention program, there seemed to be a decrease of performance tests in the control (CL) group but an increase of physical ability in all training groups. Thus, according to our findings, systematic training appears to delay aging effects. The interruption of systematic exercise, during the three-month annual pause, reversed the positive adaptations and underlined the need for uninterrupted exercise to retain better body composition and functional ability in older individuals. When exercise was interrupted at the end of the detraining period, the participants who followed training presented better values compared with baseline than their untrained sedentary counterparts.

During normal aging there is a decline in muscle mass that reaches a rate of 10% every 10 years after the age of 50 (Marcell, 2003). Muscle strength reaches a peak during the third decade, remains unchanged or decreases slightly during the fifth decade, and declines more rapidly afterward at 12–15% every decade (Hurley, 1995). Indeed, the women of our CL group who avoided training showed a large decline (10–15%) in the functional ability tests within the five-year period. Taking these facts into consideration, it appears that regular exercise is necessary to maintain functional ability in older adults despite the physiological decline due to aging. Even after the detraining periods when there was a loss of favorable adaptations, the training groups presented higher values at the end of the study as compared with the initial values and the age-related decline of the CL group (see Table 2 and Table 3).

Effects of Training on Anthropometric Characteristics

During the aging process, changes in body composition, gradual accumulation of BF and its redistribution to central and visceral depots, as well as the loss of muscle mass, affect metabolic and cardiovascular risk factors (Kay & Fiatarone Singh, 2006; Racette, Evans, Weiss, Hagberg, & Holloszy, 2006). The intervention programs used in our study revealed encouraging results after the application of aerobic, strength, and combined training in older women concerning body composition. According to our data, all trained participants reduced BF and increased FFM significantly. This moderate to large increase in muscle mass due to training affected the changes in BMI where a nonsignificant reduction was observed. In contrast, the CL group increased BMI and BF and reduced FFM. In particular, the ST group revealed better adaptations on body composition. This is probably because of our multicomponent strength training approach, which helped older women to develop muscular strength and muscle mass in a community-based setting. Along this line of thought, Toto et al. (2012) found that a multicomponent exercise program in a community-dwelling population improved physical performance and the daily lives of older adults.

In agreement with our study, Avila et al. (2010) used the combination of resistance training and dietary weight loss (control) to show that 2.5 months of moderate resistance training can help to prevent muscular atrophy in older overweight individuals (60–75 years old) despite food restriction, which is typically associated with the loss of FFM. In a well-conducted follow-up study (~five years), Manini et al. (2009) used dual-energy X-ray absorptiometry (DEXA) to measure body composition and the doubly-labeled water technique to assess energy expenditure in 302 (51 died) older adults aged 70–82 years. Furthermore, after conducting a questionnaire, they found that physical activity is associated with higher levels of FFM, but this cannot prevent negative body composition changes later in life. Compared with our study, the subjects of the above study were ~10 years older and without systematic training. Our findings, however, consistently indicate training and detraining changes in body composition (Figure 3) based on adequate training stimulus. Obviously, specific training stimulus yields appropriate responses in functional ability tests and body composition (Figures 3 and 4). Recently, Burd et al. (2013) declared that physical activity, along with dietary intervention, is able to offset the age-related loss of muscle mass.

Long-term intervention studies are difficult to carry out and are limited in the literature. There are only two long-term follow-up studies with older adults, which cannot be compared with our data. The first was on activity energy expenditure and changes in body composition without exercise intervention (Manini et al., 2009; see above), and the second was on quality of life in cancer patients (aged 68.4 ± 10.4 years) through a five-year community-based exercise intervention program (Haas et al., 2012). Our long-term follow-up study seems to be the only one with training and detraining evaluation on functional performance and health-related adaptations.

Other studies are based on shorter periods of exercise (1–2 years). For instance, Opdenacker et al. (2011) evaluated lifestyle and structured exercise effects on physical fitness and cardiovascular risk factors in older men and women aged 60–83 years for a period of 23 months. The participants showed improvements in cardiorespiratory fitness, while no long-term effects were found in body composition. The structured group showed improvements in muscular fitness, whereas the lifestyle group showed better performance in functional ability. Furthermore, Bird et al. (2011) used a randomized control study to examine the benefits of a community-based resistance exercise intervention program of 12 months in a group of healthy inactive adults aged 60–75 years. In this study, significant improvements remained evident in the exercise group after a one-year follow-up (functional test of "timed up-and-go"' and "sit-to-stand" task), while no changes were observed in the control group. Similarly in our study, comparable physiological benefits were observed in almost all training groups within the time period of 12–21 months, and no changes were noted in our control group within a period of 12 months. It should be pointed out, therefore, that no changes occurred in our control group during the first year, but this scenario completely changed in many cases after the second year since our control group followed the natural aging process (see Figures 3, 4, and 5).

Training, Detraining, and Retraining Effects

According to our design, the participants of the current study followed a training, detraining, and retraining schedule for five years. During the first year, the training period was nine months while the retraining period consisted of three months. During the second year, the retraining period was nine months while the detraining included three months. This pattern was repeated until the fifth year. Obviously, during training, we observed positive physiological adaptations, which were reversed during detraining and were regained during retraining. Moreover, our intervention groups resisted age-related decline, retained their health-related adaptations during detraining, and improved them even more during retraining.

In our study, after five years of training, muscular strength largely increased and maintained functional ability at a good level even during detraining. Therefore, strength training proved to be beneficial for older women despite aging. Community-based exercise programs enhance fitness and affect functional ability and health in older adults. Belza et al. (2006) reported significant improvement in health and physical performance of 2,889 participants (mean age 75.5 years) in the U.S. Enhance Fitness Program, after a follow-up of four months for 1,258 participants and eight months for 880 of these participants, in various community-based exercise programs. Indeed, all scientific organizations suggest that exercise should be performed regularly throughout life, and a combination of aerobic and resistance exercise activities seems to be more effective than either form of training alone (American College of Sports Medicine, 2009). In our study, the combined AS program obtained better results on the step test and chair test. It should be noted, however, that in the long run, these beneficial adaptations were also retained after detraining when compared with initial values.

An important finding in our study is that the long-term training-induced effects were maintained even after the cessation of training. This may not be expected in older individuals due to physiological aging decline. Nevertheless, muscular fitness and functional performance did not return to pretraining values during detraining (Figures 4 and 5). In particular, after the last detraining period, the AT program reached a value of 26.2% on curl-ups compared with baseline, 23.9% on the chair test, and 19.8% on the shoulder press test. The ST program also revealed improvements even after detraining. In addition, the long-term effects of the combined AS program retained the positive training-retraining effects until the last detraining period and reached a value of 30.1% on the chair test, 8.6% on the pull-down, and 7.1% on the step test compared with baseline. The CL group, however, followed the expected aging decline with a significant deterioration in functional ability. Symptoms of muscle atrophy and weakness were noticeable in the nonexercising group since lean body mass decreased, while BF and BMI increased.

Abstaining from systematic training induces negative detraining effects (Fatouros et al., 2005; Kalapotharakos et al., 2007; Tokmakidis et al., 2009) that depend on age and are not similar to both sexes (Ivey et al., 2000). The participants of the current study were older women and, according to Ivey et al. (2000), one should keep in mind that when we compare age and sex in maximal force production per unit of muscle mass (muscle quality), older women (65–75 years) cannot retain strength training-induced adaptations to the same extent (more than eight months) as older men and both young women and men (20–30 years). Fatouros et al. (2005) found that all training effects are abolished after four to eight months when a low intensity of strength training (55% 1RM) is applied to older men above 65 years of age. On the other hand, when high-intensity strength training (82% 1RM) is performed, the training effects are retained even after eight months. Taaffe and Marcus (1997) mentioned a 40% increase in muscle strength after six months of specific resistance training in men 65–75 years of age; afterward, muscle strength declined by 30% following a three-month detraining period and regained its strength after an eight-month retraining period. Our community-based programs showed a decline of about 10–15% from one year to the next in all training programs, whereas the increased values ranged from 22–35% in functional ability tests. Comparable results were obtained in patients with coronary artery disease after three months of detraining (Tokmakidis & Volaklis, 2003). These patients followed an eight-month combined strength and aerobic training program. In addition, a three-month period of detraining showed a comparable decrease of strength after three months of moderate resistance training in older men and women 60–74 years of age (Tokmakidis et al., 2009). Nevertheless, although the cessation of exercise training reversed the positive induced physiological adaptations, the training groups in our study retained some of them at an increasing rate throughout the five-year follow-up. In contrast, the CL group followed the age-related decline. Thus, regular exercise seems to fight aging and provide health benefits to older individuals.

Promotion Strategies of Physical Activity

Focusing on the promotion of physical activity among older adults, Chao, Foy, and Farmer (2000) stated that without motivation, effort is not forthcoming. Therefore, several strategies have been recommended for the promotion of physical activity in older individuals, which include components of behavior change (goal setting, self-monitoring, self-reinforcement, corrective feedback), environmental management (i.e., transportation facilities, indoor or outdoor activities, unstructured setting such as a park or neighborhood), and increased social support (Azizan, Justine, & Kuan, 2013; Marcus et al., 2006; Nelson et al., 2007; Seguin, Heidkamp-Young, Kuder, & Nelson, 2012; Wilcox et al., 2009). Moreover, it is essential to provide feedback to the participants about their progress through regular physical fitness evaluations to enhance exercise adherence (Seguin et al., 2012).

In our study the attendance rate was ranged from 83–88% during the five-year follow-up. The successful implementation of our multicomponent intervention was probably due to: (1) the variety of the physical activities applied, (2) the regular evaluation and feedback given to the participants concerning their body composition and functional ability adaptations after each training and detraining period, (3) the easy access to the exercise centers, (4) free participation, (5) the socialization among the members, and (6) the partnership during various physical fitness initiatives. These practical strategies in our study maintained the adherence of the participants and proved that initiatives with social character are more successful when they are administered in groups and are associated with better functional ability and increased physical activity levels (British Heart Foundation, 2013).

General Observations

It is worth noting that the rate of the adaptations achieved with training both in the anthropometric and in the functional ability tests were not altered with aging, at least within the time period examined in the current study and the age range of the individuals (Table 4 and Table 5). It appears that the human body can repeatedly adapt to the training stimulus and maintain or improve body composition or functional performance despite an increase in age. The interruption of the training program for short to intermediate periods of time (three months) affects the training-induced adaptations negatively, but after the resumption of training there is a return to even better physiological adaptations. Furthermore, the gain of performance during the training periods did not deteriorate completely from year to year during the three months of the detraining stages. This is important since it is possible to maintain an increased functional level despite an increase in age. Although the rate of decrease of functional performance during detraining was higher for the exercise groups compared with the CL group, functional performance was sustained to a better level (Table 5). It is important, therefore, to motivate older women to follow systematic, community-based exercise programs every year and point out that an interruption of training for some months will not completely alter all gains achieved during the training period. Finally, in our long-term study, health-related adaptations could be observed after one, two, or even five years of training. It would be interesting, however, to study the adaptability of older people during a 10-year follow-up intervention.

Limitations of the Study

The limitations of the current study include: (1) the small sample of women, (2) the restricted generalization of the data which cannot be applied to men, (3) the missing data from those who withdrew from the program, and (4) the failure to record physical activity during detraining. Furthermore, the methodology of portable body composition apparatus and the absence of a cardiorespiratory fitness test limit the outcome of the study. It should be mentioned, however, that even the availability of DEXA and the time-consuming cardiorespiratory fitness test could not be practical and easy to apply in a five-year follow-up.

Conclusion

The results of the current study showed that exercise training improved the functional ability of older women and maintained the desirable anthropometric attributes during a five-year community-based intervention. These findings suggest that all training programs used in our study lead to beneficial adaptations on muscular strength and functional fitness and facilitate the daily tasks of older women. The specific findings of the study may guide exercise specialists to prescribe the appropriate regimen according to the needs of each individual. Aerobic training (AT) and the combination of aerobic and strength (AS) may be better to improve functional ability, whereas strength training (ST) may be prescribed to manage body composition. Overall, the multicomponent approach of our community-based programs offers another alternative to apply various exercises and increase participation and adherence. This was evident during the annual nine-month training period, which induced favorable physiological effects. During the annual three-month detraining period, however, the favorable training adaptations were reversed. Nevertheless, even after detraining, values were better than baseline and control. This denotes the beneficial effects of regular exercise, which prevents the loss of muscle mass and promotes the functional ability of older individuals. Therefore, systematic exercise training should be followed throughout life to improve functional fitness in older people through community-based programs.

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