

ORIGINAL ARTICLE

A Preliminary Study to Examine the Effects of Aerobic and Therapeutic (Nonaerobic) Exercise on Cardiorespiratory Fitness and Coronary Risk Reduction in Stroke Survivors

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ABSTRACT. Rimmer JH, Rauworth AE, Wang EC, Nicola TL, Hill B. A preliminary study to examine the effects of aerobic and therapeutic (nonaerobic) exercise on cardiorespiratory fitness and coronary risk reduction in stroke survivors. *Arch Phys Med Rehabil* 2009;90:407-12.

Objectives: To compare the effects of 3 different exercise training regimens on cardiorespiratory fitness and coronary risk factor reduction in subjects with unilateral stroke.

Design: A cluster assignment by residential location repeated-measures design.

Setting: University-based medical center.

Participants: Fifty-five subjects with unilateral ischemic stroke were assigned to the following groups: intensity (n=18), duration (n=19), and therapeutic exercise (n=18).

Intervention: A 14-week intervention with subjects randomized to 1 of 3 interventions: (1) moderate intensity, shorter duration (MISD) exercise (gradually increasing exercise intensity while keeping exercise duration constant at 30 min), (2) low-intensity, longer duration (LILD) exercise (gradually increasing duration to 60 min while keeping exercise intensity constant), or (3) conventional therapeutic exercise (TE) consisting mainly of strength, balance, and range of motion activities. All groups exercised 3 days per week.

Main Outcome Measures: Peak oxygen consumption ($\dot{V}O_{2peak}$), submaximal oxygen consumption ($\dot{V}O_2$), lipid panel, and resting blood pressure.

Results: The MISD group attained more favorable effects on systolic ($P<.04$) and diastolic blood pressure ($P<.002$) and total cholesterol (TC) ($P<.036$) compared with LILD and TE groups. Both MISD ($P<.029$) and LILD ($P<.045$) showed significant reductions in triglycerides compared with TE ($P<.029$). There was no significant change in $\dot{V}O_{2peak}$ and submaximal $\dot{V}O_2$ in any of the groups.

Conclusions: Overall, both MISD and LILD conditions achieved greater clinical and significant gains in coronary risk reduction compared with TE.

Key Words: Cerebrovascular accident; Coronary circulation; Exercise; Rehabilitation; Stroke.

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REGULAR PHYSICAL ACTIVITY MAKES STRONG, positive contributions to optimal health and well-being in the general population,¹⁻³ and there is growing evidence that physical activity has substantial health benefits in improving cardiorespiratory and musculoskeletal fitness in persons with stroke.⁴⁻¹⁵ However, what is less clear is the volume and type of exercise that is associated with coronary risk reduction (ie, cardiorespiratory fitness, blood pressure, blood lipids) in this population.^{14,15} Exercise interventions that expose stroke patients to various types and amounts of exercise are needed to determine the most effective treatment strategies for reducing the risk of coronary heart disease and recurrent stroke in this population.^{4,16,17}

We conducted a preliminary study to examine the effects of 2 bouts of aerobic exercise (higher intensity/shorter duration vs lower intensity/higher duration) compared with nonaerobic therapeutic exercise in stroke survivors. Our hypothesis was that the MISD and LILD training programs would elicit greater coronary risk reduction compared with nonaerobic conventional therapeutic exercise and that the MISD group would achieve greater gains than the LILD group.

METHODS

Design

This pilot study used a cluster assignment (by geographic location because of the complexity of transporting subjects by van to the exercise facility and keeping the roundtrip travel time to under 2 hours) repeated-measures design to assess the treatment effects of 3 different types of training: (1) MISD aerobic training, (2) LILD aerobic training, and (3) conven-

List of Abbreviations

BMI	body mass index
ECG	electrocardiographic
ES	effect size
HDL-C	high-density lipoprotein cholesterol
HRR	heart rate reserve
LDL-C	low-density lipoprotein cholesterol
LILD	lower intensity, longer duration
MISD	moderate intensity, shorter duration
ROM	range of motion
TC	total cholesterol
TE	therapeutic exercise
TG	triglycerides
$\dot{V}O_{2peak}$	peak oxygen consumption
$\dot{V}O_2$	oxygen consumption

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Table 1: Study Design and Intervention Protocols

Time Period	Experimental Condition					
	Intensity-Oriented Program (MISD)		Duration-Oriented Program (LILD)		Therapeutic exercise (TE)	
	Intensity	Duration	Intensity (<50%HRR)	Duration	Intensity	Duration
Phase in (0–2 weeks)	—	—	—	—	—	—
3–6 weeks	Low (40%–49% HRR)	30 min	Low	30 min	NA	60 min
7–10 weeks	Low moderate (50%–59% HRR)	30 min	Low	45 min	NA	60 min
11–14 weeks	High moderate (60%–69% HRR)	30 min	Low	60 min	NA	60 min

Abbreviations: HRR, heart rate reserve; NA, not applicable.

tional TE. All subjects were transported to 1 location on the campus of a large medical center that contained a fitness center and rehabilitation room; they received their intervention at separate times of the day to avoid contamination between groups. Health outcomes included cardiorespiratory fitness ($\dot{V}O_{2\text{peak}}$ and submaximal $\dot{V}O_2$), blood lipids, and blood pressure.

Table 1 presents a schematic of the research design. Participants were conveniently assigned to 1 of the 3 experimental conditions. The MISD group was designed to gradually increase participants' intensity of exercise while keeping exercise duration constant (30 min). The LILD group was designed to gradually increase the length of exercise (30 to 45 to 60 min) while keeping exercise intensity constant. The TE group simulated a conventional rehabilitation program for stroke patients consisting of gait training, balance, strength, and flexibility/ROM exercises. The study lasted 14 weeks, which included a 2-week phase-in period. Participants were assessed on targeted outcome measures at baseline and at the end of the study. Both the participant and data collector were blinded to the study's hypotheses. The study protocol and consent document were approved by the Office for the Protection of Research Subjects at the university-based medical center where the study was conducted.

Sample and Setting

A total of 55 participants with unilateral stroke who had residual weakness and/or spasticity of the affected lower extremity were recruited from the neurology department. Eligibility criteria included the following: (1) poststroke at least 6 months, (2) 18 years of age or older, (3) independently ambulatory with or without an assistive device, (4) score on the Mini-Mental State Examination¹⁸ of 16 or greater, (5) permission from their physician to participate in the exercise program, and (6) participation in the program was not contraindicated by adverse events occurring during exercise.

Preintervention Screening

Before the study began, each participant received a thorough explanation of the study procedures and was required to sign a consent form. During the course of the intervention, free transportation was provided to and from the university-based fitness center for all participants.

Participants were transported to the human performance laboratory to perform a fasting blood draw, resting electrocardiogram, resting heart rate, resting blood pressure, and basal temperature. They were given explicit directions on how to prepare for each visit. Project staff called participants the night before their scheduled visit to remind them to fast before their blood test. To be approved for the $\dot{V}O_{2\text{peak}}$ testing, which occurred on a separate day after the prescreening, participants' blood tests (ie, complete blood count, enzymes, protein levels)

had to be within normal limits. If the preliminary blood work was acceptable, participants returned for a second visit to perform a graded exercise test.

Before exercise testing, each participant completed a screening instrument that included demographic information and medical history. The health information included (1) the individual's risk of coronary disease, (2) supervisory requirements for exercise testing and training, (3) potential contraindications for participation in the study, and (4) physical activity history. Determination of these factors was based on the criteria established in the American College of Sports Medicine Guidelines for Exercise Testing and Training.¹⁹

Exercise Testing and Measurements

Peak oxygen uptake. A symptom-limited graded exercise test ($\dot{V}O_{2\text{peak}}$) was performed on an electronically braked upright stationary cycle. $\dot{V}O_{2\text{peak}}$ was assessed with a Sensor-Medics 2900 Metabolic Cart^a 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 12-lead ECG machine.^b The workload was automatically adjusted by the metabolic cart. A ramp cycle ergometer testing protocol was used, which allowed participants to begin cycling at a workload of 20W and increased by 10W every minute until maximal effort was achieved. Participants were instructed to pedal at 60 rev/min. Heart rate and blood pressure were recorded every 2 minutes. Tests were terminated if one or more of the following criteria were met: (1) respiratory exchange ratio ≥ 1.1 , (2) peak heart rate within ± 10 beat/min of age-predicted maximal value, (3) abnormal blood pressure response or ECG reading, and (4) unable to continue pedaling above 50 rev/min. Participants who successfully completed the graded exercise test were eligible for the study. Individuals who had adverse coronary changes ($n=4$) during exercise testing were excluded and referred for further follow-up to their primary care physician. Submaximal $\dot{V}O_2$ at 40W was used as a measure of economy of movement. Energy cost for a particular activity is a general indicator of economy of movement.²⁰ This measure was taken during the pre/post progressive exercise test at the same time interval.

Blood lipid panel. Participants performed an overnight fast before having their blood drawn (venipuncture) by a certified phlebotomist or nurse at a referenced laboratory at a major medical center. Blood measures included TC, HDL-C, LDL-C, and TG.

Exercise Training Interventions

Subjects in the intensity-oriented program (MISD) achieved their target intensity level through changes in exercise workload (eg, increasing or decreasing rev/min or resistance on a stationary cycle or recumbent stepper). Exercise intensity was

set using the HRR established from the graded exercise test. The MISD group gradually increased the intensity of exercise by 10% every 4 weeks (40%–49%, 50%–59%, 60%–69% HRR). The duration-oriented group (LILD) maintained an intensity level below 50% of HRR while increasing exercise time from 30 to 45 to 60 minutes in 4-week increments. The TE group participated in a conventional rehabilitation program for 14 weeks for approximately 60 minutes directed by a physical therapist. Activities included gait training, balance, strength, and ROM exercises. The session began with 10 minutes of passive ROM exercises on a mat table for the upper and lower extremities. This was followed by 30 minutes of gait and balance training. Activities included walking up and down a hallway with therapist input to facilitate normal movement patterns and to teach subjects how to avoid compensatory movement patterns. After a brief rest period, a series of balance exercises were performed that required stepping over various-sized bolsters and small objects to compensate for shifts in weight and center of gravity. The session ended with strengthening activities that focused on the lower extremities with more emphasis on the hemiparetic side. Sessions were on Monday, Wednesday, and Friday. All groups exercised 3 days per week. A missed session was made up the following week on a separate day (Tuesday or Thursday) from the regularly scheduled program.

During each exercise session, resting blood pressure and heart rate were recorded when participants arrived to the exercise facility. Resting diastolic blood pressure had to be less than 100 mmHg to begin exercising. Blood pressure and heart rate were recorded several times during the exercise session. Both MISD and LILD interventions consisted of a warm-up period, exercise program, and a cool-down period. Exercise sessions were supervised by an exercise physiologist and physical therapist and several student interns to allow individual monitoring and to maintain treatment fidelity (ie, exercising at the recommended intensity/duration). The medical director was on call to answer any questions that the staff had pertaining to a specific subject. Subjects wore a Polar Vantage XL heart rate monitor^c that was programmed with an audible beeper to keep them exercising in the appropriate target heart rate zone. Participants with diabetes were required to bring their own portable glucometer and take a blood glucose measurement before and after the exercise class.

Data Analysis

Before final statistical analysis, preliminary data were analyzed by using univariate and graphic methods wherever applicable to facilitate inspection and interpretation of the data. Outliers and influential observations were identified and checked for accuracy. Data error because of data-entry oversight was appropriately corrected. Data were summarized by using descriptive statistics (eg, means and SDs for continuous variables, counts and frequencies for categorical variables). Baseline characteristics were compared using F tests (for continuous variables) or chi-square tests (for categorical data) to identify baseline differences in demographics and physiological and functional measures among the 3 experimental groups. By using on-treatment approach (including only subjects with complete data), paired *t* tests were conducted to assess pre-post changes in fitness (BMI, $\dot{V}O_{2peak}$, submaximal $\dot{V}O_2$), resting blood pressure, and blood lipids (TC, HDL-C, LDL-C, TGs) within each group. Finally, generalized linear mixed models were performed to test the effects of the exercise intervention (intensity or duration) on each outcome measure over time by using an intent-to-treat approach (including all subjects randomized to the study). Significance was established at an alpha

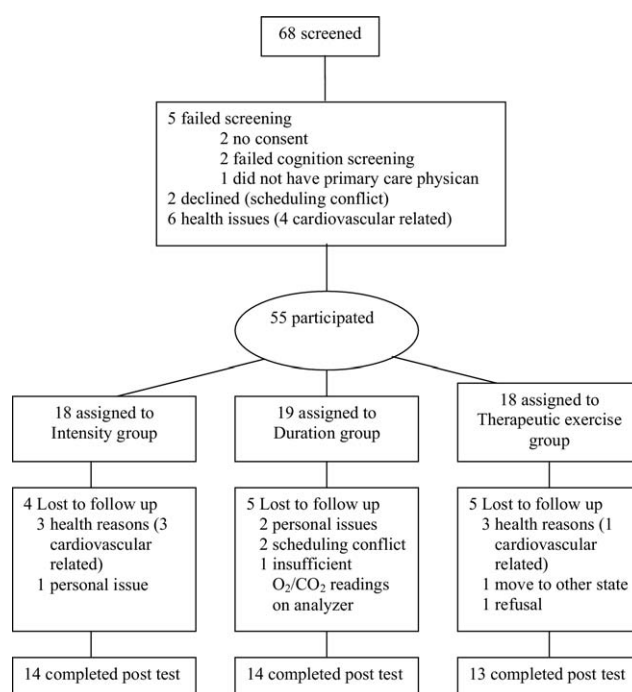


Fig 1. CONSORT diagram.

level of .05. All statistical analyses were performed by using SAS 9.1 statistical software.^d

RESULTS

Figure 1 provides a detailed study flowchart. Thirteen subjects were excluded for the various reasons listed in the figure. The remaining subjects (n=55) were assigned to 1 of 3 experimental groups. Four subjects were lost to follow-up in the MISD group, and 5 subjects were lost to follow-up in the LILD and TE groups.

Table 2 shows the subject demographics by experimental condition. Subjects were predominantly black (67%) women (60%) with a mean age of 59.6 years. Approximately 82% of the participants were overweight (BMI ≥ 25), and 56% were obese (BMI ≥ 30). The cardiorespiratory fitness level ($\dot{V}O_{2peak}$) of our stroke subjects was very low, with a mean baseline of 13.0 mL·kg⁻¹·min⁻¹. Nondisabled, sedentary but otherwise healthy individuals for the same age and sex typically have $\dot{V}O_{2peak}$ levels that range between 25 and 30 mL·kg⁻¹·min⁻¹.⁵ Subjects in the TE group were somewhat older and had a lower BMI than the other 2 treatment groups, although this was not statistically significant ($P > .05$). There were no significant differences in sex, race, and baseline $\dot{V}O_{2peak}$ values among the 3 experimental groups.

Table 3 presents means and SDs for pre-post exercise outcomes by designated group. The ESs ranged from 0.01 to 0.76 for the MISD group, 0.009 to 0.50 for the LILD group, and 0.004 to 0.39 for the TE group. There was a significant ($P < .05$) pre-post reduction for the MISD group with moderate effect sizes in resting blood pressure (both diastolic, ES=0.76, and systolic, ES=0.56), TC (ES=0.72), and TG (ES=0.73) but BMI (ES=0.01), submaximal $\dot{V}O_2$ (ES=0.40), $\dot{V}O_{2peak}$ (ES=0.09), HDL-C (0.04), and LDL-C (ES=0.47) were not statistically significant. The LILD group also exhibited a significant reduction ($P < .05$) in TG (ES=0.50) but did not attain signif-

Table 2: Subject Demographics

	Total (N=55)	Intervention Group			P*
		Intensity (N=18)	Duration (N=19)	Therapeutic exercise (N=18)	
Age (mean±SD)	59.6±10.2	55.7±12.6	59.4±7.1	63.7±9.1	.059
Sex, n (%)					.772
Male	22 (40)	6 (33)	8 (42)	8 (44)	
Female	33 (60)	12 (67)	11 (58)	10 (56)	
Race, n (%)					.459
White	10 (18)	2 (11)	2 (11)	6 (33)	
Black	37 (67)	13 (72)	15 (79)	9 (50)	
Hispanic	6 (11)	2 (11)	2 (11)	2 (11)	
Other	2 (4)	1 (6)	0 (0)	1 (6)	
BMI (kg·m ²) (mean±SD)	31.9±7.8	33.8±9.0	33.0±8.2	28.9±5.0	.124
Affected side, n (%)					.052
Right	23 (42)	7 (39)	11 (58)	5 (28)	
Left	28 (51)	10 (56)	5 (26)	13 (72)	
Unknown	4 (7)	1 (5)	3 (16)	0 (0)	
VO _{2peak} (mL·kg ⁻¹ ·min ⁻¹) (mean±SD)	13.0±4.9	14.3±6.9	12.5±3.7	12.4±3.7	.461
Comorbidities, n (%)					
Diabetes	17 (31)	6 (33)	7 (37)	4 (22)	.607
Hypertension	41 (75)	13 (72)	15 (79)	13 (72)	.862
Congestive heart failure	4 (7)	1 (6)	1 (5)	2 (11)	.780

*F test for continuous variables; chi-square test for categorical variables.

icance on the other outcomes (BMI, ES=0.01; submaximal $\dot{V}O_2$, ES=0.33; $\dot{V}O_{2peak}$, ES=0.20; diastolic BP, ES=0.49; systolic BP, ES=0.46; TC, ES=0.42; HDL-C, ES=0.15; LDL-C, ES=0.03). None of the pre-postchanges on any outcomes was significant in the TE group, and the largest ES was on TG (ES=0.39).

By using an intent-to-treat approach, table 4 provides similar results on coronary risk factors (ie, cardiorespiratory fitness, blood pressure, lipid panel) for the generalized linear mixed models analysis. There were significant group/time interaction effects on diastolic blood pressure, TC, and LDL-C. Post hoc contrast analysis indicated that the MISD group attained more favorable effects on diastolic blood pressure, TC, and LDL-C across time compared with the TE group ($P<.05$) but not the LILD group. There was also a significant time effect for TG ($P=.007$) because all 3 groups showed a decrease over the 14-week intervention period. Compared with the TE group, the

MISD group also showed overall significantly lower TC ($P=.027$) and LDL-C ($P=.035$). Post hoc comparisons found no differences on any health outcomes between MISD and LILD groups. Overall, there were no significant group/time effects on $\dot{V}O_{2peak}$, submaximal $\dot{V}O_2$, and HDL-C.

DISCUSSION

The findings from this preliminary study partially supported our hypothesis that an MISD training protocol would elicit greater improvements on selected coronary risk factors (ie, blood pressure, lipids) compared with LILD aerobic exercise and conventional nonaerobic TE. Although the LILD group showed a similar trend as the MISD group, the gains were smaller and only one of the measures reached statistical significance (TG). The conventional TE group showed no significant improvement on any of the outcomes.

Table 3: Outcome Measures by Pre-Posttest and Experimental Condition

Variables	MISD (n=14)				LILD (n=14)				TE (n=13)			
	Pretest	Posttest	Effect Size	P*	Pretest	Posttest	Effect Size	P*	Pretest	Posttest	Effect Size	P*
Cardiorespiratory fitness												
BMI (kg·m ²)	33.3±9.0	33.2±9.1	.011	.818	30.5±5.7	30.5±5.3	0.009	.887	29.6±5.4	29.4±5.1	.038	.432
Submaximal $\dot{V}O_2$ (40W)	10.61±3.8	9.36±2.3	.398	.190	9.57±2.0	8.95±1.8	0.329	.371	9.59±2.2	9.89±2.8	.119	.509
VO _{2peak} (mL·kg ⁻¹ ·min ⁻¹)	15.06±7.4	15.71±7.6	.087	.239	13.27±3.6	14.02±3.9	0.200	.279	12.57±4.2	12.22±3.6	.090	.467
Blood pressure												
Diastolic (mmHg)	77.7±10.3	69±12.6	.756	.002	84.2±10.4	78.3±13.6	0.487	.081	77.3±11.5	76.8±8.8	.049	.875
Systolic (mmHg)	129.5±13.5	119.2±22.0	.564	.048	130.7±13.2	122.3±22.3	0.458	.188	130.3±17.3	127.7±15.6	.158	.575
Lipid panel (mg/dL)												
Total cholesterol	173.6±25.6	158.2±16.3	.718	.036	182.4±35.5	170.3±19.1	0.424	.113	196.1±41.8	196.3±50.9	.004	.963
HDL-C	52.5±14.8	51.9±16.1	.039	.747	57.8±27.5	54±21.4	0.154	.340	57.7±18.3	59.2±23.3	.072	.475
LDL-C	101±23.4	91.4±16.6	.473	.192	96.7±29.8	96.1±16.9	0.025	.935	113.2±35.1	119.5±40.3	.167	.280
TG	100.6±42.4	73.8±29.9	.731	.029	139.8±61.9	106.4±70.5	0.503	.045	113.1±63.1	92.6±40.8	.386	.128

NOTE. Values are mean ± SD unless otherwise indicated. Boldface values indicate statistical significance (ie, < .05).

*Paired *t* test; 4, 5, and 5 subjects in MISD, LILD, and TE groups, respectively, did not complete the posttest.

Table 4: Results of Mixed Models on Coronary Risk Factors

	Cardiorespiratory Fitness				Blood Pressure			
	Submaximal $\dot{V}O_2$		VO_{2peak}		Diastolic Blood Pressure		Systolic Blood Pressure	
	b*	P	b	P	b	P	b	P
Time	0.396	.695	-0.613	.542	-0.035	.972	-0.350	.728
Group (MISD) [†]	-0.535	.597	1.675	.100	-1.663	.102	-1.041	.303
Group (LILD) [†]	-0.963	.344	0.692	.492	-0.194	.847	-0.789	.434
Time×group (MISD)	-1.552	.132	1.351	.183	-2.134	.038	-1.184	.242
Time×group (LILD)	-0.948	.351	1.452	.153	-0.982	.331	-0.532	.597

	Lipid Panel							
	Total Cholesterol		HDL-C		LDL-C		Triglycerides (TG)	
	b	P	b	P	b	P	b	P
Time	0.633	.530	0.736	.466	1.557	.126	-1.507	.007
Group (MISD) [†]	-2.277	.027	-0.680	.500	-2.175	.035	-0.990	.327
Group (LILD) [†]	-1.572	.123	-0.740	.463	-1.693	.097	0.515	.609
Time×group (MISD)	-2.115	.040	-0.686	.496	-2.247	.029	-0.410	.684
Time×group (LILD)	-1.544	.130	-1.439	.157	-1.178	.245	-0.482	.632

NOTE. Boldface values indicate statistical significance (ie, < .05).

*Standardized coefficient.

[†]Reference group for experimental condition was TE.

Surprisingly, we did not see a statistically significant improvement in cardiorespiratory fitness (VO_{2peak}) or submaximal $\dot{V}O_2$ for any of the groups. However, subgroup analysis showed small, clinical improvements of 4.3% for the MISD group and 5.7% for the LILD group on VO_{2peak} , whereas the TE group had a contrary reduction of 2.8%. Although we were expecting changes in VO_{2peak} to be similar to previously reported values from randomized controlled trials (9.0%⁸ to 22.5%),¹² it is difficult to make comparisons across studies because of the heterogeneity of the sample (eg, age, race/ethnicity, disability status, length of stroke, type and severity of stroke, body composition, etc). Our stroke cohort had very high mean BMIs ($M=31.9 \text{ kg}\cdot\text{m}^2\pm 7.8$), and the majority were obese (56%), and predominantly black (67%) women (60%). Although there were no improvements in VO_{2peak} or submaximal $\dot{V}O_2$, the percent improvement in submaximal $\dot{V}O_2$, which has been reported to be an indicator of improved physiologic reserve and gross motor efficiency,^{5,20} was 11.8% ($ES=0.40$) for the MISD group and 6.4% ($ES=.33$) for the LILD group, whereas the TE group had a contrary reduction of 3.1%. These findings could be considered clinically relevant for the MISD group in particular and to a lesser extent for the LILD group based on their moderate effect sizes and percent improvement.

The nonsignificant findings on the cardiorespiratory fitness outcomes could be caused by the study's low statistical power. Because of the small sample size, the pilot study was only powered to detect a minimum effect size of 0.50 for within factor, 0.75 for between factor, and 0.47 for the within-between interaction at an alpha level of .05. A larger study is warranted for further investigation of these interesting trends.

There is a need to continue to explore the utility of aerobic exercise training programs in stroke survivors to determine the precise training doses needed to achieve coronary risk factor reduction (ie, blood pressure, lipids).¹⁵ A shorter-duration (30 min), higher-intensity training bout may be more practical in terms of application in rehabilitation and community-based settings in which supervision time may be limited or adherence to longer-duration aerobic exercise (ie, 60 min) may be difficult to attain for many stroke survivors.

Although research on nondisabled populations often associates "dose response" with all-cause mortality,¹ what may be more important for stroke survivors is the need to examine the effects of exercise training in enhancing or maintaining functional mobility, reducing coronary risk and recurrent stroke, and minimizing certain secondary conditions (eg, fatigue, severe deconditioning). Rehabilitation professionals need more effective treatment strategies for targeting these outcomes in people with stroke, and future clinical trials should continue to identify specific dose-response effects of various forms of aerobic exercise training.

Study Limitations

The small sample size, group assignment based on geographic cluster, lack of an attentional control group, and the significantly higher percentage of blacks who were obese limit the generalizability of our findings to the broader population of persons with stroke. Similarly, only subjects approved through an in-depth medical screening were allowed to participate in the study. Although subjects were blinded to specific treatment outcomes, it was impractical to completely blind testers to subject treatment assignment during aerobic exercise training as a result of personnel constraints. However, every effort was made to reduce bias among testers by not allowing pretest data to be known during posttesting. Although our data are intriguing in terms of showing a trend for more favorable gains in coronary risk factor reduction with the higher intensity, shorter duration bout of exercise, more research is needed with larger samples to determine the precise dose of aerobic exercise needed to achieve coronary risk reduction in this population.

CONCLUSIONS

This preliminary study showed that an aerobic exercise training program for chronic stroke survivors using a higher-intensity, shorter duration threshold (50%–70% HRR for 30 min per session 3 days a week) resulted in more favorable changes in certain coronary risk factors compared with a lower-

intensity, longer duration training program (<50% HRR for 60 min per session 3 days a week) and a conventional (nonaerobic) therapeutic exercise program. Although our findings showed a positive trend in coronary risk reduction with the shorter, more intense bout of exercise, the small sample size affected our ability to find significance on several key outcomes.

Coronary risk reduction is an essential part of treatment for stroke survivors.^{16,21} The use of aerobic exercise in reducing blood pressure and blood lipids in persons with chronic stroke can have a substantial benefit in their overall health and wellness during and after recovery.²²⁻²⁶ Randomized controlled trials with adequate power are needed to establish more evidence that aerobic exercise training has a significant effect on coronary risk reduction in stroke populations.

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Suppliers

- SensorMedics Metabolic Cart; VIASYS Respiratory Care, 22745 Savi Ranch Parkway, Yorba Linda, CA 92887-4645.
- Marquette, 8200 West Tower Ave, Milwaukee, WI 5322.
- Polar Electro Inc, 1111 Marcus Ave, Suite M15, Lake Success, NY 11042-1034.
- SAS Institute Inc, 100 SAS Campus Dr, Cary, NC 27513-2414.