Aerobic Exercise Training and Cardiorespiratory Fitness in Older Adults: A Randomized Control Trial

Richard A. Boileau, Edward McAuley, Demetra Demetriou, Naveen K. Devabhaktuni, Gregory L. Dykstra, Jeffery Katula, Jane Nelson, Angelo Pascale, Melissa Pena, and Heidi-Mai Talbot

A trial was conducted to examine the effect of moderate aerobic exercise training (AET) on cardiorespiratory (CR) fitness. Previously sedentary participants, age 60–75 years, were randomly assigned to either AET treatment or a control group for 6 months. The AET consisted of walking for 40 min three times/week at an intensity that elevated heart rate to 65% of maximum heart rate reserve. The control group performed a supervised stretching program for 40 min three times/week. CR fitness was assessed before and after the treatments during a grade-incremented treadmill walking test. Both absolute and relative peak $\dot{V}O_2$, significantly increased ($p < .01$) in the AET group, whereas they decreased modestly in the control group. Maximum treadmill time increased significantly ($p < .01$) in the AET group relative to the control group. These results indicate that CR fitness as measured by peak $\dot{V}O_2$ modestly improves in the elderly with a moderate-intensity, relatively long-term aerobic exercise program.

Key Words: aging, aerobic exercise, physical activity, cardiorespiratory fitness, randomized trial

Aging is characterized by functional decline in the cardiorespiratory system, as well as other body systems, resulting in diminished physical capacity for work and less independent living. The decline in physical functioning in the U.S. older adult population has been identified as a major public health problem and has elicited substantial research efforts targeted at improving the functional life span. Part of the age-related functional decline can be attributed to a pattern of decreased physical activity and an associated decrease in physical fitness as one ages. Regular physical activity is associated with maintaining and improving physical health, functional capacity, functional life span, and general well-being.

The body of evidence, both epidemiologic and experimental, is substantial in support of the positive impact of physical activity and aerobic exercise training on mortality (Blair et al., 1989; Paffenbarger et al., 1993), several chronic diseases including coronary heart disease (Powell, Thompson, Caspersen, & Ford, 1987).

The authors are with the Department of Kinesiology at the University of Illinois, Urbana-Champaign, Urbana, IL 61801.
non-insulin-dependent diabetes (Helmrich, Ragland, Leung, & Paffenbarger, 1991),
and selected cancers (Lee, Paffenbarger, & Hsieh, 1991), as well as chronic-disease
risk factors such as hypertension (Tipton, 1991), blood lipid profiles (Haskell,
1986), body composition (Bouchard, Depres, & Tremblay, 1993), bone mineral
density (Dalsky et al., 1988), glucose tolerance and insulin sensitivity (Ivy, 1987),
immune function (Nehlsen-Cannarella et al., 1991), and depression (O’Connor,
Aenchbacher, & Dishman, 1993). In spite of these positive indications, recent
estimates of adult physical activity levels meeting the Centers for Disease Control
and Prevention recommendations suggests that only 22% of the population engage
regularly in physical activity at a level necessary to obtain minimal health benefits
(Pate et al., 1995). Moreover, this level of participation is lower among the elderly.
Whereas the age-related decline in cardiorespiratory function and fitness is
well known (Buskirk & Hodgson, 1987), the specific age-related mechanisms
responsible for the decline are not well understood. Several possible explanations,
both central and peripheral, have been proposed based on comparative studies of old
and young participants, including decrements in cardiac function associated with a
decrease sympathetic drive or responsiveness, as well as a decline in peripheral
oxygen uptake related to redistribution of blood flow and an age-related decrease
in muscle mass (Stanford, 1988).

The aging cardiorespiratory system is, in general, responsive to aerobic
exercise training. A recent meta-analysis (Green & Crouse, 1995) that summarized
29 studies of adults ≥60 years of age found that, on average, maximal oxygen uptake
($\text{VO}_2\text{max}$) increased by 22% in response to aerobic exercise training. Much of the
literature, however, on which this finding is based involved studies conducted on
small, nonrandomly assigned samples or that excluded subjects with health risks or
evidence of chronic disease. An aspect uncommon to most studies is the use of an
alternative activity (i.e., nonaerobic) for the control group in order to equalize the
attention received by both groups. Furthermore, few studies have investigated
whether there is a difference in the cardiorespiratory response to exercise training
between elderly men and women.

In the present study, a randomized control trial was conducted with minimal
exclusions with respect to disease and risk factors so that the results could be applied
to a typical ambulatory older adult population. The purpose of the study was to
assess the effects of aerobic exercise training (AET) on cardiorespiratory (CR)
fitness and endurance.

**Methods**

**PARTICIPANT RECRUITMENT AND RANDOMIZATION**

Sedentary older ($M = 65.5$ years) adults were recruited through local media
advertising to participate in a 6-month, randomized, controlled exercise trial.
Inclusion criteria for participation in the program were (a) age 60–75 years; (b)
being sedentary, as defined by a lack of regular involvement in exercise during the
previous 6 months, determined by an exercise history questionnaire; (c) being
healthy to the degree that participation in exercise testing and an exercise program
would not exacerbate any existing disease condition; (d) a personal physician’s
clearance for participation; (e) adequate mental status; (f) corrected (near and far)
visual acuity of 20/40 or better; (g) no evidence of clinical depression or affective disorders; and (h) a willingness to be randomly assigned to a treatment condition.

An initial pool of 596 volunteers who indicated interest in participation were contacted by telephone for preliminary screening. Following this screening, 363 individuals were not contacted further because they did not meet the inclusion criteria. The majority of these individuals were either the wrong age or were unwilling to commit to all study protocols. Each participant was informed of all research activities and signed a consent form approved by the University of Illinois Institutional Review Board. Subsequently, voluntary withdrawals and medical exclusions resulted in 174 participants beginning the trial.

Participants were assigned to one of two treatment conditions: an AET program or a stretching and toning (control) program. The latter program served as an attention control group against which to assess the effects of the AET program. Because of the age of the group being studied, there was a high likelihood of participants’ taking a variety of prescription medications on a regular basis. Several classes of medications commonly used by older adults could have implications for physiological and psychological outcomes. From a physiological standpoint, the most commonly prescribed drugs of concern are therapies for cardiovascular disease. Therapies such as beta blockers and diuretics can reduce cardiovascular responsiveness to exercise training. From a psychological perspective, neuroleptic, antidepressant, and anxiolytic agents are the major drug classifications that can affect psychosocial and cognitive function. To limit the potential effects of imbalances between treatment groups with respect to the use of these four classes of pharmacologic agents, we employed a modification of the baseline-adaptive randomization scheme of Begg and Iglewicz (1980).

After initial simple randomization of the first 10 participants, the optimal allocation for each successive participant was determined using Begg and Iglewicz’s (1980) minimization criterion, based on binary variables distinguishing the use or nonuse of each of the four medication classes. However, because it is especially desirable to maintain a random component in the allocation of each participant in a single-institution trial such as is proposed here, a 3:1 biased coin allocation favoring the optimal choice was used for participant assignment (cf., Pocock, 1983). This process was then implemented within each stratum of important baseline variables (e.g., gender and age), thus minimizing differences between groups. A total of 153 participants completed both the interventions and the pre- and postexercise testing. However, 28 participants from this cohort did not perform valid exercise tests or had begun taking medications during the trial, which contraindicated their inclusion in the analysis. Thus, a total of 125 participants, 58 AET (13 men, 45 women) and 67 control (19 men, 48 women), successfully completed the protocol and were included in the analysis.

EXERCISE TESTING

Prior to exercise testing, each participant completed an inventory providing demographic information and details of his or her medical history and lifestyle/exercise habits. The health information obtained was used (a) to assess the individual’s risk of cardiovascular disease, (b) to determine supervisory requirements for exercise testing and training, (c) to identify potential contraindications for participation in the study, and (d) to ascertain the physical activity histories of all
participants. Determination of these factors was based on the criteria established in the American College of Sports Medicine’s (ACSM’s) Guidelines for Exercise Testing and Training (1995). The assessment of activity histories was a very simple self-reporting of average days per week spent exercising, average number of minutes per exercise session (0 = none, 1 = less than 5 min, 2 = 5–15 min, 3 = 20+ min), and average intensity of a typical bout (0 = none, 1 = easy, 2 = moderate, 3 = somewhat difficult, 4 = hard). This information was used to corroborate the participants’ sedentary status. Participants were certified for exercise testing based on the above information, as well as their personal physicians’ recommendations and the research physician’s evaluation of both resting and exercise EKG and blood pressure.

Pre- and postintervention testing were conducted during a walking graded exercise test to assess the effect of the interventions on cardiorespiratory function and endurance performance. Specifically, oxygen uptake (VO₂) and heart rate (HR) were measured during both submaximal and maximal treadmill walking on a motorized treadmill by employing a modified Balke protocol (ACSM, 1995). The protocol involved walking at a speed of 2–3 mph with increasing grade increments of 2% every 2 min. VO₂ and HR were measured continuously every minute, and blood pressure was measured during the 2nd min of each workload until the test was voluntarily terminated by the participant because of volitional exhaustion. Peak VO₂ was assessed and defined as the highest attainable VO₂ during a maximal effort on the graded exercise test. The peak VO₂ was adopted because only 66% of the 125 participants attained a verifiable VO₂max in which a plateau in VO₂ was demonstrated between two or more work levels. In order for a maximal effort to be verified, two of three criteria had to be met, including (a) a plateau in VO₂ between two or more workloads, (b) a respiratory exchange ratio ≥1.05, and (c) a heart rate ≥95% of the age-predicted maximum (i.e., 220 – age).

VO₂ was determined from expired air sampled by open-circuit spirometry using an on-line, computer-based acquisition system. Participants breathed through a two-way, high-velocity nonrebreathing valve (Hans Rudolph Model 2700). The volume of expired air was measured by a gas-flow meter (KL Engineering Model S-430). The oxygen and carbon dioxide concentrations of expired air were assessed by Ametek (Pittsburgh, PA) oxygen (Model S-3A1) and carbon dioxide (Model CD-3A) analyzers. Analyzers were calibrated prior to and during each testing session using gases of known concentrations. Data from the gas analyzers and flow meter were converted to digital signals and sent to an IBM-compatible PC for calculation of VO₂ converted to STPD on a minute-by-minute basis. HR was measured during each work stage through continuous, direct, 12-lead electrocardiographic monitoring. Blood pressure was measured by auscultation and a sphygmomanometer. A research physician and nurse monitored and supervised all aspects of the graded exercise testing. Endurance performance was the maximum amount of time the participant walked on the treadmill during the graded exercise test.

EXERCISE TRAINING

After completing the baseline exercise testing, participants began a three-sessions-per-week, 6-month regimen of either AET or a stretching/toning program. The programs were conducted separately, with attendance recorded to monitor adherence to treatment.
The AET program followed the ACSM (1995) guidelines consisting of a warm-up period; a moderate, prescribed walking program; and a cool-down period. The duration of the prescribed walking aspect was gradually increased from 15 min initially to 40 min by the 12th week and maintained at that duration per session through the 24th week. The initial exercise intensity was set at 50% of heart rate reserve (HRR), based on a resting HR taken prior to the exercise test and a maximal HR obtained during exercise testing. This intensity was gradually increased to 65% at the 12th week and maintained at that level throughout the duration of the intervention. Participants were trained to take resting and exercise heart rates so that they could regularly monitor HRR-based intensity, and they reported their rating of perceived exertion, as well. Logs were kept of each exercise session to monitor participant compliance to the exercise prescription.

The control group underwent a stretching/toning regimen that provided a similar amount of attention from exercise leaders as in the AET group. Each session lasted 40 min and included warm-up, stretching/toning exercises according to procedures described by Hockey (1993), and a cool-down period.

STATISTICAL ANALYSIS

Statistical analysis was conducted with SPSS version 6.1.4. Means and standard errors of mean (SEMs) are reported unless otherwise noted. A $2 \times 2$ analysis of covariance was employed to evaluate the effect of the interventions on cardiorespiratory function and endurance. The main effects of intervention (AET vs. control) and gender (male vs. female) and the interaction of the main effects were evaluated for each parameter. The pretraining value was used as the covariate, and the change from pre- to posttraining of each respective parameter was the dependent variable. A probability of $p \leq .05$ was used to determine statistical significance.

Results

PARTICIPANT CHARACTERISTICS

The initial physical characteristics of the participants by treatment and gender are shown in Table 1. The treatment groups were similar in age, height, weight, and body mass index (BMI) at baseline. The mean BMI values of 29.1 and 29.2 kg/m$^2$ for the AET and control groups, respectively, were substantially above the minimum overweight classification values of $\geq 27.8$ for men and $\geq 27.3$ for women used in NHANES analyses (Kuczynski, Flegal, Campbell, & Johnson, 1994). The generally low peak VO$_2$ of 21.7 ml·kg$^{-1}$·min$^{-1}$ for the total sample (see Table 2) corroborates the self-reported activity status of the group, who reported being active less than twice a week ($M = 1.15$, $SD = 1.80$) for less than 15 min per session at an easy to moderate intensity.

EXERCISE ADHERENCE

Substantial effort was made to minimize potential attrition during the course of this study. Strategies that have been effectively employed in other studies were instituted at the onset of the interventions, for example, maximizing self-efficacy
Table 1 Initial Physical Characteristics of the Participants

<table>
<thead>
<tr>
<th>Variable</th>
<th>AET Group</th>
<th>Control Group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total</td>
<td>Women (n = 45)</td>
</tr>
<tr>
<td>Age, years</td>
<td></td>
<td></td>
</tr>
<tr>
<td>M</td>
<td>67.4</td>
<td>67.8</td>
</tr>
<tr>
<td>SEM</td>
<td>0.7</td>
<td>0.8</td>
</tr>
<tr>
<td>Height, cm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>M</td>
<td>164.1</td>
<td>160.5</td>
</tr>
<tr>
<td>SEM</td>
<td>1.1</td>
<td>0.8</td>
</tr>
<tr>
<td>Weight, kg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>M</td>
<td>78.2</td>
<td>74.5</td>
</tr>
<tr>
<td>SEM</td>
<td>1.9</td>
<td>2.0</td>
</tr>
<tr>
<td>BMI, kg/m²</td>
<td></td>
<td></td>
</tr>
<tr>
<td>M</td>
<td>29.1</td>
<td>29.0</td>
</tr>
<tr>
<td>SEM</td>
<td>0.6</td>
<td>0.8</td>
</tr>
</tbody>
</table>

Note. AET = aerobic exercise training, BMI = body mass index, M = mean, SEM = standard error of the mean.

for exercise, promoting social support, and interpreting physiological responses (McAuley, Courneya, Rudolph, & Lox, 1994). These strategies were promoted via constant feedback relative to progress; establishment of buddy groups; monthly group socials following activity, with juices and health snacks provided; potluck dinners; and prizes. The overall adherence rate was 81% in terms of participants completing the program. Attendance rates did not differ significantly between treatment conditions (t = .88, p > .30). The program consisted of 70 activity days, with the mean number of days attended being 56.67 (±1.3). The mean number of days of attendance by condition was 55.72 (±1.9) for the AET group and 57.61 (±1.6) for the control group.

CARDIORESPIRATORY FITNESS AND ENDURANCE PERFORMANCE

Results of the effect of the intervention on selected resting and maximal variables are detailed in Table 2. The overall decreases observed in resting HR, blood pressure, and maximal HR were similar between treatment groups, indicating no intervention effect on these measures. Both absolute (l/min) and relative (ml·kg⁻¹·min⁻¹) peak VO₂ increased significantly (p < .01), however, by 4.2% and 5.1%, respectively, in the AET group relative to the decrements of -2.1% and -2.8% in the control group for the two expressions. Body weight significantly (p < .02) decreased in the AET group (-2.1%) relative to the decrease observed in the control group (-1.1%). The changes in body weight explain the difference in the peak VO₂ percentage change between the absolute and relative expressions for the treatment
<table>
<thead>
<tr>
<th>Variable</th>
<th>AET Group</th>
<th>Control Group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total (n = 58)</td>
<td>Women (n = 45)</td>
</tr>
<tr>
<td>Peak $\dot{V}O_2$, l/min</td>
<td></td>
<td></td>
</tr>
<tr>
<td>pre</td>
<td>1.68 ± 0.07</td>
<td>1.49 ± 0.05</td>
</tr>
<tr>
<td>diff</td>
<td>0.07 ± 0.03*</td>
<td>0.04 ± 0.02*</td>
</tr>
<tr>
<td>Peak $\dot{V}O_2$, ml·kg$^{-1}$·min$^{-1}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>pre</td>
<td>21.6 ± 0.7</td>
<td>20.3 ± 0.7</td>
</tr>
<tr>
<td>diff</td>
<td>1.05 ± 0.3*</td>
<td>0.70 ± 2.3*</td>
</tr>
<tr>
<td>Peak $O_2$ pulse, ml/beat</td>
<td></td>
<td></td>
</tr>
<tr>
<td>pre</td>
<td>10.9 ± 0.4</td>
<td>9.8 ± 0.3</td>
</tr>
<tr>
<td>diff</td>
<td>0.49 ± 1.3</td>
<td>0.28 ± 0.2</td>
</tr>
<tr>
<td>HR max, b/min</td>
<td></td>
<td></td>
</tr>
<tr>
<td>pre</td>
<td>154.8 ± 2.2</td>
<td>153.8 ± 2.6</td>
</tr>
<tr>
<td>diff</td>
<td>-0.5 ± 1.4</td>
<td>-0.3 ± 1.6</td>
</tr>
<tr>
<td>Max walk time, min</td>
<td></td>
<td></td>
</tr>
<tr>
<td>pre</td>
<td>11.7 ± 3.0</td>
<td>11.0 ± 2.8</td>
</tr>
<tr>
<td>diff</td>
<td>1.4 ± 0.3*</td>
<td>1.4 ± 0.4*</td>
</tr>
<tr>
<td>HR rest, b/min</td>
<td></td>
<td></td>
</tr>
<tr>
<td>pre</td>
<td>77.3 ± 1.5</td>
<td>77.7 ± 1.7</td>
</tr>
<tr>
<td>diff</td>
<td>-4.7 ± 1.4</td>
<td>-3.7 ± 1.6</td>
</tr>
<tr>
<td>BP syst, mm Hg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>pre</td>
<td>139.6 ± 3.0</td>
<td>139.8 ± 3.6</td>
</tr>
<tr>
<td>diff</td>
<td>-2.7 ± 2.9</td>
<td>-2.9 ± 3.5</td>
</tr>
<tr>
<td>BP diast, mm Hg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>pre</td>
<td>83.2 ± 1.3</td>
<td>83.1 ± 1.6</td>
</tr>
<tr>
<td>diff</td>
<td>-4.7 ± 1.2</td>
<td>-4.2 ± 1.5</td>
</tr>
</tbody>
</table>

*Note. $\dot{V}O_2$ = oxygen uptake, HR = heart rate, BP syst = resting systolic blood pressure, BP diast = resting diastolic blood pressure. *Mean difference between pre- and postexercise training is statistically significant at $p < .01$ between AET and control groups. There was no gender-by-treatment interaction ($p > .05$).
groups. When comparing the difference between the changes in treadmill walking time for the AET and control groups, the 12.1% increase observed in the AET group was significantly greater than the 1.8% increase in the control group. No treatment-by-gender interaction was observed \((p > .05)\) for any of the cardiorespiratory function or endurance performance variables.

After the intervention programs, all participants were interviewed by telephone regarding the extent to which they had been involved in additional aerobic physical activity outside the structured interventions. Participants who had been active outside the program during the trial indicated the number of times per week, minutes per session, and type of activity in which they had engaged. To determine whether self-reported additional activity influenced changes in physical fitness, we compared the physiological responses of those who did and did not report extra activity within the two treatment conditions. Of the 125 participants completing the trial, 115 responded to the questionnaire—55 AET and 60 control. In the AET group, 10 reported some additional activity and 45 no activity, whereas in the control group 22 reported engaging in additional activity and 38 reported none. This cohort of 115 participants was further analyzed by subgroup within the AET and control groups to assess the influence of additional aerobic physical activity on peak \(\dot{V}O_2\) and maximum treadmill walk time. The results are presented in Figure 1. Although the increases in peak \(\dot{V}O_2\) with additional physical activity within the AET and control groups were not statistically significant \((p > .05)\), the increase in peak \(\dot{V}O_2\) is about 90% greater in the AET group with additional activity, and the decrease in the control group is less with additional aerobic activity than with no

![Figure 1](image)

**Figure 1.** The influence of additional aerobic exercise (+AE) on peak \(\dot{V}O_2\) and maximal treadmill (TM) walk time. Within the AET group, 10 (18%) reported some additional aerobic activity and 45 no activity, whereas in the control group 22 (37%) reported engaging in additional aerobic activity and 38 no activity.
additional aerobic activity. Somewhat similar results can be seen for maximal treadmill walk time.

**Discussion**

Previously sedentary older adults randomly assigned to either an aerobic exercise training program or a control treatment of stretching/toning exercise were studied over a 6-month period. Significant efforts were made to maintain the two cohorts by using an array of strategies that have been useful in previous trials (King et al., 1992; McAuley et al., 1994). The potential for substantial attrition, often approaching 50% in the first 6 months of the initiation of exercise training, is well documented (Dishman, 1994). The overall adherence rate of 81% for this study, similar for both treatment groups, suggests that the strategies for maintaining interest and attendance in the interventions were quite successful.

The data presented indicate that regular, moderate aerobic exercise consisting of a structured walking program can improve cardiorespiratory fitness, as evidenced by improvement in both peak VO\(_2\) and endurance performance. A unique feature of this study was the use of a control condition in which the participants received similar attention/supervision to that provided to the AET group. This allowed the two groups to be more effectively compared. It is noteworthy that a program of stretching/toning exercise did not prevent a small decline in peak VO\(_2\) over the 6-month intervention trial. The increase in relative peak VO\(_2\) of 5.1% in the AET group was similar to the 6-month improvement in the high-intensity, group-based and home-based cohorts observed by King, Haskell, Taylor, Kraemer, and DeBusk (1991) in a community-based clinical trial of older adults. They also observed a decrease in peak VO\(_2\) in their control group. On the other hand, Swoap, Norvell, Graves, and Pollock (1994) reported much higher VO\(_2\)max responses in older adults training at moderate (16.5%) and high intensity (23.8%) over a 6-month period.

In the present study, the significant increase observed in peak VO\(_2\) of 5.1% in the AET group, relative to the decline of -2.8% in the control group, represents a net change of 7.9%, a value considerably lower than the mean value of 22% reported by Green and Crouse (1995) in a meta-analysis of 29 aerobic-training studies on older adults. The effect size for the present study, computed as the mean difference between the AET and control group changes divided by the pooled standard deviation of the mean difference, was 0.66 and is below the median of the studies analyzed by Green and Crouse. Nonetheless, this difference is considered a moderate-size effect (Cohen, 1977), and the exercise protocol probably represents one that older individuals are likely to maintain. Other evidence of improved cardiorespiratory fitness was the significant increase of 1.4 min (12.1%) in treadmill walk time in the AET group, compared with an increase of 0.2 min (1.8%) in the control group.

There are several possible explanations for the smaller changes in peak VO\(_2\) observed in this study. Many studies screen and exclude participants with underlying pathological conditions and significant risk factors. Although our exclusion criteria certainly eliminated individuals for whom stress testing and supervised exercise were medically contraindicated, our inclusion criteria were quite liberal. Evidence
of this includes the number of participants reporting significant medical conditions (10.2% cardiovascular disease, 35% hypertension, 22% arthritis, 11.2% diabetes, and 11% cancer) and the percentage (approximately 25%) of participants taking one or more medications for various chronic diseases and risk factors. In addition, the fact that the cohort in general was significantly overweight (mean BMI > 29 kg/m²) necessitated a more deliberate and moderate approach to the AET program. Although the participants were quite compliant with the exercise prescription, the volume and intensity of training were by necessity moderate, which might have limited somewhat the magnitude of improvement in observed peak VO₂. It is possible that a substantially higher exercise-training intensity could have produced larger increases in peak VO₂. However, we would argue that high-intensity training programs are unlikely to result in behavior that is maintained in the long term by older adults, particularly once the program is terminated and the onus is on the individual to exercise on his or her own.

Improved cardiorespiratory function and fitness were observed during maximal exercise, but no significant changes during intervention were found in resting HR or resting blood pressure or in submaximal exercise HR or VO₂ responses. Although not statistically different, there was some indication of a greater decrease in the AET group than in the control group for both resting and submaximal exercise HR. Thus, we were not able to confirm the results of other studies showing training-related decrements in resting and submaximal exercise HR or systolic blood pressure (Blumenthal et al., 1989; Hardman, Jones, Norgan, & Hudson, 1992; Sidney & Shephard, 1978; Stanford, 1973).

Our recruitment efforts resulted in an imbalance in men and women entered and randomized into the study. Women represented 78% of the AET group and 72% of the control group. Although there was no significant interaction of gender by treatment, there was a significant \( p < .01 \) training-induced gender effect. The peak VO₂ (ml · kg⁻¹ · min⁻¹) increased significantly more for men (8.8%) than for the women (3.4%), whereas the decrease for women (−3.1%) was slightly more than it was for the men (−1.9%) in the control group. It is possible that the imbalance in gender within the treatment conditions influenced the gender effect seen in this study. Nonetheless, the significantly greater increase in peak VO₂ for men supports observations of King et al. (1991) in their high-intensity group-based cohort but contradicts the observations of other studies, in which training effects of men and women were similar (Posner, Gorman, Klein, & Woldow, 1986).

Finally, the influence of additional physical activity was investigated by a questionnaire after completion of the 6-month treatment programs. The total response was 92%, with 18% of the AET group and 37% of the controls reporting having engaged in additional physical activity. The 18% in the AET group who engaged in physical activity outside the structured intervention averaged 3.2 ± 2.2 days/week and 21.9 min/day additional activity. The 37% in the control group averaged 3.0 ± 1.3 days/week and 103.1 ± 61.8 min/day additional activity.² Whereas participants in the AET group engaging in additional physical activity showed an 8.8% and 14% increase in peak VO₂ and maximal treadmill walk time,

²It should be noted that these statistics are skewed by a few individuals who spent several hours per day golfing.
respectively, compared with the 4.5% and 10% of those who did not engage in additional physical activity, the differences were not statistically significant. Similar results were observed for peak VO₂ in the control group. Despite the lack of statistically significant differences between groups engaging in additional physical activity within the respective treatment groups, there was some indication that those who engaged in more physical activity over the experimental period realized more cardiorespiratory fitness benefits.

In summary, this study has demonstrated that moderate aerobic exercise training improves cardiorespiratory fitness and endurance in older adults. In this study, men improved more than women did. Moreover, evidence is provided that the moderate exercise intensity employed in this study could enable the maintenance of reasonably high adherence rates in relatively long-duration exercise trials.

References


**Acknowledgment**

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