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The Effects of a Calisthenics and a Light Strength Training Program on Lower Limb Muscle Strength and Body Composition in Mature Women

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ABSTRACT

This study evaluated and compared the effectiveness of an aerobics-calisthenics (A-CAL) and an aerobics/weight training (A-WT) programs on lower limb strength and body fat (%). Thirty-five adult women (age 42.1 ± 5.2 years) were randomly assigned to A-CAL ($n = 14$), A-WT ($n = 14$), or a control group ($n = 7$). The A-CAL and A-WT trained 3 days per week for 10 weeks. Maximal bilateral isometric and isokinetic knee extension (KEXT) and flexion (KFLEX) torque, squat jump (SJ), and body fat (%) were measured before and immediately after training. The results revealed nonsignificant differences between A-CAL and A-WT ($p > 0.05$). Both A-CAL and A-WT improved SJ ($p < 0.001$). A-WT increased isometric torque of KEXT and KFLEX ($p < 0.05$), isokinetic torque of KFLEX ($p < 0.05$), and decreased body fat (%) ($p < 0.05$) when compared with controls. In summary, the application of a 10-week light-weight training program improved selected strength parameters of healthy women, compared with controls, but the effectiveness of the calisthenics exercises as an independent form of strength training is dubious.

Key Words: calisthenics, dynamic constant resistance training, isokinetic evaluation

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Introduction

A well-rounded program that contains activities to develop both strength and aerobic power is required to maximize physical fitness and health benefits. The inclusion of strength training in adult fitness programs should be effective in the development and maintenance of muscular strength and endurance (2, 16, 19) as well as in improving body composition (11, 17, 29). In fact, the position stand of American College of Sports Medicine (ACSM) (3) recommends resistance exercise as supplemental to endurance exercise to treat obesity and prevent weight regain. Strength training is also reported to have additional benefits, such as injury prevention (13, 19, 34) prevention of osteoporosis (13, 19, 38), and improvement of cardiovascular risk factors (17, 38, 39).

Resistance training is a mode of training that rises in popularity the last 10 years. More and more women perform resistance training, using free weights or machines, as part of their physical conditioning. Several studies have demonstrated the ability of dynamic constant external resistance training to produce significant increases in lower limb muscle strength in women (6, 11, 41). Body composition changes induced by resistance training have also been investigated widely, indicating that this mode of training produce significant changes in percentage of body fat in women (6, 8, 11, 31, 40, 41).

Calisthenics are another popular form of strength training. They include exercises that are performed against body weight without the need for any apparatus or machinery. Calisthenics are more cost effective and accessible to anyone. They may be utilized as components of aerobic classes, but they can be also solely performed in work and home environment. Although resistance training programs provide quantitative information as to the loads imposed on the subjects, calisthenics may provide beneficial and safe means for development and maintenance of functional strength, muscle endurance, coordination, and flexibility (2, 32, 34, 35).

Table 1. Initial physical characteristics of the training and control groups (mean ± *SD*).*

Group	*n*	Age (y)	Train age	Height (cm)	Weight (kg)	BMI	% Body fat
A/CAL	12	42 ± 5.3	6.8 ± 2.8	163.8 ± 5.3	68.0 ± 12.6	25.3 ± 4.1	30.7 ± 6.8
A/WT	12	41 ± 5.1	7.9 ± 2.9	162.9 ± 4.6	61.8 ± 8.5	23.3 ± 3.0	28.0 ± 6.1
C	7	42 ± 6.0	7.2 ± 2.5	163.0 ± 4.2	59.4 ± 4.8	22.5 ± 1.5	27.6 ± 3.3

* A/CAL = aerobics/calisthenics-training group ($n = 12$); A/WT = aerobics/weight-training group ($n = 12$); C = control group ($n = 7$); BMI = body mass index. There were no statistically significant differences between the 3 groups in any variable ($p > 0.05$).

Despite their popularity, there is limited information regarding the effects of this mode of exercise on strength and body composition. Furthermore, strength changes elicited by calisthenics, compared with those elicited following a resistance training program, have not been widely investigated. If calisthenics are to be considered as an alternative form of strength training performed at low cost for recreational purposes, its effects, compared with resistance training programs, need to be assessed. Therefore, the purpose of this study was to examine the effects of an aerobic-calisthenics and an aerobics and light-weight training program on muscle strength and body composition in mature women. It was hypothesized that strength improvements would be significantly different between the two exercise programs.

Methods

Experimental Approach to the Problem

The experimental design of this study was a factorial design. Baseline muscular strength and body composition were measured approximately a week before the start of the program. Subjects were then randomly assigned into 1 of 3 treatment groups: (1) aerobics-calisthenics training (A-CAL, $n = 14$), (2) aerobics-weight training (A-WT, $n = 14$) and, (3) control group (C, $n = 7$). The C group was instructed to avoid structured exercise or activities other than those required for normal daily living throughout the study. Physical characteristics (Table 1) and strength performance (see Tables 5 and 6) were not significantly different ($p > 0.05$) among the 3 groups at the beginning of the study. The training groups were assigned in the 2 programs for a period of 10 weeks. To determine alterations in lower extremity strength and percentage of body fat changes, individuals underwent a physical fitness evaluation prior to and following completion of the program. Muscular strength was determined utilizing both dynamic and static strength measurements.

Subjects

Thirty-five women (age 42.16 ± 5.27 years) were recruited on a volunteer basis. Institutional Review Board approval and written informed consent were obtained from all subjects before participation in the study. A PAR-Q and a physical activity–related questionnaires were completed prior to initiation of the study to assess the health and physical activity status of the participants. None of the subjects had musculoskeletal dysfunction or other medical conditions that would contraindicate exercise. None of them had been involved in regular physical activity for a period of 6 months before the study or ever undergone weight training. Subjects were informed that attendance was required at more than 85% of sessions to remain in the study. They were asked to refrain from any other physical activity throughout the study.

Instrumentation

A Cybex Norm dynamometer (Lumex Corporation, Ronkohoma, NY) was used for the isokinetic and isometric measurements. The system records the moment, angular position, and velocity of the dynamometer lever arm at a rate of 500 Hz. Dynamic explosive force was measured on Ergojump (Bosco) (5) using a maximal vertical squat jump (SJ). This device consists of a contact mat connected to a digital timer and is highly reliable ($r = 0.94$–0.97) (4, 5). The height of rise (centimeters) of the center of gravity in the SJ was calculated from the flight time. Percentage of body fat was measured using a bioelectrical impedance analysis method (Bodystat Limited, Douglas, UK). Bodystat 1500 is a portable single-frequency bioelectrical impedance measurement unit that measures impedance value of the body at a fixed frequency of 50 kHz. The high accuracy of this unit has been reported elsewhere (22, 36).

Testing Protocol

Isokinetic and isometric tests were performed from the seated position. Velcro straps were used to stabilize the trunk, waist, and upper portion of the thigh of the subjects on the chair. Prior to the test the dynamometer was calibrated according to the procedure recommended by the manufacturer. Participants had a 5-minute warm-up session on a stationary bicycle before the tests.

A familiarization with the testing protocol and a warm-up, consisting of 3 submaximal concentric repetitions at each angular velocity tested were per-

Table 2. Summary of training protocols.

Mode of training	Frequency	Intensity	Exercise duration	Repetitions/ set	Sets	Rest period
A/CAL						
Aerobics	3/week	70–90% maximum heart rate	20 min			
Calisthenics			25 min	12–15	2–3	60 sec
A/WT						
Aerobics	3/week	70–90% maximum heart rate	20 min			
Weight train		12RM	25 min	10–12	3	60 sec

formed. The isokinetic testing protocol consisted of 3 maximal bilateral knee extension (KEXT) and flexion (KFLEX) efforts at concentric angular velocities of 1.05 rad·s^{-1} and 3.15 rad·s^{-1}. The range of motion (ROM) was from 0° (full extension) to 90° of knee flexion. The subjects had visual feedback and were instructed to work as hard as possible. All tests were separated by a 3-minute rest period to avoid any fatigue effects. Maximal peak KEXT and KFLEX torque was defined as the highest value of the torque (N·m) recorded during the 3 efforts.

The isometric testing protocol included 1 submaximal effort for familiarization and warm-up and 1 maximal isometric KEXT and KFLEX effort at 65° and 25° of knee flexion angles respectively (15, 18, 27, 33). The subject was instructed to gradually build up tension against the machine's movement arm over 3–4 seconds by slowly extending the legs. Once maximum effort was developed, the subject was encouraged to maintain this force for an additional 4–6 seconds and then gradually release this force by relaxing the quadriceps muscles. Maximal isometric KFLEX strength was measured using the same method. Isokinetic and isometric testing were performed separately on both legs for each subject.

The testing protocol of squat jump test consisted of 3 efforts out of which only the best maximum, in terms of height, was recorded. The subjects kept their trunks in an upright posture and their hands on their hips. The test started from a semisquat position with the knees flexed at 90° because the knee is best stabilized at this angle during the phase of contact with the ground (5).

The percentage of body fat was assessed 1 week prior to the initiation of the program. Subjects abstained from exercise at least 12 hours and from food and drink at least 8 hours prior to the test. No alcohol or caffeine was consumed during the 24 hours prior to the test. It was ascertained that the subjects met all bioelectrical impedance analysis guidelines and standardized testing procedures were followed.

Experimental Aerobic Training Protocol

Both training programs consisted of 3 supervised sessions per week performed on alternative days. The aerobic segment was the same for both groups and consisted of approximately 20 minutes of moderate-impact aerobic choreography. The impact level was based on the type of exercises and the rhythm of the music (125–140 b·min^{-1}). Emphasis was given to lower body movements and large movement of the body through space (10). The exercise intensity was determined at 70–90% of the predicted maximum heart rate (HR_{max}) because this was estimated on the basis of age (220 − age [years] = HR_{max} [bp]) (18). The modification of exercise intensity was initially (following week 2) succeeded by emphasizing traveling more through space and increasing the way the horizontal movement of the center of gravity of the body. From the fifth week onward, exercise intensity increased by the further addition of lower limb lifting movements to the basic steps. Following week 7, exercise intensity was altered by increasing the tempo of the music but maintaining the same ROM. The exercise intensity was monitored using sport testers.

Experimental Strength Training Protocol

The present protocol was designed so that total body workout is achieved. However, the main focus of this protocol was to strengthen the lower limb muscles, especially the muscle groups that surround the knee and hip joints. These muscles were selected because they stabilize the knee and hip and provide partial protection against joint injury and soreness (10). Balanced strength between the antagonistic muscle groups is necessary; thus, the hamstrings need to be strengthened along with the quadriceps.

The strength training segment for the A-CAL group included the following calisthenic exercises: squats, static knee extensions–hip flexions (stationary lunges), and lunges (15). The training protocol also included abdominal crunches, push-ups, and pull-ups to provide gains in strength for upper-body muscle groups. The calisthenics intensity was modified by increasing progressively the number of repetitions and sets during the training period. In the beginning of the program, the training protocol included 2 sets of 12 repetitions each. From the third week onward, repetitions were increased to 15. Following week 5, 3 sets

Table 3. Knee extension training data for A/WT group (mean ± *SD*).†

	n	Weight (kg)	Reps
Week 1	12	68.4 ± 10.9	12 ± 1.4
Week 5	12	91.4 ± 10.3	11.2 ± 1.5
Week 10	12	102.0* ± 11.2	10.3 ± 1.5

† Training data are averaged for weeks 1, 5, and 10. Reps = repetitions; A/WT = aerobics/weight-training group.
* Significant difference from baseline ($p < 0.05$).

Table 4. Knee flexion training data for A/WT group (mean ± *SD*).†

	n	Weight (kg)	Reps
Week 1	12	58.2 ± 9.8	11.5 ± 0.5
Week 5	12	82.5 ± 6.6	11.2 ± 1.5
Week 10	12	89.6* ± 10.5	10.3 ± 1.0

† Training data are averaged for weeks 1, 5, and 10. Reps = repetitions; A/WT = aerobics/weight-training group.
* Significant difference from baseline ($p < 0.05$).

of 12 repetitions each were performed. Finally, from the seventh week onward, repetitions were increased to 15, and sets and rest periods remained the same (Table 2). The summary of training protocols is depicted in Table 2.

The strength training protocol for the A-WT group consisted of 3 types of lifting exercises: leg extensions, leg curls, and hip extensions, which were performed on constant resistance training machines (TECHNOGYM, Gambettola, Italy). As with the A-CAL group, the protocol also included abdominal crunches, bench press, and lat pull-down exercises to provide a whole-body workout. All subjects were pretested by performing a 12-repetition maximum (RM) test. The initial exercise intensity was based on this pretraining test. For each training session, subjects completed 3 sets of full ROM of the former exercises using an amount of weights that allowed 10–12 repetitions, with failure because of muscular fatigue occurring during the last repetition. Participants were required to rest for 60 seconds between each set. When 3 sets of 12 repetitions were comfortably performed on a particular exercise, the resistance was increased by approximately 20% during the subsequent training session. All training sessions were monitored by experienced personnel. The number of repetitions completed and the weight load lifted during each training session were recorded. Training data for KEXT and KFELX are presented in Tables 3 and 4.

Each repetition for all exercises was performed at a moderate to slow speed, in a controlled manner. The concentric phase of the contraction was performed for

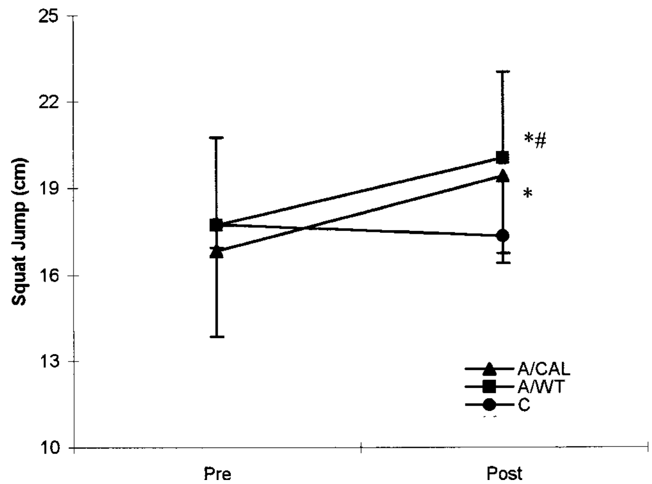

Figure 1. Pre- and posttraining values of squat jump (SJ) for the aerobics/calisthenics (A-CAL), aerobics/weight training (A-WT), and control group (C). * $p < 0.05$ vs. baseline; # $p < 0.05$ vs. control group.

2 seconds (raising the resistance or body weight) and the eccentric phase for 4 seconds (lowering the resistance or body weight). All training sessions lasted approximately 60 minutes and began with 5 minutes of general warm-up exercise. Training session attendance records were kept.

Control Group

The subjects were asked not to engage in any regular training during the 10-week training period. To ensure that the C group subjects did not initiate regular exercise during the study, they were requested to complete an activity log and submit it for review weekly.

Statistical Analyses

Pre- and posttraining data were analyzed by a 2-factor (group × time) analysis of variance with repeated measures on 1 factor (time). When a statistically significant *F*-ratio was achieved, a Tukey honestly significant difference post hoc test for unequal sample sizes was used to detect significant differences among mean values. Significance was accepted at $p \leq 0.05$.

Results

Subjects

Of 35 subjects, 31 (12 of each training group and 7 of the controls) completed the study. Stable body weight was also reported for the last 6-month period. Physical characteristics (Table 1), strength performance, and percentage of body fat for each group did not differ significantly ($p > 0.05$) at the beginning of the study.

Pre–Post Changes

Squat Jump Testing. SJ height (mean ± *SD*) before and after training are illustrated for each group in Figure 1. No significant differences were noted between the A-CAL and A-WT groups at week 0 or week 10. Both

Table 5. Squat jump and bilateral isometric peak torque values before and after 10 weeks of training or control period (mean ± *SD*).†

Group	Baseline	10 Wk
Squat jump (cm)		
A/CAL	16.83 ± 2.6	19.41 ± 3.1*
A/WT	17.73 ± 2.3	20.03 ± 2.8*,**
C	17.75 ± 0.8	17.35 ± 0.6
RKEXT peak torque (N·m)		
A/CAL	133.42 ± 20.0	148.33 ± 24.3*
A/WT	145.0 ± 20.8	158.92 ± 25.4*,**
C	132.71 ± 39.4	126.29 ± 30.9
LKEXT peak torque (N·m)		
A/CAL	132.42 ± 20.6	143.42 ± 24.1
A/WT	140.42 ± 19.7	165.42 ± 24.6*,**
C	126.29 ± 26.4	108.57 ± 30.8
RKFLX peak torque (N·m)		
A/CAL	75.0 ± 13.2	86.17 ± 14.2
A/WT	80.5 ± 13.1	96.17 ± 11.9*,**
C	77.0 ± 12.3	74.0 ± 13.0
LKFLX peak torque (N·m)		
A/CAL	77.42 ± 14.2	86.0 ± 17.2
A/WT	76.92 ± 19.3	97.0 ± 20.8*,**
C	76.86 ± 11.8	76.14 ± 7.8

† A/CAL = aerobics/calisthenics-training group (n = 12); A/WT = aerobics/weight-training group (n = 12); C = control group (n = 7); RKEXT = right knee extensors; LKEXT = left knee extensors; RKFLX = right knee flexors; LKFLX = left knee flexors.

* Significantly different from baseline at $p < 0.05$.

** Significantly different from control group at $p < 0.05$.

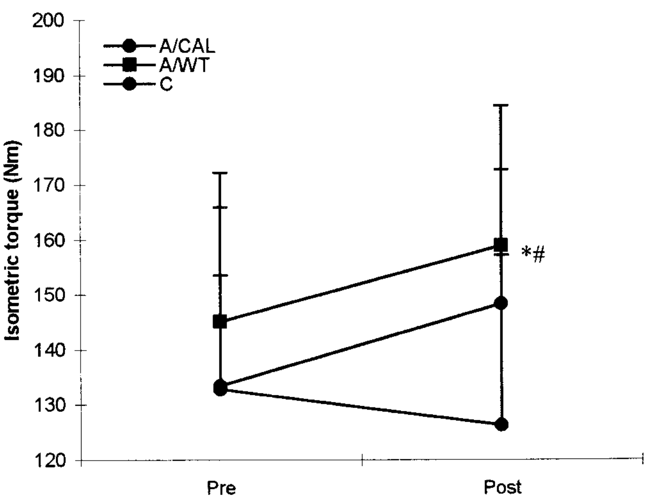

Figure 2. Pre- and posttraining values of right knee extension (RKEXT) isometric torque for the aerobics/calisthenics (A-CAL), aerobics/weight training (A-WT). and control group (C). * $p < 0.05$ vs. baseline; # $p < 0.05$ vs. control group.

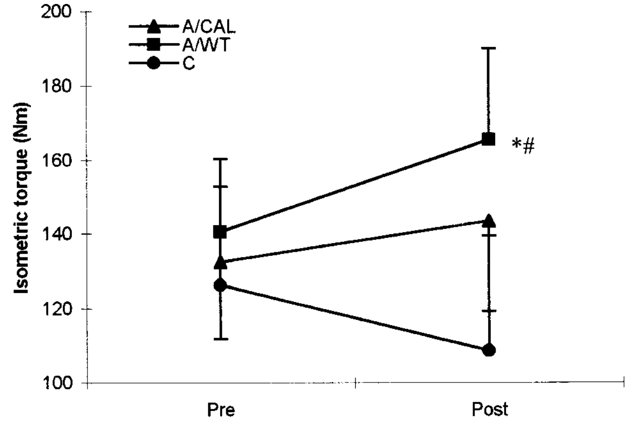

Figure 3. Pre- and posttraining values of left knee extension (LKEXT) isometric torque for the aerobics/calisthenics (A-CAL), aerobics/weight training (A-WT), and control group (C). * $p < 0.05$ vs. baseline; # $p < 0.05$ vs. control group.

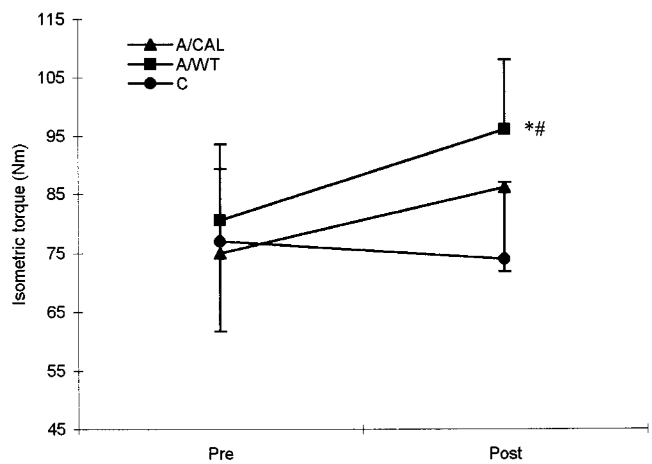

Figure 4. Pre- and posttraining values of right knee flexion (RKFLX) isometric torque for the aerobics/calisthenics (A-CAL), aerobics/weight training (A-WT), and control group (C). * $p < 0.05$ vs. baseline; # $p < 0.05$ vs. control group.

training groups increased significantly the SJ height ($p < 0.001$). No changes were found for the C group. There was a significant difference in SJ height ($p < 0.05$) between the A-WT and C groups in the end of intervention, with the A-WT group exhibiting significantly higher height performance ($p < 0.05$) than the C group. SJ values are depicted in Table 5.

Isometric Testing. Table 5 shows the pre- and posttest means (±*SD*) for peak isometric torque values for KEXT and KFLEX. There were no significant differences ($p > 0.05$) in isometric torque values between the 2 training groups after the 10-week period. In contrast, there were significant differences ($p < 0.05$) between the A-WT and the C groups, with the A-WT group exhibiting significantly higher strength values ($p < 0.05$) than those of the C group (Table 5). The A-WT group improved bilateral peak isometric KEXT and

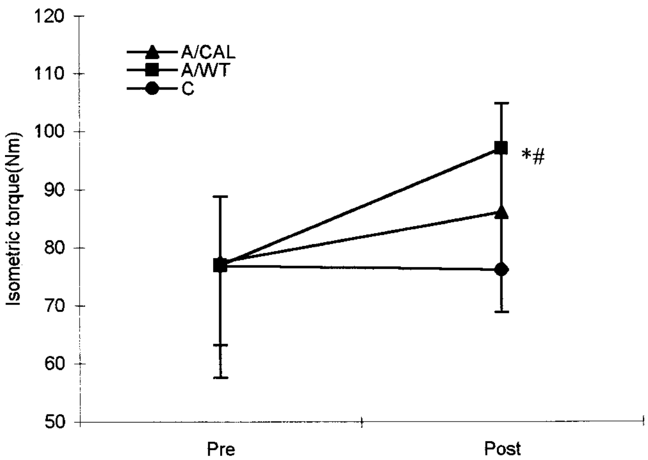

Figure 5. Pre- and posttraining values of left knee flexion (LKFLX) isometric torque for the aerobics/calisthenics (A-CAL), aerobics/weight training (A-WT), and control group (C). * $p < 0.05$ vs. baseline; # $p < 0.05$ vs. control group.

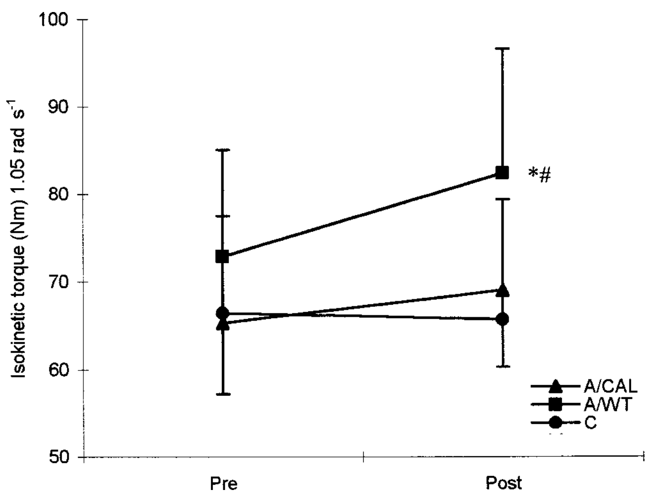

Figure 6. Pre- and posttraining values of right knee flexion (RKFLX) isokinetic torque at 1.05 rad·second^{-1} for the aerobics/calisthenics (A-CAL), aerobics/weight training (A-WT), and control group (C). * $p < 0.05$ vs. baseline; # $p < 0.05$ vs. control group.

KFLEX torque significantly ($p < 0.05$) from pre- to posttraining. Isometric torque values before and after training are illustrated in Figures 2–5.

Isokinetic Testing. Tables 6 and 7 show the pre- and posttest means (±*SD*) for peak isokinetic torque values for KEXT and KFLEX. No significant differences ($p > 0.05$) were found between the 2 training groups on the isokinetic peak torque tests of KEXT and KFLEX at both concentric angular velocities of 1.05 rad·s^{-1} and 3.15 rad·s^{-1}. Neither of the training groups increased significantly ($p > 0.05$) the peak isokinetic torque of KEXT. On the contrary, the A-WT group improved significantly bilateral isokinetic KFLEX torque at 1.05 rad·s^{-1}. There was a significant difference ($p < 0.05$) in isokinetic torque values of KFLEX between the A-WT and C groups, with the A-WT group exhibiting

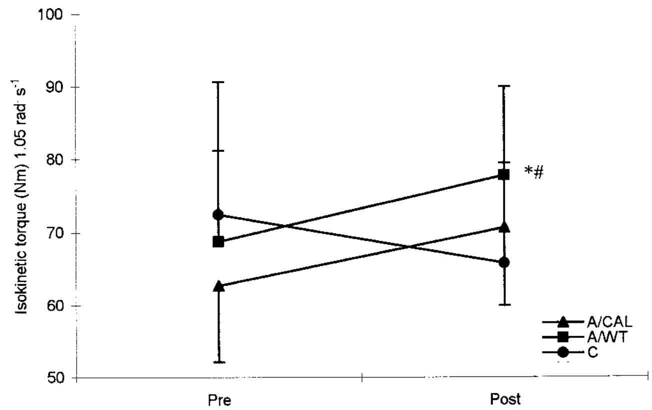

Figure 7. Pre- and posttraining values of left knee flexion (LKFLX) isokinetic torque at 1.05 rad·second^{-1} for the aerobics/calisthenics (A-CAL), aerobics/weight training (A-WT), and control group (C). * p <0.05 vs. baseline; # $p <$ 0.05 vs. control group.

Table 6. Bilateral isokinetic peak torque values of KEXT at 1.05 rad·s^{-1} and 3.15 rad·s^{-1} before and after 10 weeks of training or control period (mean ± *SD*).*

Group	Baseline	10 Wk
RKEXT peak torque (N·m)		
1.05 rad·s^{-1}		
A/CAL	115.6 ± 20.8	115.5 ± 17.4
A/WT	113.6 ± 13.4	112.8 ± 14.3
C	105.5 ± 20.7	102.1 ± 20.9
3.15 rad·s^{-1}		
A/CAL	72.3 ± 16.8	73.4 ± 13.2
A/WT	75.5 ± 10.3	74.5 ± 11.2
C	71.1 ± 15.7	65.4 ± 17.9
LKEXT peak torque (N·m)		
1.05 rad·s^{-1}		
A/CAL	111.7 ± 20.8	110.6 ± 16.52
A/WT	112.1 ± 14.9	114.1 ± 13.7
C	100.8 ± 11.7	96.8 ± 11.1
3.15 rad·s^{-1}		
A/CAL	72.4 ± 11.6	75.6 ± 11.9
A/WT	72.4 ± 9.5	76.1 ± 10.7
C	63.6 ± 8.7	60.8 ± 11.4

* A/CAL = aerobics/calisthenics training group (n = 12); A/WT = aerobics/weight training group (n = 12); C = control group (n = 7); RKEXT = right knee extensors; LKEXT = left knee extensors.

significantly higher strength values ($p < 0.05$) than those of the C group (Table 7).

Body Composition. The changes of the percentage of body fat (mean ± *SD*) are presented in Table 8. For the A-CAL training group, the pre- and posttest percent body fat was not significant different ($p > 0.05$). On the contrary, significant decrease ($p < 0.05$) in percentage of body fat was found in the A-WT group after

Table 7. Bilateral isokinetic peak torque values of KFLX at 1.05 rad·s^{-1} and 3.15 rad·s^{-1} before and after 10 weeks of training or control period (mean ± *SD*).†

Group	Baseline	10 Wk
RKFLX peak torque (N·m)		
1.05 rad·s^{-1}		
A/CAL	65.3 ± 8.1	69.0 ± 8.7
A/WT	72.8 ± 12.3	82.4 ± 14.2*,**
C	66.4 ± 11.1	65.7 ± 13.7
3.15 rad·s^{-1}		
A/CAL	41.2 ± 7.8	41.7 ± 9.5
A/WT	46.5 ± 8.8	49.7 ± 9.3
C	45.7 ± 10.7	44.5 ± 13.7
LKFXL peak torque (N·m)		
1.05 rad·s^{-1}		
A/CAL	62.7 ± 10.6	70.6 ± 10.7
A/WT	68.7 ± 12.5	77.8 ± 12.2*,**
C	72.4 ± 18.3	65.8 ± 13.7
3.15 rad·s^{-1}		
A/CAL	39.9 ± 6.7	42.4 ± 5.8
A/WT	44.6 ± 8.1	49.7 ± 10.0
C	45.4 ± 7.6	45.0 ± 10.1

† A/CAL = aerobics/calisthenics training group ($n = 12$); A/WT = aerobics/weight training group ($n = 12$); C = control group ($n = 7$); RKFLX = right knee flexors; LKFLX = left knee flexors.

* Significantly different from baseline at $p < 0.05$.

** Significantly different from control group at $p < 0.05$.

Table 8. Changes in percent of body fat following 10 wk of training or control period (mean ± *SD*).†

Group	Body mass (kg)		% Body fat	
	Pre	Post	Pre	Post
A/CAL	68.8 ± 12.6	67.9 ± 12.5	30.7 ± 6.8	30.7 ± 6.2
A/WT	61.8 ± 8.5	61.5 ± 8.0	28.0 ± 5.8	26.6 ± 5.8*
C	59.2 ± 4.6	59.0 ± 4.6	27.6 ± 3.0	27.9 ± 3.1*

† A/CAL = aerobics/calisthenics-training group ($n = 12$); A/WT = aerobics/weight-training group ($n = 12$); C = control group ($n = 7$).

* Significantly different from baseline at $p < 0.05$.

training. A slight increase was observed for the control group in this variable. There was no significant difference among the 3 groups.

Discussion

The results showed that both A-CAL and A-WT increased jumping performance. To our knowledge, there are no studies comparing the effectiveness of these different modes of training on SJ performance. The subjects of the A-CAL training group were trained with multijoint exercises. Thus, the improvement for this group may have been due to improved co-ordination. For the A-WT group, a partial explanation for the improvements in explosive strength of the trained muscles recorded at the jumping action may be related to possible training-induced changes in the voluntary or reflex induced rapid neural activation of the motor units (35). Heavy loads are required to ensure the recruitment of fast twitch motor units, which are important for dynamic performance (30). The 15% improvement reported by Hakkinen et al. (24) is similar to our findings, although the present training program did not use explosive strength training. Typical heavy resistance strength training using high resistance and slow velocities of muscle action, similar to those used in the present study, leads to primary improvements in maximal strength, and the improvements are reduced at higher velocities (19, 25). However, training adaptations may not always follow the velocity-specific training principle, depending on the training status of the individual. For individuals with low levels of strength, as those used in the present study, improvements throughout the force-velocity spectrum may be produced regardless of the training resistance or style used (26).

We hypothesized that there would be significant differences between the A-CAL and A-WT groups in peak isometric and isokinetic torque of KEXT and KFLEX. Our data show that there was no significant difference between the 2 groups following the 10-week training period. However, the A-WT group elicited significant gains in peak isometric torque of KEXT and KFLEX. A factor that may contribute to training responses for the A-WT group is the slow speed of the exercises completed during training. Slow, controlled movements were used in an attempt to minimize the influence of momentum and emphasize the eccentric portion of the movement. As it has been suggested elsewhere, exercise at slow speeds closely simulates isometric effort (28, 33).

In the present study, the peak isometric KEXT torque for the A-WT increased by 11.3% (Figures 2 and 3). Similar results have been reported by Braith et al. (7) and Young et al. (42) who applied leg extension exercise programs for 10 and 5 weeks, respectively. Using same or longer training protocols, other studies (12, 28, 37) reported increases in peak isometric torque ranging from 26.8 to 31% that are higher, compared with those found in the present study. In contrast, Fry et al. (20) did not observe any significant improvements in peak isometric torque of KEXT resulting from an 8-week weight training program.

The A-WT group demonstrated an increase of 22.7% in KFLEX, which is slightly higher, compared with 18.76 and 17.7% reported by Cureton et al. (12)

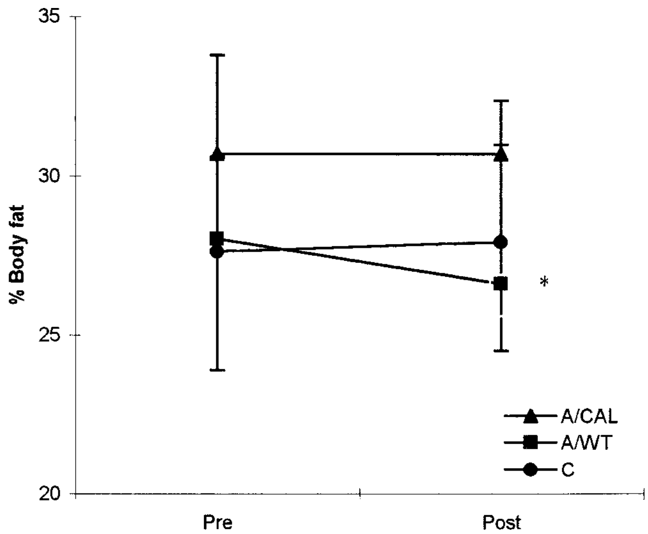

Figure 8. Pre- and posttraining values of percent of body fat for the aerobics/calisthenics (A-CAL), aerobics/weight training (A-WT), and control group (C). * $p < 0.05$ vs. baseline.

and Starkey et al. (37), respectively. Both these studies used longer training programs (14–16 weeks) and younger subjects (26–35 years), compared with the present study, and therefore the observed differences are reasonable.

There were no significant changes in KEXT torque after training for either group. These findings are similar to those of Fry et al. (20) and Cullinen and Caldwell (11), who reported insignificant isokinetic torque increases for KEXT after 8- and 12-week strength training programs, respectively.

A significant increase was observed for the A-WT group in peak isokinetic torque of KFLEX at 1.05 rad·s^{-1} (Figures 6 and 7). The fact that improvement was observed only at the slow velocity tested may have been due to the slow speed of the exercise completed during training. To our knowledge, subjects in only one other study trained their KFLEX muscles and used a testing method consistent with the exercise in this study. Cullinen and Caldwell (11) reported a 22.7% increase in peak isokinetic torque of KFLEX after a 12-week resistance training program when this tested at a velocity of 2.10 rad·s^{-1}.

The results also indicated that percentage of body fat did not differ significantly between the 2 training groups. However, the A-WT training group demonstrated a significant loss in percentage of body fat without any change in body weight (Figure 8). Thus, a favorable body composition effect was observed using aerobics combined with weight training. On the contrary, the A-CAL training group did not demonstrate any changes in this variable. Previous research in women yielded similar decreases in percentage of body fat resulting from dynamic constant external resistance training (6, 8, 11, 29, 31, 41, 42).

It should be noted that the results of the present study are specific to the characteristics of the training programs applied. More specifically, the participants performed a light resistance exercise program, corresponding 10–12 RM. The design of the resistance exercise program was based on previous ACSM position stands that adult novice lifters should use loads corresponding to 8–12 RM (2, 3). Furthermore, our subjects progressed in terms of loading because training load increased by 20%, when the subjects were able to successfully perform 3 sets of 12 repetitions. Finally, in terms of training volume, the ACSM guidelines for novice individuals were followed because a general resistance training program consisting of multiple sets was applied (2, 3). However, it must be acknowledged that that duration of the training program was relatively short (10 weeks). The above indicate that the present results are specific to the light intensity and relatively short duration of resistance exercise training program and can not be applied to the effects of resistance training on strength parameters in general. It is conceivable to postulate that longer or heavier resistance exercise programs may have results in greater improvements in the strength training group.

Practical Applications

Within the scope and limitations of this study, increased muscular strength and decreased body fat were achieved by middle-aged women participating in a 10-week aerobic and light-weight training program. In contrast, aerobic-calisthenics training has not been shown to provide the necessary stimulus to improve muscular fitness either or body composition. These findings have important practical implications for adult fitness programs and particularly for individuals with little experience in strength training. Furthermore, the light-weight training program may reduce the risk of musculoskeletal injury and enhance adherence to the exercise program. It must be noted, however, that the use of periodization in the resistance training program may be necessary to stimulate further adaptation toward higher levels of muscular strength.

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