Exercise training in a predominantly African-American group of stroke survivors

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ABSTRACT

RIMMER, J. H., B. RILEY, T. CREVISTON, and T. NICOLA. Exercise training in a predominantly African-American group of stroke survivors. Med. Sci. Sports Exerc., Vol. 32, No. 12, 2000, pp. 1990 –1996. Purpose: The purpose of this study was to determine the effects of a 12-wk exercise training program in a predominantly African-American group of stroke survivors with multiple comorbidities. Methods: A lag-control group design was employed to provide training to all participants (N = 35). Two 12-wk training iterations were arranged. Participants trained 3 d·wk⁻¹ for 60 min·d⁻¹ (cardiovascular, 30 min; strength, 20 min; flexibility, 10 min). Outcome measures included peak VO₂ (mL·min⁻¹, mL·kg⁻¹·min⁻¹), maximal workload (MW), time to exhaustion (TTE), 10 RM on two LifeFitness strength machines, grip strength (GS), body weight (BW), total skinfolds (TS), waist to hip ratio (WHR), hamstring/low back flexibility (HLBF), and shoulder flexibility (SF). Results: Compared with controls, the exercise group showed significant gains in peak VO₂ (P < 0.01), strength (P < 0.01), HLBF (P < 0.01), and body composition (BW and BMI, P < 0.05; TS, P < 0.01). There was no significant difference between exercise and controls on WHR, SF, and GS. Discussion: A supervised exercise training program for stroke survivors with multiple comorbidities was highly effective in improving overall fitness, potentially reducing the risk of further disease and disability. Greater effort must be made on the part of the public health community to increase access to community-based physical activity programs for persons with stroke. Key Words: STROKE, CEREBROVASCULAR ACCIDENT, CVA, EXERCISE TRAINING, PHYSICAL ACTIVITY, PHYSICAL FITNESS, DISABILITY, HEALTH PROMOTION

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stroke is the third leading cause of death in the United States and the leading cause of neurological disability (6). In the United States alone, there are an estimated 731,000 strokes that occur each year and approximately 4 million stroke survivors (10). Although stroke affects people of all races and in all parts of the world, there is a disproportionately higher incidence among African-Americans (4).

People who survive a stroke must often live with significant physical limitations (9,14,21). Secondary conditions associated with stroke include paralysis, decreased mobility, low fitness, and depression (24). Multiple comorbidities are also found among stroke survivors. These include hypertension, hyperlipidemia, coronary heart disease, diabetes, and obesity (9,17). The synergy between the loss of physical function and an exacerbation of comorbidities severely compromises the physical independence and overall quality of life of stroke survivors (33).

Information on the effects of exercise training to improve fitness in persons with stroke, and more specifically in African-Americans with stroke, is lacking (20,22,31). Because the prevalence of stroke and its cardiovascular sequelae is higher in African-Americans than whites (4), interventions aimed at this population are particularly important. The purpose of this study was to determine the effects of a 12-wk exercise training program in a predominantly African-American group of stroke survivors with multiple comorbidities. Our hypothesis was that an intensive training program would improve overall fitness in persons with stroke.

METHODS

Study Participants

Participants were 35 stroke survivors (9 male, 26 female, mean age = 53.2 yr ± 8.3) recruited from several local hospitals and clinics in the Chicago area. The following eligibility criteria were used: (a) age 30-70 yr; (b) able to walk a minimum of 50 feet with or without an assistive aid; (c) poststroke at least 6 months; (d) serve as their own guardian; (e) reside within a 1-h commute of the intervention site; and (f) written permission of primary care physician. Sixty-two participants met the eligibility criteria. Thirty-five participants were randomly selected and agreed to enroll in the study.

Participants were transported by van to a university-based fitness center to receive their exercise program. After a thorough explanation of the study, all participants signed an informed consent that was approved by the Office for the
Protection of Research Subjects (OPRS) at the University of Illinois at Chicago.

Screening Protocol

Participants were transported to the Clinical Research Center at the University of Illinois at Chicago Medical Center to perform a fasting blood draw, resting ECG, resting heart rate, resting blood pressure (standing, seated, supine), and basal temperature by nursing staff at the hospital. Participants were given explicit directions on how to prepare for each visit. Project staff called participants the night before their scheduled visit to remind them that they had to fast before their blood test. To be approved for peak VO₂ testing, participants' blood screening tests (i.e., CBC, electrolytes, coagulants) had to be within normal limits. If the preliminary blood work was acceptable, the participants returned for a second visit to perform a graded exercise test. Participants who completed the graded exercise test were then scheduled for a third appointment, which included the remainder of fitness testing (flexibility and strength).

Exercise Testing and Measurements

Peak oxygen uptake (cardiovascular fitness). A symptom-limited graded exercise test (peak VO₂) was performed on a electronically braked upright stationary cycle (SensorMedics Ergometrics 800, Yorba Linda, CA). Lying, seated, and standing blood pressure, and resting heart rate, were recorded before peak VO₂ testing. Peak VO₂ was assessed with a SensorMedics 2900 Metabolic Cart (Yorba Linda, CA) under the supervision of a physician and exercise physiologist. The machine was calibrated before each test with standard gases. Heart rate was monitored continuously with a Marquette Max-1 12-lead ECG machine (Milwaukee, WI).

All tests were conducted with a workload controlled by the metabolic cart. A ramp cycle ergometer testing protocol was used, which allowed participants to begin cycling at a workload of 20 W and increased by 10 W every minute until maximal effort was achieved. Participants were instructed to pedal at 60 revolutions per minute (rev·m⁻¹). Heart rate and blood pressure were recorded every 2 min. Tests were terminated if one or more of the following criteria were observed: (a) respiratory exchange ratio (RER) ≥ 1.1; (b) peak heart rate within ± 10 beat·min⁻¹ of age-predicted maximal value; (c) abnormal blood pressure response or ECG reading; or (d) unable to continue pedaling above 50 rpm.

Strength. Strength was assessed on the LifeFitness (Franklin Park, IL) bench press and seated leg press machines. Participants were instructed on proper lifting technique before being tested. The participants performed a 10 repetition maximum (10 RM) on each machine. Strength assessment was conducted on separate days from the peak VO₂ tests. Handgrip strength was measured with a Grip-A handgrip dynamometer (Tokyo, Japan). Participants were allowed three attempts with each hand and the best score was recorded.

Flexibility. Hamstring and low back flexibility was assessed with a modified sit and reach test. Participants were asked to sit on a bench with their legs fully extended and their feet placed flat against a sit and reach box. Participants extended their arms and reached for their feet. The distance from the middle finger to the center of the box was recorded for each of three trials and the best score was used.

Body composition. Height, weight, skin-fold measures, and waist to hip ratio (WHR) were recorded by a trained tester using the procedures of Lohman et al. (16). Skinfold measurements were taken with a Harpenden skinfold caliper (West Sussex, England) at the chest, abdomen, and thigh locations for men, and triceps, suprailliac, and thigh locations for women. The sum of the three measures was used as the actual score.

Exercise Training Protocol

The goal of the training program was to have each participant engage in an hour a day of physical activity, 3 days a week. The exercise intervention consisted of the following components: cardiovascular endurance (30 min), muscle strength and endurance (20 min), and flexibility (10 min). During the first 2 wk of the study, participants went through an educational program that included instruction in measuring their own rating of perceived exertion (RPE), using the equipment safely, and understanding the warning signs for when to stop exercising (i.e., chest discomfort, dizziness). During weeks 3 and 4, emphasis was placed on reaching and maintaining their prescribed training levels on one or more of the following machines: recumbent stepper, upright stepper, stationary cycle (recumbent and upright), treadmill, and elliptical Cross-Trainer. Participants selected their own equipment. By week 5, participants began exercising in their designated training zone, provided the target heart rate range (THRR), rate/pressure product (RPP), and blood pressure (BP) were within prescribed limits.

The intensity level of the strength and cardiovascular components were established for each participant by the medical director of the project. Intensity level for the cardiovascular exercise was based on the participants’ laboratory peak VO₂ measure. The heart rate that the participant attained at a respiratory exchange ratio (RER) of 1.00 was used to set the THRR. Five beats·min⁻¹ was subtracted from this value, and the THRR for the participants was then set at this heart rate to10 beats·min⁻¹ below this heart rate. For example, if a participant’s heart rate was 130 beats·min⁻¹ at an RER = 1.00, subtracting 5 beats·min⁻¹ from this value would put the ceiling heart rate at 125 beats·min⁻¹. The THRR was then set at 115–125 beats·min⁻¹.

Participants who had an abnormal blood pressure response during the exercise test (systolic BP ≥ 220, diastolic BP ≥ 110 mm Hg) had a modification to their exercise prescription. They were instructed not to exceed a rate pressure product (RPP) (systolic BP × HR) of greater than 200. The RPP was calculated by multiplying HR × SBP divided by 100. For example, if a participant’s blood pressure response during an exercise session was 180 mm Hg at
a heart rate of 130 beats-min⁻¹, the RPP would be 180 × 130/100, or 234. Because the value is over 200, the work-
load was decreased to allow RPP to fall below 200. Two
participants used only RPP to gauge their exercise intensity,
whereas the remaining participants (N = 33) used it in
conjunction with their THR.

Strength training was initiated at 70% of the participants’
10 RM for one set of 15–20 repetitions. When participants
were able to complete 25 repetitions for two consecutive
sessions with proper lifting technique (i.e., proper biome-

cchanical motion, avoidance of Valsalva maneuver),
the weight was increased by 10% of their 10 RM. Participants
were instructed that the last two repetitions should feel
somewhat hard on the RPE scale (12–13). Participants
trained on the following LifeFitness (Franklin Park, IL)
equipment: bench press, seated leg press, seated leg curl,
triceps push-down, seated shoulder press, seated row, lat
pull-down, and biceps curl. Blood pressure and RPE were
recorded at the completion of each set.

Participants were taught a variety of stretching exercises
for upper and lower body muscle groups. They stretched
at the beginning of each exercise session, at the end of the
cardiovascular exercise session, between strength exercises,
and at the end of the exercise session. Stretches were held
for 15–30 s.

Monitoring the Exercise Sessions

Exercise sessions were supervised by an exercise physi-
ologist, a graduate research assistant, two undergraduate
interns in exercise physiology, and three volunteers.
The medical director was on call to answer any questions that
staff had pertaining to a specific participant. Each staff
member supervised one to three participants. Participants
wore Polar Vantage XL heart watch monitors (Port Wash-
ington, NY) to assure that they were exercising in the
appropriate target heart rate zone.

When participants arrived to the exercise facility, resting
blood pressure and heart rate were recorded. Participants’
esting diastolic blood pressure (DBP) had to be less
than100 mm Hg to begin exercising. Exercise was termi-
nated if blood pressure reached 220/110 mm Hg or higher
and was only resumed when blood pressure dropped below
this value. Blood pressure, heart rate, and RPE were re-
corded every 10 min during the exercise session.
Participants with diabetes were required to bring their own porta-
able glucometer and take a blood glucose measurement
before and after the exercise class. Orange juice was avail-
able for participants who became hypoglycemic (<50
mg·dL⁻¹).

Research Design and Statistical Methods

The present study employed a pretest/posttest lag control
group design with two 12-wk iterations. During the first
iteration, 18 participants received the health promotion in-
tervention and 17 participants served as lag controls. Both
groups were assessed before (pretest) and after (posttest 1)
the first iteration. Participants who served as lag controls

(N = 17) received the health promotion intervention during
iteration 2 and were assessed a third time at the end of this
iteration (posttest 2). This design was chosen as an ethical
means of assessing the efficacy of the health promotion
intervention without withholding treatment from research
participants. A series of 2 (treatment vs control) × 2 (pre vs
post) mixed factorial analyses of variance (ANOVA)s were
conducted to assess the effects of the exercise intervention
on body composition, cardiovascular, strength, and flexibil-
ity outcomes. The statistical package used to perform these
analyses was SPSS version 9.0.

RESULTS

Descriptive data on the subjects are presented in Table 1.
The majority of subjects were African-American (88.6%),
women (74.3%), unemployed (60%) or retired (40%), and
overweight (14.3%) or obese (65.7%). The major self-re-
ported chronic secondary conditions included hypertension
(62.9%), back pain (54.3%), arthritis (44.7%), hyperlipid-
emia (40%), depression (40%), and diabetes (25.7%). Par-
ticipants in the study reported using a number of assistive
devices to enhance mobility, including the use of a cane
(54.3%), braces (31.4%), walker (20.0%), and/or wheelchair
(11.4%). Table 2 presents means and standard deviations on
each of the outcome measures stratified by experimental
group, and Table 3 presents the results of the analyses.

Cardiovascular fitness. Six subjects were excluded
from analysis of cardiovascular outcomes due to the follow-

† Some subjects used more than one assistive device.

TABLE 1. Sample demographics (N = 35).

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>SD</th>
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</thead>
<tbody>
<tr>
<td>Age</td>
<td>53.17</td>
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</tr>
<tr>
<td>BMI</td>
<td>32.75</td>
<td>8.36</td>
</tr>
<tr>
<td>No. of chronic conditions</td>
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<td>2.16</td>
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<tr>
<td>Gender</td>
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<td></td>
</tr>
<tr>
<td>Male</td>
<td>9</td>
<td>25.7</td>
</tr>
<tr>
<td>Female</td>
<td>26</td>
<td>74.3</td>
</tr>
<tr>
<td>Ethnicity</td>
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<td></td>
</tr>
<tr>
<td>African-American</td>
<td>31</td>
<td>88.6</td>
</tr>
<tr>
<td>White</td>
<td>2</td>
<td>5.7</td>
</tr>
<tr>
<td>Hispanic</td>
<td>2</td>
<td>5.7</td>
</tr>
<tr>
<td>Chronic conditions</td>
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<td></td>
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<tr>
<td>Hypertension</td>
<td>22</td>
<td>62.9</td>
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<tr>
<td>Back pain</td>
<td>19</td>
<td>54.3</td>
</tr>
<tr>
<td>Arthritis</td>
<td>16</td>
<td>44.7</td>
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<tr>
<td>Hyperlipidemia</td>
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<td>40.0</td>
</tr>
<tr>
<td>Depression</td>
<td>14</td>
<td>40.0</td>
</tr>
<tr>
<td>Diabetes</td>
<td>9</td>
<td>25.7</td>
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<td>Weight category*</td>
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<tr>
<td>Normal weight</td>
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<tr>
<td>Overweight</td>
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<td>14.3</td>
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<tr>
<td>Obese</td>
<td>23</td>
<td>65.7</td>
</tr>
<tr>
<td>Assistive device use*</td>
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<td></td>
</tr>
<tr>
<td>Cane</td>
<td>19</td>
<td>54.3</td>
</tr>
<tr>
<td>Braces</td>
<td>11</td>
<td>31.4</td>
</tr>
<tr>
<td>Walker</td>
<td>7</td>
<td>20.0</td>
</tr>
<tr>
<td>Wheelchair</td>
<td>4</td>
<td>11.4</td>
</tr>
</tbody>
</table>

* Overweight-BMI = 25–29.9 kg·m⁻²; obesity - BMI ≥ 30 kg·m⁻² (ref. 7).
interactions were observed on the following cardiovascular outcomes: peak VO\(_2\) (mL·min\(^{-1}\)), \(F(1,40) = 20.72, P < 0.01\), \(ES = 0.34\); mL·kg\(^{-1}\)·min\(^{-1}\)–F (1,40) = 19.58, \(P < 0.01\), \(ES = 0.33\); time to exhaustion, \(F(1,40) = 8.49, P < 0.01\), \(ES = 0.18\); and maximum workload, \(F(1,40) = 16.53, P < .0.05\), \(ES = 0.29\). Post hoc comparisons (dependent \(t\) tests) revealed that absolute (mL·min\(^{-1}\)) and relative (mL·kg\(^{-1}\)·min\(^{-1}\)) peak VO\(_2\) increased significantly for treatment group (absolute—\(t\) (28) = 4.14, \(P < 0.01\); relative—\(t\) (28) = 4.02, \(P < 0.01\)) and decreased significantly for controls (absolute—\(t\) (12) = 2.51, \(P < 0.05\); relative—\(t\) (12) = 2.36, \(P < 0.05\)). Treatment group subjects made significant gains on time to exhaustion (\(t\) (29) = −6.01, \(P < 0.01\)) and maximum workload (\(t\) (29) = −7.69, \(P < 0.01\)), whereas controls showed no change.

Muscular strength and endurance. Pre/post changes on muscular strength and endurance as measured by bench press, leg press, and hand grip exercises were evaluated. Significant group \(\times\) time interactions were observed on bench press. (\(F(1,46) = 22.77, P < 0.01\), \(ES = 0.33\)) and leg press. (\(F(1,46) = 108.59, P < 0.01\), \(ES = 0.70\)). Unlike controls, treatment group subjects evidenced significant gains in strength and endurance on the bench press (\(t\) (30) = −6.32, \(P < 0.01\)) and leg press machines (\(t\) (30) = −15.69, \(P < 0.01\)). Group \(\times\) time interactions on hand grip (both affected and unaffected side) were nonsignificant, though a significant time effect was observed for hand grip (unaffected) (\(F(1,45) = 9.74, P < 0.01\), \(ES = 0.18\)).

Flexibility. A significant group \(\times\) time interaction effect was observed on the sit and reach test (\(F(1,45) = 8.14, P < 0.01\), \(ES = 0.15\)). In contrast to controls, treatment group subjects evidenced significant gains in hamstring and low back flexibility (\(t\) (30) = −3.97, \(P < 0.01\)). No significant interaction effects were observed for shoulder flexibility (affected and unaffected side), though a significant time main effect was found on the unaffected side (\(F(1,45) = 7.24, P < 0.01\), \(ES = 0.14\)).

Body composition. Significant group \(\times\) time interactions were observed on the following measures: body weight, (\(F(1,47) = 5.04, P < 0.05\), \(ES = 0.10\)), BMI, (\(F(1,47) = 4.80, P < 0.05\), \(ES = 0.09\)), and total skinfolds (\(F(1,45) = 29.43, P < 0.01\), \(ES = 0.40\)). Post hoc comparisons revealed that, unlike controls, treatment group subjects evidenced significant reductions in body weight (\(t\) (32) = 2.30, \(P < 0.05\)), BMI, (\(t\) (32) = 2.20, \(P < 0.05\)), and total skinfolds (\(t\) (31) = 7.35, \(P < 0.01\)). No significant group \(\times\) time interaction was observed on waist:hip ratio.

Pre/post percent gain on fitness outcome measures. Figure 1 presents pre/post percent gains on selected outcome measures. Among treatment group subjects, pre/post changes ranged from a reduction of 10.7% on skinfolds, to an increase of 97.1% on the bench press. Among controls, pre/post differences ranged from a reduction in peak VO\(_2\) of 9.5%, to an increase in time to exhaustion of 29.6%. Treatment group subjects evidenced sizable gains in cardiovascular fitness, strength, and flexibility. Control group subjects evidenced decreased fitness on peak VO\(_2\) (−9.5%), bench press (−6.97%), skinfolds (+2.0%), and sit and reach (−5.1%).

**DISCUSSION**

The results of our study demonstrated that a 1-h a day, 3-d a week program consisting of cardiovascular endurance, muscular strength and endurance, and flexibility significantly improved the fitness levels of stroke survivors. These findings are particularly noteworthy given the extensive number of comorbidities (e.g., hypertension, obesity, diabetes, depression) that accommodated the participants’ primary disability (stroke), the extremely low baseline levels of fitness, and the absence of physical activity in the participants’ daily regimen. Because stroke recurrence is relatively

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**TABLE 2.** Group means and standard deviations on exercise outcomes at baseline and follow-up.

<table>
<thead>
<tr>
<th>Health Outcomes</th>
<th>Treatment Group</th>
<th>Control Group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre</td>
<td>Post</td>
</tr>
<tr>
<td>Body composition</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Body weight (kg)</td>
<td>93.39 ± 26.76</td>
<td>92.13 ± 26.06</td>
</tr>
<tr>
<td>BMI</td>
<td>33.18 ± 8.51</td>
<td>32.75 ± 8.29</td>
</tr>
<tr>
<td>Total skinfold (mm)</td>
<td>97.60 ± 35.66</td>
<td>86.19 ± 30.92</td>
</tr>
<tr>
<td>Waistchip ratio</td>
<td>0.88 ± 0.01</td>
<td>0.87 ± 0.01</td>
</tr>
<tr>
<td>Cardiovascular</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Max workload (W)</td>
<td>64.33 ± 25.42</td>
<td>82.60 ± 31.55</td>
</tr>
<tr>
<td>Peak VO(_2) (mL·min(^{-1}))</td>
<td>1155.41 ± 337.48</td>
<td>1256.62 ± 381.85</td>
</tr>
<tr>
<td>Peak VO(_2) (mL·kg(^{-1})·min(^{-1}))</td>
<td>13.34 ± 4.22</td>
<td>14.43 ± 4.03</td>
</tr>
<tr>
<td>Time to exhaustion (s)</td>
<td>309.70 ± 150.57</td>
<td>436.81 ± 181.26</td>
</tr>
<tr>
<td>RER</td>
<td>1.06 ± 0.13</td>
<td>1.18 ± 0.17</td>
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<tr>
<td>Strength</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bench press (lbs)</td>
<td>26.05 ± 15.20</td>
<td>38.84 ± 22.64</td>
</tr>
<tr>
<td>Leg press (lbs)</td>
<td>147.08 ± 60.87</td>
<td>234.52 ± 62.51</td>
</tr>
<tr>
<td>Hand grip (affected)</td>
<td>20.35 ± 13.51</td>
<td>20.81 ± 13.28</td>
</tr>
<tr>
<td>Hand grip (unaffected)</td>
<td>30.69 ± 11.30</td>
<td>32.81 ± 12.36</td>
</tr>
<tr>
<td>Flexibility</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sit and reach (in.)</td>
<td>9.52 ± 12.47</td>
<td>17.31 ± 9.43</td>
</tr>
<tr>
<td>Shoulder flex. (affected)</td>
<td>28.05 ± 23.61</td>
<td>22.14 ± 19.93</td>
</tr>
</tbody>
</table>

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**EXERCISE TRAINING FOR STROKE SURVIVORS**
TABLE 3. Analysis of variance results on body composition, cardiovascular, strength and flexibility outcomes.

<table>
<thead>
<tr>
<th>Health Outcomes</th>
<th>Group Time X</th>
<th>Main Effects and Interactions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>F</td>
<td>ES**</td>
</tr>
<tr>
<td>Body composition</td>
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<tr>
<td>Body weight</td>
<td>0.30</td>
<td>0.01</td>
</tr>
<tr>
<td>BMI</td>
<td>0.06</td>
<td>0.00</td>
</tr>
<tr>
<td>Waist-Hip ratio</td>
<td>0.03</td>
<td>0.00</td>
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<tr>
<td>Skinfolds</td>
<td>0.06</td>
<td>0.00</td>
</tr>
<tr>
<td>Cardiovascular</td>
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</tr>
<tr>
<td>Peak VO2 (mL)</td>
<td>0.88</td>
<td>0.02</td>
</tr>
<tr>
<td>Peak VO2 (mL·kg⁻¹·min⁻¹)</td>
<td>0.15</td>
<td>0.00</td>
</tr>
<tr>
<td>Max workload</td>
<td>0.99</td>
<td>0.02</td>
</tr>
<tr>
<td>Time to exhaustion</td>
<td>2.15</td>
<td>0.05</td>
</tr>
<tr>
<td>Strength</td>
<td></td>
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</tr>
<tr>
<td>Bench press</td>
<td>2.94</td>
<td>0.06</td>
</tr>
<tr>
<td>Leg press</td>
<td>9.47**</td>
<td>0.17</td>
</tr>
<tr>
<td>Hand grip (affected)</td>
<td>0.13</td>
<td>0.00</td>
</tr>
<tr>
<td>Hand grip (unaffected)</td>
<td>1.72</td>
<td>0.04</td>
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<tr>
<td>Flexibility</td>
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</tr>
<tr>
<td>Sit and reach</td>
<td>2.52</td>
<td>0.05</td>
</tr>
<tr>
<td>Shoulder flex. affected</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Shoulder flex. unaffected</td>
<td>1.09</td>
<td>0.02</td>
</tr>
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</table>

*Effect size (eta²).
* P < .05, **P < .01.

high (25,33), and cardiac disease remains the leading prospective cause of death in long-term stroke survivors (29,30), there is also a strong need to prevent further decline and reduce the incidence of disease and disability in this population through increased physical activity and fitness (3,18,22).

Several recent studies have reported that there is a strong association between physical fitness and physical function (1,5,8,11,15,19). Morey and coworkers (19) examined the relationship between physical fitness and physical independence in 161 older men and women (mean age = 72.5 yr) and concluded that exercise training to enhance physical function needed to include a combination of strength, cardiorespiratory endurance, and flexibility. Ferketch and coworkers (8) developed a fitness training program for older women (60–75 yr) and found that strength and endurance training was important for improving physical independence. Cress et al. (5) developed a fitness training program for older adults (>70 yr) and noted that improvements in maximal oxygen consumption and muscle strength resulted in greater gains in physical functioning and physical independence. In a large-scale epidemiologic study that examined the relationship between physical fitness, physical activity, and functional limitation in 4670 adults aged 40 and older, investigators concluded that physically fit and physically active individuals reported less functional limitation (i.e., performing daily activities or household activities) (13). Based on these findings, the significant improvements that we obtained in aerobic power, muscle strength and endurance, flexibility, and body composition have important implications for maintaining physical independence and reducing the severity of comorbidities in persons with stroke.

What was particularly striking about our results was the substantial enthusiasm and interest displayed by most of the participants toward improving their health. This was reflected in an attendance rate of 93% with none of the participants dropping out of the program. Although there were a few participants who had to be called frequently to encourage them to attend the program, the majority were independently motivated to continue exercising for the length of the study. We attributed this high participation rate to a number of factors. First, participants were transported to and from the exercise facility free of charge, and there was also no charge for the program. Second, participants exercised with other stroke survivors who had similar physical limitations and problems (i.e., depression, social isolation, difficulty walking). The bonding that occurred between participants may have motivated them to continue with the program. The participants were able to learn from each other and establish friendships during the course of the program. Because they traveled together on the same van for several hours a week, many participants socialized with other participants and from the exercise site. Third, the staff in the exercise center provided constant verbal encouragement and support. On days when a participant did not show up for class, the person was called immediately to discuss their absence. This continuous monitoring may have motivated the participants to adhere to the program.

Our findings also demonstrated that when safety precautions and proper screening procedures were implemented before the training program was initiated, persons with stroke and multiple comorbidities were able to exercise safely and improve their overall fitness. Of a total of 1224 h of exercise training (34 participants × 36 h of exercise) and 68 h of cardiovascular and strength testing, there were a total of three adverse events. One event occurred during the exercise training program. A participant experienced dizziness and became mildly incoherent after completing an exercise session. She was transported to the emergency room, where she was admitted for observation. She was later discharged and upon the advice of her neurologist, she was readmitted to the program and successfully completed the

remainder of the exercise sessions. Two subjects also experienced complications during the exercise testing. One participant appeared to have a mild seizure during the post-exercise peak VO₂ test, and another participant experienced a drop in blood pressure after completing an exercise screening pretest. Both participants received emergency medical care and were discharged. The participant who experienced a drop in blood pressure was excluded from the study.

It should be emphasized that supervision of exercise training programs for individuals with stroke is critical during the early stages of training. Given the many comorbidities that accompany stroke (i.e., hypertension, diabetes, obesity), persons with this condition must be taught the warning signs for when to stop exercising. The educational component of our program was extremely important for teaching stroke participants how to exercise safely.

It is important for the public health community to establish community-based exercise programs for persons with stroke in order to lower the incidence of recurrent strokes, reduce the onset and severity of secondary conditions, and improve functional mobility and physical independence. As HMOs continue to decrease the amount of time allotted for rehabilitation (12,26), alternative strategies for extending care into the community (i.e., home-based and community-based exercise programs) take on greater importance. Interventions that successfully promote physical activity among persons with stroke and can be maintained for a longer period of time (e.g., > 1 yr) are direly needed (27,28).

Conclusion

There are few exercise training studies that have been designed for persons with stroke (23). Our results demonstrated that in a predominantly African-American group of stroke survivors with multiple comorbidities, significant improvements in fitness were obtained. Because we were able to eliminate significant barriers to participation (i.e., free transportation, no cost to the program), our attendance was very high (93% of all exercise sessions were attended) and no one dropped out of the program.

Our data show that persons with stroke can make significant gains in fitness, thus having the potential to reduce the risk for further disease and functional decline. Gains in cardiovascular endurance, muscular strength and endurance, flexibility, and body composition can have a dramatic effect in improving the overall health of stroke survivors. There is a pressing need to encourage persons with stroke to become more physically active and physically fit. In the same manner that the public health community is advocating for higher levels of physical activity participation among the general population (2,32), efforts must be established to promote higher levels of physical activity and fitness among persons with stroke.

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