Effects of Early Exercise Engagement on Vascular Risk in Patients with Transient Ischemic Attack and Nondisabling Stroke

James Faulkner, PhD,* Danielle Lambrick, PhD,† Brandon Woolley, BSc,* Lee Stoner, PhD,* Lai-kin Wong, BNurs (hons),‡ and Gerard McGonigal, MD§

The objective of this study was to conduct a randomized, parallel-group clinical trial assessed the efficacy of a health-enhancing physical activity program (exercise and education) on vascular risk factors and aerobic fitness in patients who have experienced a transient ischemic attack (TIA) or nondisabling stroke. Sixty patients (69 ± 11 years) completed a baseline (BL) vascular risk stratification and aerobic fitness examination (cycle test) within 2 weeks of symptom onset. Subjects were then randomized to either an 8-week, twice weekly exercise program or to a usual-care control (CON) group. Postintervention (PI) assessments were completed immediately after the intervention and at 3-month follow-up. A series of primary (systolic blood pressure [SBP]) and secondary (vascular risk factors like total cholesterol [TC], high-density lipoproteins, etc.; Framingham risk score; peak oxygen uptake) outcome measures were assessed. Significantly greater reductions in SBP (mean change ± SD; −10.4 ± 9.2 mm Hg) and TC (−.53 ± .90 mmol/L) were observed between BL and PI assessments for the exercise group compared with the CON group (−1.9 ± 15.4 mm Hg and −.08 ± .59 mmol/L, respectively) ($P < .05$). These improvements were maintained between the PI and the 3-month follow-up assessment ($P > .05$). Significant improvements in aerobic fitness were also observed and maintained at the 3-month follow-up assessment after regular exercise participation ($P < .05$). The early engagement in exercise resulted in significant improvements in vascular risk factors and fitness in those diagnosed with TIA. As these beneficial effects were maintained up to 3 months after completing the exercise program, exercise should be considered a useful additive treatment strategy for newly diagnosed TIA patients. Future research should examine the long-term efficacy of such programs. **Key Words:** Exercise—education—TIA—acute interventional treatment—prevention.

Introduction

Transient ischemic attack (TIA) is a clinical syndrome consisting of rapidly developing clinical signs of focal disturbance of cerebral function lasting less than 24 hours, although most typically last no longer than 1 hour, with no apparent cause other than vascular.[1-3] Individuals classified with a nondisabling stroke (NDS) have minor residual symptoms that are

From the *School of Sport and Exercise, Massey University, Wellington, New Zealand; †Institute of Food, Nutrition and Human Health (IFNHH), Massey University, Wellington, New Zealand; ‡Clinical Nurse Specialist, Internal Medicine, Wellington Hospital, Wellington, New Zealand; and §Consultant Geriatrician and Stroke Physician, York Teaching Hospitals, National Health Service (NHS), Foundation Trust, York, UK.

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Address correspondence to James Faulkner, PhD, School of Sport and Exercise, Massey University, Wellington, Private Bag 756, 6140, Wellington, New Zealand. E-mail: j.faulkner@massey.ac.nz.

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managed by the same treatment paradigm as TIA. Many people who present with a TIA or NDS have predisposing modifiable vascular risk factors such as hypertension, tobacco use, diabetes mellitus, hyperlipidemia, obesity, and physical inactivity.[4] Current treatment strategies employed as a preventative measure to reduce the risk of a recurrent stroke or TIA predominantly include the prescription of antiplatelet- or anticoagulation agents and blood pressure– and cholesterol-lowering treatments.[5]

Exercise-based cardiac rehabilitation is an accepted component of the multifactorial secondary preventative strategy used to improve modifiable risk factors among coronary artery disease (CAD) patients.[6-8] Given this, a similar multifactorial approach could be of benefit as a secondary prevention strategy for TIA patients. Although lifestyle interventions are recognized as cornerstones of secondary prevention programs for cerebrovascular disease, physical activity is not universally applied or accepted in current cerebrovascular secondary prevention programs.[9-11] A failure to both rapidly assess and appropriately manage patients presenting with a TIA represents a missed opportunity for the prevention of recurrent TIA or stroke.[12]

Recent research has considered the utility of physical activity as a secondary prevention strategy for nonacute ischemic stroke (>1-year poststroke)[6] and TIA patients (up to 12 months post-TIA diagnosis).[13] Such research has demonstrated improvements in aerobic capacity and vascular risk factors either after a 10-week[6] or 6-month[13] exercise program. However, individuals presenting with a TIA have an elevated risk of experiencing a recurrent TIA or full stroke and other cardiovascular events, including myocardial infarction and sudden death, soon after the initial event.[5,13] Meta-analyses of patients with TIA have shown the short-term risk of stroke after TIA to be up to 10% at 2 days and between 9% and 17% at 90 days.[3,14,15] As such, this time frame represents a "critical window" in which to deliver an appropriate secondary prevention program. It is, therefore, important to determine the effects of early engagement in exercise on the vascular risk factors and aerobic fitness of TIA patients soon after symptom diagnosis as the early implementation of exercise after TIA diagnosis may be an important secondary prevention strategy for this population.

The purpose of this study was to assess the efficacy of an 8-week health-enhancing physical activity program (HEPAP) on vascular risk factors and markers of fitness in TIA and NDS patients, recruited within 2 weeks of symptom onset. We hypothesized that HEPAP would elicit favorable improvements in vascular risk factors and aerobic fitness and that these benefits would be maintained 3 months after completing the exercise program.

Methods

The trial was approved by New Zealand (NZ)'s Central Regional Health and Disabilities Ethics Committee and registered with the Australian and NZ Clinical Trials Registry (ACTRN12611000630910).

Subjects

Individuals residing within NZ's Capital and Coast District Health Board catchment area who were diagnosed with new TIA and did not meet exclusion criteria were eligible to participate. Exclusion criteria were as follows: unstable cardiac conditions, uncontrolled diabetes mellitus, severe claudication, oxygen dependence, significant dementia, inability to communicate in English, or unable to perform a cardiac rehabilitation exercise program (ie, immobile). Participants were required to comply with drug treatment and standardized therapy in accordance with recommendations from the stroke physician. Informed consent was obtained after the participants were given a detailed description of study procedures.

Study Design

The study was a single-center, randomized, parallel-group clinical trial. TIA was confirmed by a specialist physician at Wellington Hospital within 7 days of symptom onset. Eligible subjects were contacted by telephone and invited to attend a baseline (BL) assessment at the exercise physiology laboratory at the local academic institution. The BL assessment included a vascular risk assessment and aerobic fitness test. Subjects were randomized on completion of the BL assessment. Subjects were randomly assigned using simple randomization procedures (computerized random numbers) to either an 8-week exercise and education intervention (HEPAP) or to a usual-care control (CON) group. Details of the allocated group were given on a piece of paper contained within sequentially numbered, opaque-sealed envelopes. The randomization procedures were prepared by an investigator with no clinical involvement in the trial. Although subjects and the health and exercise practitioner were aware of the allocated treatment condition, outcome assessors and data analysts were kept blinded to the allocation.

HEPAP comprised 2 sessions per week, consisting of a 90-minute exercise and a 30-minute education session that discussed secondary prevention and educational information (ie, leaflets). HEPAP was conducted by a health and exercise practitioner. The CON group only received standard secondary prevention and educational information from the hospital. Subjects completed identical assessments as BL on completion of the intervention (postintervention [PI]) and at a 3-month follow-up assessment (3PI). Emergency procedures and an automated

defibrillator were in place during each assessment and HEPAP session to ensure that appropriate care was available if any adverse events were encountered during testing.

Sample Size

A sample size of 30 patients per group (n = 60) was deemed necessary to detect a reduction in our primary outcome measure (systolic blood pressure [SBP]) after early engagement in exercise. This figure is in agreement with the study of Santos-Hiss et al,[16] based on acute myocardial infarction patients, using a 2-sided 5% significance level and a power of 80% (mean difference 7 mm Hg; pooled standard deviation 5.8 mm Hg). This included an anticipated 25% participant drop-out rate between pre- and postassessments.

Baseline Assessment

A health history questionnaire and a vascular risk stratification assessment were completed at BL. The risk stratification comprised total cholesterol (TC), high-density lipoproteins (HDLs), TC:HDL ratio, fasting blood glucose (FBG), resting supine SBP and diastolic blood pressure (DBP), body mass index (BMI), waist circumference (WC) and hip circumference (HC), WC:HC ratio, smoking history, and family history.[17] Framingham risk scores were calculated to estimate the 10-year risk for CAD, myocardial infarction, and stroke.

A symptom-limited exercise electrocardiographic treadmill stress test, using a standardized modified Bruce protocol,[17] was conducted to determine whether it was clinically safe for participants to engage in the program. The exercise test was terminated when the subject reported volitional exhaustion or when their heart rate (HR) reached 85% of age-predicted maximum or if predetermined physiological responses were observed from the exercise electrocardiogram (eg, 2 mm ST depression). After a 60-minute recovery period, subjects performed an aerobic fitness assessment (cycle ergometry test) that comprised two (30 W and 60 W) 3-minute submaximal stages during which a cadence of 60 rpm was maintained.[17] Participants' HR (Polar, Kempele, Finland), blood pressure, and ratings of perceived exertion (RPE) were monitored in the final 30 seconds of both stages of the exercise test. A regression equation, which used the HRs reported from the 2 exercise stages and age-predicted maximal HR,[17] enabled a predicted maximal oxygen consumption (VO_2peak) to be estimated from the exercise test.

HEPAP Group

Subjects randomized to HEPAP completed twice weekly, group-based (3-5 patients) exercise sessions for 8 weeks. Exercise was prescribed on a one-to-one basis by health and exercise practitioners. In accordance with recommendations for moderate physical activity participation, participants completed 30 minutes of aerobic exercise at each exercise session.[17] This included 15 minutes of continuous walking and 15 minutes of continuous cycling, with an interim period of 30 minutes of active recovery (resistance/balance exercises) between bouts. Blood pressure, HR, and RPE were measured before, during, and after each bout of aerobic exercise. Participants exercised between 50% and 85% of age-predicted maximal HR during all aerobic exercise tasks. The exercise intensity typically increased by ~5% each week, although the rate of progression was dependent on how the subject felt during each session. Subjects also completed 60 minutes of resistance training (ie, alternate arm biceps curl and shoulder press), postural and co-ordination exercises using buso and swiss balls, and flexibility exercises. Thirty minutes of resistance-type exercise occurred after the walk and 30 minutes after the cycle. Subjects were instructed not to exercise beyond an RPE of 15 ("hard" feeling of exertion) during both aerobic and resistance exercise. Exercise practitioners also ensured that subjects did not exercise above 85% of their age-predicted maximal HR or beyond intensities defined by their cardiac risk at BL.

Participants took part in a 30-minute group-focused education session, which was designed to facilitate patients with a greater sense of understanding and management of their condition on completion of the second exercise session of each week. These sessions were constructed in line with the health belief model for behavior change. The education session focused on vascular risk factors, stroke prevention, nutrition, blood pressure, adherence to medication, stress management, and emotional and behavioral changes after TIA. A didactic approach was implemented for the education sessions. Herein, the health and exercise practitioner would introduce some background information on a topic (ie, nutrition) and then facilitate a group discussion surrounding patient perspectives and usual practices concerning the given topic.

Statistical Analyses

In accordance with previous research,[6] the primary outcome measure for this study was SBP. All other risk factors (TC, HDL, TC:HDL, FBG, DBP, BMI, WC, HC, WC:HC ratio), Framingham cardiac risk scores, and measures of aerobic fitness (ie, VO_2peak) were classified as secondary outcome measures.

Independent samples *t* tests (age, certain lifestyle factors) and Pearson chi-squared tests (descent, job, marital status, family history of cardiovascular disease (CVD), personal history of CVD, signs and symptoms of CVD, certain lifestyle factors, medication) were used to compare BL data between conditions (HEPAP, CON). Separate 2-factor repeated-measures analysis of variance (RM_ANOVA): Test (BL, PI, 3P1) × Condition (HEPAP, CON) were used to assess vascular risk factors, Framingham

risk scores, medication use, and VO_2peak between groups. A 3-factor RM_ANOVA: Test (BL, PI, 3P1) × Condition (HEPAP, CON) × Stage (1 and 2) were used to examine the SBP, DBP, HR, and RPE from the 2 stages of the aerobic (cycle) fitness assessment. Where statistical differences were observed during RM_ANOVA, post hoc analyses for multiple comparisons were conducted (*t* tests; Tukey honestly significant difference [HSD]). Bonferroni adjustments were used where applicable to reduce the risk of incurring type I error. An intention-to-treat analysis was used on all repeated-measures statistical procedures, whereby the last recorded data from a participant's subsequent assessment was carried forward and used in place of any missing assessments thereafter. Effect sizes are reported to describe the importance of the relevant findings in practical terms.[18] Partial eta-squared (η_p^2) was used as a measure of effect size, with .0099, .0588, and .1379 representing a small, medium, and large effect.[19]

Results

Of the 60 participants who completed BL, 95% (n = 57) attended the PI assessment. Three subjects were unable to be assessed at PI because of depression (n = 1; HEPAP), lack of patient time (n = 1; CON), or migration (n = 1; CON). A further 3 subjects were unable to be reassessed at the follow-up assessment because of lack of patient time (n = 1; CON), uncontrolled atrial fibrillation (n = 1; CON), and death (n = 1; CON). Four patients experienced a recurrent TIA before the follow-up assessment (n = 2, HEPAP; n = 2, CON). There were no significant differences in subject characteristics or medication use at BL ($P > .05$; Table 1).

HEPAP subjects participated in 94% of all available exercise sessions. Ninety percent of participants (n = 27) were able to complete 15 minutes of continuous walking or cycle exercise during HEPAP. The remaining 10% (n = 3) completed 5-15 minutes of intermittent exercise for the treadmill and cycle bouts.

Vascular Risk Factors and Medication Use

There were no differences in vascular risk factors at BL between conditions (all $P > .05$; Table 2). When comparing BL with PI and 3PI, RM_ANOVA revealed a significant Test by Condition interaction for SBP ($F_{2,104} = 3.85$, $P < .05$) and TC ($F_{2,106} = 3.17$, $P < .05$). Post hoc analysis revealed a significant decrease in SBP and TC between BL and PI for HEPAP but not CON (Table 2). This equated to a mean decrease in SBP of −10.4 ± 9.2 mm Hg for HEPAP but only −1.9 ± 15.4 mm Hg for CON. For TC, the mean decrease for HEPAP was −.53 ± .90 mmol/L compared with −.08 ± .59 mmol/L, respectively, for CON. Post hoc analysis also demonstrated a significant difference in TC between BL and 3PI ($P < .05$; Table 2). This equated to a mean decrease in TC of −.44 ± .88 mmol/L and −.04 ± .60 mmol/L for HEPAP and CON, respectively. There were no significant interactions for all other vascular risk factors. However, a time main effect was observed for SBP, TC, HDL, and TC:HDL ratio (all $P > .05$; Table 2).

A significant change in Framingham CAD, CVD, myocardial infarction, and estimated risk of death from CAD was observed (all $P < .05$). Post hoc analysis revealed a significantly greater change in each of the earlier measures between BL and PI (Table 3). There were no differences in medication use between HEPAP and CON ($P > .05$) at BL (2.87 ± 1.07 versus 2.85 ± 1.01), PI (2.99 ± 1.06 versus 3.07 ± .97), or 3PI (2.90 ± 1.04 versus 3.00 ± .96), respectively.

Aerobic Fitness Assessment

A significant Test by Condition interaction was demonstrated for predicted VO_2peak from the cycle ergometry test ($F_{2,86} = 4.50$, $P < .05$; $\eta_p^2 = .095$). The interaction was located between BL and PI whereby an increase in predicted VO_2peak was observed for HEPAP (30.6 ± 6.2 versus 33. 1 ± 2.6 mL/kg/min for BL and PI, respectively), but a decrease was observed for CON (29.8 ± 8.4 versus 26.4 ± 5.4 mL/kg/min for BL and PI, respectively; $P < .05$). There were no further changes in predicted VO_2peak for HEPAP or CON at the follow-up assessment (32.2 ± 5.5 and 25.4 ± 4.1 mL/kg/min, respectively; $P > .05$).

As demonstrated in Table 4, a significant Test by Condition interaction was observed for SBP ($F_{2,88} = 3.75$, $P < .05$; $\eta_p^2 = .113$) and RPE ($F_{2,88} = 6.19$, $P < .01$; $\eta_p^2 = .183$). Post hoc analysis revealed a significantly lower SBP at PI compared with BL for HEPAP (148 ± 16 versus 160 ± 19 mm Hg, respectively) but not for CON (154 ± 15 versus 155 ± 19 mmHg, respectively). Similar findings were observed at PI and BL for the RPE (10.3 ± 2.4 versus 11.4 ± 1.6, respectively for HEPAP, and 11.5 ± 2.3 versus 10.9 ± 2.1, respectively, for CON). Post hoc analysis revealed no further changes in either of these measures between PI and the follow-up assessment (both $P > .05$). As expected, a time main effect was observed for SBP, HR, and RPE (all $P < .05$). There were no Condition main effects or Condition by Test interactions for HR or DBP.

Discussion

The implementation of an 8-week exercise and education program within 2 weeks of a TIA or NDS resulted in a significant improvement in SBP, the primary outcome measure of this study. Improvements in a secondary outcome measures (ie, TC, VO_2peak) were also observed in those subjects who engaged in regular exercise participation soon after TIA diagnosis. Given that the risk of a recurrent event is at its highest soon after TIA, and as approximately 12% of patients will die within 1 year of a TIA,[20] these findings may have significant implications

Table 1. *Demographic and other characteristics for both groups (HEPAP and CON)*

	HEPAP		CON		
	n	%	n	%	*P* value
Participants (n)	30	50	30	50	
Age (y)	68 ± 11		69 ± 10		.370
Gender (n)					
Male	16	53	15	50	.501
Female	14	47	15	50	
Descent (n)					
European	27	90	26	87	.490
Maori	1	3	0	0	
Pacifica	1	3	2	7	
Asian	1	3	1	3	
Indian	0	0	1	3	
Marital status (n)					
Married	22	73	19	63	.754
Single	2	7	3	10	
Partner	1	3	2	7	
Divorced	1	3	3	10	
Widowed	4	13	3	10	
Job (n)					
Employed	8	27	7	23	.922
Unemployed	2	7	1	3	
Part-time	4	13	6	21	
Retired	16	53	16	53	
Family history of CVD					
Myocardial infarction	14	47	16	53	.904
Heart surgery	4	13	4	13	1.000
Stent	1	3	3	10	.068
Catheter	0	0	3	10	.171
Heart defect	3	10	1	3	.319
Stroke	12	40	13	43	1.000
Personal history of CVD					
Hypertension	18	60	23	77	.451
High cholesterol	15	50	19	63	.644
Diabetes	4	13	7	23	.411
Heart problems	5	17	10	33	.207
Artery diseases	3	10	4	13	1.000
Thyroid disease	0	0	1	3	.567
Lung disease	2	7	2	7	1.000
Asthma	6	20	5	17	.561
Cancer	5	17	8	27	.439
Kidney disease	3	10	2	7	.673
Hepatitis	2	7	1	3	.586
Signs and symptoms of CVD					
Chest pain	10	33	11	37	1.000
Dyspnea	18	60	17	57	.492
Heart palpitations	10	33	9	30	.624
Skipped heart beats	9	30	7	23	.434
Heart murmur	2	7	4	13	.498
Intermittent leg pain	9	30	12	40	.640
Syncope	17	57	12	40	.068
Fatigue	12	40	15	50	.655
Snoring	10	33	17	57	.167
Back pain	12	40	16	53	.499
Orthopedic problems	12	40	20	66	.067

(*Continued*)

Table 1. (*Continued*)

	HEPAP		CON		
	n	%	n	%	*P* value
Lifestyle factors					
Current smoker (pack years)	2*	7	3†	10	1.000
Duration smoking (y)	54 ± 8		35 ± 15		.213
Previous smoker	18	60	17	57	.492
Quit duration (y)	28 ± 18		28 ± 12		.992
Alcohol consumption	20	66	19	63	.476
Current weight loss plan	1	3	2	7	.675
Everyday activity: sedentary	9	30	6	20	.745
Light	11	37	17	57	
Moderate	7	23	7	23	
Vigorous	1	3	1	3	
Medication					
Statins	25	83	25	83	
Antithrombotic	26	87	23	77	
Angiotensin converting enzyme inhibitor (ACEI)	9	30	14	47	
Diuretics	8	27	11	37	
Calcium blockers	9	30	7	23	
Beta blockers	7	23	5	17	
Anticoagulants	2	7	4	13	
Other antihypertensives	2	7	1	3	
Mean medication use	2.87 ± 1.07		2.85 ± 1.01		.887

*Current smokers who smoke between .5 and 1.0 packs per day.
†Current smokers who smoke <.5 packs per day.

Table 2. *Vascular risk factors at BL, PI, and 3PI assessments*

	HEPAP			CON			Test by Condition interaction	
	BL	PI	3PI	BL	PI	3PI	*P* value	η_p^2
SBP (mm Hg)*	140.0 ± 14.3	128.7 ± 13.8	132.3 ± 14.3	137.9 ± 12.0	136.4 ± 16.9	134.0 ± 15.5	.024†	.069
DBP (mm Hg)	81.9 ± 8.1	79.8 ± 8.7	78.1 ± 10.0	80.4 ± 8.0	80.2 ± 9.8	79.5 ± 16.13	.342	.020
TC (mmol/L)*‡	4.14 ± 1.22	3.57 ± .69	3.70 ± .90	4.10 ± 1.09	4.06 ± 1.00	4.06 ± .96	.020†	.074
HDL (mmol/L)§	1.31 ± .60	1.31 ± .64	1.38 ± .63	1.28 ± .52	1.38 ± .51	1.43 ± .55	.255	.026
TC:HDL ratio‡	3.71 ± 1.82	3.26 ± 1.42	3.07 ± 1.18	3.54 ± 1.34	3.27 ± 1.44	3.19 ± 1.43	.208	.042
FBG (mmol/L)								
All	5.91 ± 1.48	5.60 ± 1.48	5.69 ± 1.41	5.88 ± 1.02	5.87 ± 1.07	5.95 ± 1.20	.250	.024
Nondiabetic	5.31 ± .66	5.12 ± .92	5.19 ± .82	5.50 ± .60	5.48 ± .69	5.57 ± .98	.666	.009
Diabetic	8.13 ± 1.57	7.35 ± 1.91	7.52 ± 1.64	7.20 ± 1.14	7.26 ± 1.06	7.27 ± 1.03	.215	.130
Weight (kg)	75.4 ± 14.5	75.2 ± 14.3	75.1 ± 13.8	80.4 ± 15.7	81.1 ± 14.9	80.6 ± 15.0	.775	.005
BMI (kg/m^2)	28.2 ± 4.3	28.1 ± 4.4	28.1 ± 4.2	28.8 ± 5.2	29.1 ± 5.1	28.9 ± 5.1	.779	.005
WC (cm)	94.4 ± 14.8	92.8 ± 13.2	91.9 ± 12.5	98.6 ± 14.2	99.4 ± 14.6	99.3 ± 14.3	.086	.047
HC (cm)	98.0 ± 11.2	96.7 ± 11.4	96.3 ± 10.5	102.4 ± 12.9	101.1 ± 13.2	101.0 ± 12.6	.980	.000
W-HC	.96 ± .09	.96 ± .06	.95 ± .07	.96 ± .09	.98 ± .09	.98 ± .09	.359	.020

Abbreviations: BMI, body mass index; DBP, diastolic blood pressure; FBG, fasting blood glucose; HDL, high-density cholesterol; HC, hip circumference; SBP, systolic blood pressure; TC, total cholesterol; WC, waist circumference; W-HC, waist-to-hip circumference.
*Significant time main effect between BL and PI ($P < .05$).
†Significant Test by Condition interaction ($P < .05$).
‡Significant time main effect between BL and 3PI ($P < .05$).
§Significant time main effect between PI and 3PI ($P < .05$).

Table 3. *Framingham scores for CAD risk at BL, PI, and 3PI*

	BL	PI	3PI
CAD	11.2 ± 8.8	9.0 ± 8.2*	8.0 ± 6.5
Myocardial infarction	5.4 ± 5.8	4.0 ± 5.5*	3.5 ± 4.5
Stroke	5.0 ± 3.4	4.3 ± 2.3	4.0 ± 2.7
CVD	19.9 ± 11.4	16.9 ± 11.6*	15.7 ± 9.4
CAD_D	3.4 ± 4.0	2.7 ± 4.0*	2.1 ± 2.6
CVD_D	7.1 ± 7.4	6.2 ± 7.7	4.9 ± 5.6

Abbreviations: CAD, coronary artery disease; CAD_D, death from CAD; CVD_D, death from CVD.

Values reported as mean ± SD for the entire study sample.

*Significant time main effect ($P < .05$).

for exercise prescription policy and prevention of new (ie, stroke) or recurrent (ie, TIA) cerebrovascular events.

This study demonstrated a significantly greater reduction in SBP (−10.4 ± 9.2 mm Hg) and TC (−.53 ± .90 mmol/L) between BL and PI for HEPAP compared with CON (−1.9 ± 15.4 mm Hg and .08 ± .59 mmol/L, respectively). The 7.3% and 9.1% change in SBP and TC, respectively, after as little as 8 weeks of exercise participation relates to a moderate effect size (.069 and .074, respectively). Interestingly, our findings are of a greater magnitude than other studies that have employed longer duration exercise interventions for ischemic stroke[6] and TIA patients.[13] For example, Prior et al[13] demonstrated a 2.4% and 6.8% improvement in SBP and TC, respectively, after a much longer exercise program (6-month, 50-session, 20- to 60-minute aerobic exercise per session). These studies recruited patients who were greater than 1-year poststroke[6] or up to 12 months post-TIA diagnosis.[13] It is plausible that the delay in implementing the exercise programs in the aforementioned studies may have influenced the effectiveness of their interventions, particularly when considering that a critical window in which to deliver an appropriate secondary prevention program likely exists. Certainly, our data appear to suggest that early exercise engagement, within the first few weeks of symptom onset, is particularly important with regards to improving certain vascular risk factors.

A trend toward the lowering of DBP (−2.3%), FBG (−5.3%), TC:HDL ratio (−12.2%), and WC (−1.3%) was evident after 8 weeks of exercise (Table 2). Such improvements were maintained until the 3-month follow-up assessment. These findings complement previous research that has revealed favorable changes in TC:HDL ratio, triglycerides, WC, and body weight after regular physical activity.[13] With the exception of TC:HDL ratio, vascular risk factors remained relatively unchanged in the CON group throughout the study. The Framingham risk score showed improvements between BL and PI for 4 of 6 measures, though similar results were demonstrated between both conditions. If confirmed in larger research studies, these moderate effect sizes will be of importance in improving the vascular risk profile in TIA and NDS patients.

Physical fitness significantly improved in the intervention group. Although oxygen uptake was not measured directly, similar to previous research,[6,13] HEPAP elicited a mean change in VO_2peak of 2.5 mL/kg/min. This equated to an 8.2% improvement in aerobic fitness. Further support for the importance of early engagement was demonstrated when interpreting the aerobic fitness of the CON group as a 3.4 mL/kg/min mean change (decrease) in VO_2peak was observed. This equated to a 11.4% decrement in aerobic capacity. Importantly, HEPAP participants maintained their aerobic fitness at the 3-month follow-up assessment. When considering the physiological and perceptual responses at the 2 submaximal stages to the aerobic fitness test, HEPAP initiated a substantial reduction in SBP and RPE (Table 4), further demonstrating the positive fitness

Table 4. *Mean (±SD) physiological response from the 2-stage aerobic (cycle) fitness assessment for both groups (HEPAP, CON) and each assessment (BL, PI, and 3PI)*

		Stage 1 (30 W)			Stage 2 (60 W)		
		BL	PI	3PI	BL	PI	3PI
HR (beats/min)*	HEPAP	91 ± 13	88 ± 13	91 ± 11	106 ± 13	100 ± 13	104 ± 14
	CON	96 ± 13	97 ± 13	95 ± 11	110 ± 13	113 ± 13	111 ± 14
RPE*†	HEPAP	10.1 ± 2.1	9.1 ± 2.5	9.0 ± 2.6	12.7 ± 1.5	11.4 ± 2.8	11.5 ± 2.4
	CON	9.7 ± 1.6	10.0 ± 2.5	9.9 ± 2.0	12.1 ± 1.9	12.9 ± 2.1	12.8 ± 2.4
SBP (mm Hg)*†	HEPAP	149 ± 34	141 ± 14	141 ± 14	171 ± 23	155 ± 17	155 ± 16
	CON	149 ± 13	146 ± 16	147 ± 16	162 ± 16	162 ± 18	161 ± 17
DBP (mm Hg)	HEPAP	85 ± 8	80 ± 8	81 ± 8	86 ± 8	81 ± 8	81 ± 8
	CON	84 ± 9	82 ± 10	81 ± 9	84 ± 11	82 ± 11	82 ± 9

Abbreviations: DBP, diastolic blood pressure; SBP, systolic blood pressure.

*Significant time main effect between stage 1 and stage 2 ($P < .001$).

†Significant Test by Condition interaction between HEPAP and CON for stage 1 and stage 2 ($P < .05$).

benefits associated with taking part in an exercise and education program.

An important characteristic of successful behavior change is that individuals continue to engage in lifestyle modifications once the stimulus (ie, structured exercise sessions) has been removed. The education component was included in the intervention as a means for patients to understand the effect and value of long-term change in lifestyle behavior.[21] A recent meta-analysis for stroke patients revealed that end-of-intervention benefits gained from regular physical fitness training do not persist after an intervention has ceased.[22] In the present study, the changes in SBP and TC were maintained for 3 months PI, suggesting that the educational component may be a useful adjunct to the exercise program. Further assessments at 12 months are already planned to assess the longevity of the benefits from this program. The PREVENT[23] and CRAFTS[24] trials are also investigating the short- and long-term efficacy of exercise and education programs in modifying vascular risk in TIA patients within 90 days of symptom onset.

The main limitations of the study reflect the relatively small sample size and recruitment from a single stroke center. Notably, the study was not powered to detect reduced recurrence rates for TIA or stroke. As such, a large, multisite randomized controlled trial is necessary to detect the practical viability of implementing an exercise and education program immediately after TIA or NDS diagnosis. Nevertheless, the pragmatic study design, one that had clear exclusion criteria, is a particular strength to the research. Although further information on the recruitment and compliance to the trial is reported elsewhere,[25] our findings are applicable to the "real-world" TIA services that assess predominantly white European populations. However, as the intervention was a composite of both exercise and education, it is therefore difficult to establish whether the observed changes were because of an increase in regular, structured physical activity or because of an elevated awareness of the need to improve lifestyle factors (ie, diet) as highlighted in the education sessions. Future research should therefore consider the individual effect that exercise (ie, aerobic versus resistance versus aerobic + resistance) and education has on vascular risk factors and fitness in such population groups. We would also like to recognize a potential statistical flaw. Although the study implemented the Framingham risk score as a secondary outcome measure, previous research has suggested that it may not be valid for non-Caucasians or older individuals.[26] Furthermore, although the sample size was adequately powered in relation to the primary outcome measure (SBP), other vascular risk factors (FBG, HDL, etc.) may have been underpowered. Randomized controlled trials with a larger TIA population are therefore needed to examine the effect of early exercise engagement on the myriad of vascular risk factors.

In conclusion, this study demonstrates the beneficial effects of taking part in an exercise and education program soon after diagnosis on vascular risk factors and aerobic fitness for TIA and NDS patients. Favorable changes were maintained for 3 months after the completion of the program, which may have significant implications for exercise prescription policy after TIA or NDS. Further research is necessary to assess the longevity of the observed, positive short-term changes and whether such changes may result in a reduced recurrence rate of TIA and stroke.

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