Effects of 12 Weeks of Aerobic Circuit Training on Aerobic Capacity, Muscular Strength, and Body Composition in College-Age Women

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Reference Data

ABSTRACT
This study determined the effects of a combined aerobic and circuit weight training program on maximal oxygen consumption, body composition, and muscular strength of college-age women. Of the 33 who volunteered to participate, 17 were randomly assigned to the exercise program while the remaining 16 served as controls. The training involved a 45-min circuit of 30 activities including five 3-min aerobic exercises and 25 30-sec weight training or calisthenic exercises. The subjects exercised at 40 to 50% of their 1-RM for each weight station. Workloads for the aerobic stations were assigned based on the workload needed to elicit 75 to 85% of the maximal heart rate reached during the $\text{VO}_2$ max test. Data were analyzed using a repeated measures ANOVA with significance established at $p < 0.05$. The exercise group had significant increases in $\text{VO}_2$ max, upper body strength, and lower body strength, and significant increases in skinfold sum and percent body fat. This indicates that an aerobic circuit weight training program is an effective way to improve cardiovascular fitness, body composition, and muscular strength in college-age women.

Key Words: percent body fat, $\text{VO}_2$ max, weight training, aerobic training

Introduction
Previous studies on the effects of circuit resistance training (CRT) have shown that it may elicit a general overall conditioning effect, and several studies have reported modest gains in strength along with improvements in body composition (12, 13, 14, 24). However, CRT programs have not been found as effective as traditional aerobic training programs such as jogging for improving cardiorespiratory fitness or $\text{VO}_2$ max. The failure to produce substantial improvements in $\text{VO}_2$ max has been attributed to the low relative $\text{VO}_2$ required for circuit weight training despite the increases in heart rate during training (18).

Gettman et al. (14) combined a circuit training program with 30-sec intervals of running and found increases in $\text{VO}_2$ max along with improvements in strength. Our study was designed with longer intervals of aerobic activity as well as circuit weight training stations and large-muscle-group calisthenics. Therefore the purpose of this study was to determine the effects of a combination aerobic and circuit weight training program on cardiorespiratory fitness, body composition, and muscular strength of college-age women.

Methods
Subjects
Thirty-three women 18 to 23 years of age (20.6 ± 1.4) served as subjects for this study. Written informed consent was obtained in accordance with guidelines established by the university's human subjects committee, and each subject completed a health history and an activity questionnaire. None had any experience in moderate or intense endurance training or strength training, nor were they currently involved in any type of training on a regular basis. Seventeen subjects were randomly assigned to the aerobic circuit training group (ACT) while the remaining 16 served as a nonexercise control group.

Pretest Protocol and $\text{VO}_2$ Testing
All subjects attended two orientation sessions designed to familiarize them with the strength training equipment and the treadmill testing procedures. The ACT group attended three additional sessions to practice the activities included in the circuit.

Before and after training, all subjects completed a graded exercise test on a Quinton 2000 treadmill to determine maximal oxygen consumption, or $\text{VO}_2$ max.
running. Several factors have been shown to contribute to improvements in VO\textsubscript{2} max including exercise intensity, frequency of training, and initial fitness level of the individual prior to training (22).

The pretraining maximal values for VO\textsubscript{2} were within the average range for women of comparable age (6) and were similar to the values reported by Wilmore et al. (25). The threshold intensity of exercise needed to elicit a cardiovascular training effect has been shown to be 55 to 90% of maximal heart rate (1, 2). Exercise intensity was maintained at 75 to 85% of each individual's maximal heart rate during all aerobic activities. A unique feature of the present study was the use of five different modes of aerobic activity. The frequency, intensity, and duration of the different aerobic stations were the same and total caloric expenditure for each aerobic activity was similar. Lieber et al. (20) have demonstrated that training adaptations are independent of the mode of aerobic activity, provided that the intensity levels are equivalent.

The improvements in VO\textsubscript{2} max shown in this study indicate that the training was an adequate stimulus for enhancing maximal aerobic power. The ACT program is a form of interval training. Interval training consists of a series of short, regularly repeated periods of work interspersed with adequate rest periods. The rest interval allows for a partial restoration of energy stores, slows the accumulation of lactic acid, and delays the onset of fatigue. As a result the subject is able to accomplish greater amounts of work at a higher intensity (9, 10, 11). During the 12-week training period there were periodic adjustments in work intensity based on each individual's heart rate response to each aerobic activity.

The effects of the ACT program are further illustrated by the changes in muscular strength following training. The percentage of improvement ranged from 14% for the latissimus pull to 26% improvement (or increase) for the leg extension measurement. The improvements in bench press and leg press were 21% and 23%, respectively. Jackson et al. (19) have shown that the bench press and leg press tests are the most valid measurement of an individual's upper and lower body strength. The changes found in our study are similar to the results reported from studies that employed circuit weight training (13, 14, 25).

Although a few studies have shown that simultaneous strength and endurance training reduces the ability to increase muscular strength but does not compromise endurance conditioning, the focus of those studies was strength enhancement (7, 16, 17). In the study by Hickson (16), the training program was specifically designed to improve leg strength and the amount of weight lifted was near maximal for each session. Our purpose was to determine whether a program that combined circuit training and endurance training could lead to an improvement in overall strength and cardiovascular fitness levels. Subjects lifted between 40 and 50% of their 1-RM and were able to progressively increase the weight lifted throughout the study.

The use of circuit training that employs lighter weights and a greater number of repetitions has been shown to elicit changes of 5 to 10% in VO\textsubscript{2} max and strength improvements ranging from 8 to 30% (13). The results of our study indicated there were significant increases in both strength and endurance following the training program. Further research is needed to determine whether this type of training would elicit similar results in men and in older adults, and whether the circuit would be effective as an off-season or rehabilitation program for athletes.

**Practical Applications**

The use of a combined aerobic and circuit training program resulted in an increase in strength and cardiorespiratory fitness and a decrease in percent body fat in college-age women. This study also indicated that simultaneous aerobic and weight training of moderate intensity did not compromise either the development of strength or VO\textsubscript{2} max. This finding has important implications for the person who wants to improve overall physical fitness in a short time and fulfill the ACSM guidelines (1). It is important to note, however, that this ACT program was designed to improve overall fitness and may not be suitable for those desiring great gains in strength.

An additional advantage is that the circuit can accommodate individuals of varying fitness levels within a class setting and can be modified depending on the equipment available. For example, if treadmills are not available, rope skipping will provide an alternative aerobic activity. Our department offers several classes each semester and student comments have been very positive; the circuit is enjoyable and the program is individualized based on initial level of fitness.

**References**


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