J Rehabil Med 2007; 39: 88–90

**SHORT COMMUNICATION**

# EFFECTS OF EXERCISE INTERVENTION ON PATIENTS WITH STROKE WITH PRIOR CORONARY ARTERY DISEASE: AEROBIC CAPACITY, FUNCTIONAL ABILITY AND LIPID PROFILE: A PILOT STUDY

Ai-Lun Yang, PhD[1], Shin-Da Lee, PhD[2], Chia-Ting Su, PhD[3], Jue-Long Wang, MD[4] and Ko-Long Lin, MD[4]

*From the Departments of [1]Physical Therapy and [3]Occupational Therapy, College of Medicine, National Cheng Kung University, Tainan, [2]School of Physical Therapy, Chung-Shan Medical University, Taichung and [4]Departments of Physical Medicine and Rehabilitation, Veterans General Hospital – Kaohsiung, Kaohsiung, Taiwan*

***Objective:*** **To assess the effects of exercise intervention on aerobic capacity, functional ability and lipid profile in patients after stroke with prior coronary artery disease.**
***Patients:*** **Fifteen patients after stroke with prior coronary artery disease.**
***Methods:*** **Patients were enrolled in a moderate-intensity exercise intervention using a graded treadmill for 12 weeks. Before and after the intervention, their aerobic capacity and functional ability were assessed by the exercise testing and Barthel index, respectively. The total cholesterol (TC), low-density lipoprotein cholesterol (LDL), high-density lipoprotein cholesterol (HDL), triglyceride, and TC/HDL were also evaluated using an enzyme auto-analyser.**
***Results:*** **After training, the patients' absolute peak oxygen consumption ($\dot{V}O_2$) was increased ($p < 0.01$); their functional ability was significantly improved ($p < 0.01$); and their TC, LDL, triglyceride, and TC/HDL levels were significantly reduced ($p < 0.01$). However, HDL level did not change significantly. In addition, Pearson analysis demonstrated a strong correlation between the increase in peak $\dot{V}O_2$ and the decrease in TC/HDL ($r = –0.72$, $p < 0.01$).**
***Conclusion:*** **These results suggest that exercise intervention is beneficial for aerobic capacity, functional ability, and some parts of the lipid profile in patients after stroke with prior coronary artery disease.**

*Key words:* physical activity, cerebrovascular accident, ischaemic heart disease, oxygen consumption, activities of daily living, lipoproteins.

J Rehabil Med 2007; 39: 88–90

*Correspondence address: Ko-Long Lin, Departments of Physical Medicine and Rehabilitation, Veterans General Hospital – Kaohsiung, 386 Ta- Chung 1st Rd., Kaohsiung 813, Taiwan. E-mail: kllin@isca.vghks.gov.tw*

Submitted December 20, 2005; accepted May 2, 2006.

## INTRODUCTION

Stroke is the leading cause of death and adult disability in the USA. The common risk factors for stroke are hypertension, diabetes mellitus, smoking, obesity, elevated cholesterol levels, and physical inactivity (1). Several studies have shown that patients after stroke have a high prevalence of asymptomatic coronary artery disease (CAD) (2, 3). Cardiovascular co-morbidity may contribute to complications in the treatment and the course of the illness, to a limited recovery of function, and even to early mortality (3). Thus, interventions to improve the prognosis for patients after stroke with concurrent CAD should be of great interest.

Exercise training can improve sensorimotor function, increase aerobic exercise capacity, and reduce energy expenditure in patients after stroke (4–6). Beneficial effects of exercise training on patients with CAD have also been observed, such as an increase in peak oxygen uptake ($\dot{V}O_2$peak) and a decrease in total cholesterol (TC) (7, 8). The previous study indicated that patients after stroke with prior CAD had less functional improvement during rehabilitation than those without prior CAD (9). It might reasonably be expected that therapeutic programs are more difficult for patients with concurrent stroke and CAD. Until now, few studies have examined the ways in which exercise intervention influences the prognosis of patients with concurrent stroke and CAD. Thus, the aims of the present study were: (*i*) to evaluate the effects of 12-week exercise intervention on aerobic capacity, functional ability, and lipid profile in patients after stroke with prior CAD, and (*ii*) to examine the correlation between changes in patients' exercise capacity and lipid profile.

## METHODS

### *Subjects*

Fifteen patients after stroke with mild-to-moderate hemiparetic gait and a history of CAD were recruited from the Kaohsiung Veterans General Hospital, Taiwan. The patients comprised 9 men and 6 women age range 52–77 years. Within one year after the onset of stroke, they had a walking disability with an asymmetric walking pattern. CAD was defined as any manifestation of heart disease within 10 years. To preclude possible training effects before our intervention, patients with regular aerobic exercise were excluded. Table I shows the clinical characteristics of these patients who enrolled in the study. The Ethics Committee of Medicine at the National Cheng Kung University approved all procedures, and informed consent was obtained from all patients for their participation in this study.

### *Exercise testing and training*

The symptom-limited treadmill exercise testing with open-circuit spirometry was designed to measure the patients' aerobic capacity



 ISSN 1650-1977
DOI: 10.2340/16501977-0021

Table I. *Clinical and demographic characteristics of patients after stroke (n = 15)*

| Characteristics | |
|---|---|
| Mean age (SD), years | 64.13 (7.58) |
| Age range, years | 52–77 |
| Ratio men: women | 9:6 |
| Mean weight (SD), kg | 65.80 (8.39) |
| Weight range, kg | 52–83 |
| Mean height (SD), m | 1.63 (0.06) |
| Height range, m | 1.55–1.73 |
| Body mass index (SD), kg/m$^2$ | 24.59 (2.71) |
| BMI range, kg/m$^2$ | 18.0–28.6 |
| Side of stroke, *n* (%) | |
| Left | 6 (40) |
| Right | 7 (47) |
| Bilateral | 2 (13) |
| Coronary artery disease, *n* (%) | |
| Myocardial infarction | 9 (60) |
| CABG | 4 (27) |
| PTCA | 2 (13) |
| Hypertension , *n* (%) | 10 (67) |
| Diabetes mellitus, *n* (%) | 8 (53) |

SD: standard deviation, CABG: coronary artery bypass graft,
PTCA: percutaneous transluminal coronary angioplasty.

at baseline and after the 12-week exercise intervention. The testing system (Metamax 3B, Cortex Biophysik GmbH Co., Germany) consisted of a treadmill, gas analyser, and electrocardiographic monitor. Exercise testing was performed with a treadmill velocity of 0.5 mph and a grade of 0% for 2 minutes, then a constant velocity of 1 mph and grade increments of 3.5%, which were adjusted every 2 minutes until the patient reported subjective unbearable symptoms (10). Peak oxygen consumption ($\dot{V}O_2$) was determined until patients were fatigued volitionally or limited by the symptom according to the established guidelines (11). Also $\dot{V}O_2$ at the anaerobic threshold (AT $\dot{V}O_2$) was determined by the V-slope method during exercise testing (12). Heart rate and blood pressure were monitored throughout the exercise testing. A physician and a physical therapist conducted the exercise testing according to established guidelines (11).

Intensity of the treadmill training was set at 50–60% of the patients' heart rate reserve, which was determined according to the formula of Karvonen (6). Because of the patients' limitations in gait velocity, the workload was graded by progressively increasing the inclines of treadmill at low velocity. Exercise training was started at 40–50% of the patients' heart rate reserve and advanced as tolerated. All patients trained on the treadmill for 50 minutes per session (including warm-up and cool-down periods), 3 sessions per week, for 12 weeks.

### *Measurement of functional ability and lipid profile*

Barthel index (BI) is commonly used to assess the functional ability of stroke patients in 10 items. The scores are multiples of 5 with a range of 0–100. The patients' performance on the BI was evaluated by a physiotherapist before and after the exercise intervention. In addition, blood samples were collected from fasting patients to determine their lipid profile, which included values for TC, low-density lipoprotein cholesterol (LDL), high-density lipoprotein cholesterol (HDL), triglyceride, and the TC/HDL. The serum concentrations of lipid levels were measured using enzymatic methods and an automatic analyser.

### *Statistical analysis*

Data were expressed as mean with standard deviation. A paired *t*-test was applied to compare patients' aerobic capacity and lipid profile; Wilcoxon signed-rank test was applied to compare patients' functional ability at baseline and at the end of exercise intervention. The Pearson correlation was used to determine the relationship between the increase in peak $\dot{V}O_2$ and the decrease in TC/HDL, and was expressed by correlation coefficient *r*. Differences were considered significant at $p < 0.05$.

## RESULTS

Fifteen patients completed the 12-week exercise intervention. During the training periods, there were no adverse effects or complications with exercise training. Table II showed that the aerobic capacity (peak $\dot{V}O_2$ and AT $\dot{V}O_2$) and cardiovascular adaptation were significantly improved after the 12-week exercise intervention.

Likewise, total scores of the BI were significantly increased after the 12-week exercise intervention in these patients (median scores: from 70 to 90; interquartile range: 65–80 and 75–100, respectively; $p < 0.01$). In addition, exercise intervention significantly reduced serum concentrations of TC, LDL, and triglyceride in these patients (TC: from 227.67 (SD 41.47) to 180.93 (SD 40.54); LDL: from 149.33 (SD 37.87) to 109.93 (SD 29.34); triglyceride: from 181.73 (SD 63.90) to 123.14 (SD 61.49) mg/dl). Although HDL level tended to increase with exercise training, the effect was not statistically significant. The TC-to-HDL ratio was significantly reduced during the 12-week training program (from 5.14 (SD 1.13) to 3.76 (SD 0.46); $p < 0.01$). In addition, Pearson analysis showed a strong correlation between the increase in peak $\dot{V}O_2$ and the decrease in TC/HDL after the exercise intervention ($r = -0.72$, $p < 0.01$).

## DISCUSSION

The results clearly demonstrated that: (*i*) the 12-week exercise intervention induced favourable cardiovascular adaptation and significantly improved peak exercise capacity in these patients; (*ii*) the total scores of BI were significantly enhanced

Table II. *Effects of 12-week exercise intervention on exercise capacity in the 15 patients after stroke with prior coronary artery disease. Data is given as mean, with SD in parentheses*

| Variable | Baseline | 12 weeks |
|---|---|---|
| Resting HR (beats/min) | 78.07 (11.06) | 72.67 (8.85)** |
| Resting sBP (mmHg) | 140.50 (13.17) | 134.86 (8.76)** |
| Resting dBP (mmHg) | 84.57 (4.69) | 80.43 (5.09)** |
| Peak $\dot{V}O_2$ (l/min) | 0.74 (0.17) | 0.92 (0.23)** |
| Peak $\dot{V}O_2$ (ml/kg/min) | 11.24 (2.42) | 14.06 (3.19)** |
| AT $\dot{V}O_2$ (l/min) | 0.54 (0.11) | 0.62 (0.12)** |
| AT $\dot{V}O_2$ (ml/kg/min) | 8.25 (1.98) | 9.45 (1.72)** |
| Peak HR (beats/min) | 110.27 (14.56) | 121.80 (13.19)** |
| Peak sBP (mmHg) | 164.67 (16.76) | 172.33 (15.60)** |
| Peak dBP (mmHg) | 96.58 (8.98) | 95.82 (5.56) |
| Peak RER | 1.06 (0.08) | 1.18 (0.11)** |
| Resting lactate (mg/dl) | 9.99 (1.20) | 10.00 (1.15) |
| Peak lactate (mg/dl) | 20.15 (4.48) | 32.49 (9.36)** |

**$p < 0.01$ compared with baseline.
HR: heart rate, sBP: systolic blood pressure, dBP: diastolic blood pressure, peak $\dot{V}O_2$ : peak oxygen consumption, AT $\dot{V}O_2$ : anaerobic threshold, RER: respiratory exchange ratio.

after the exercise intervention; (*iii*) TC, LDL, triglyceride, and TC/HDL were significantly reduced, but HDL did not change, after the exercise intervention; and (*iv*) the correlation between increased peak $\dot{V}O_2$ and decreased TC/HDL was significant.

The safety and efficacy of the low-velocity graded treadmill testing in the design of adequate exercise prescription has been evaluated and used in patients after stroke (6, 10). In the current study, the similar graded treadmill testing was designed to measure the patients' peak exercise capacity at baseline and at the end of the 12-week exercise intervention. These 15 patients after stroke with prior CAD could perform this graded treadmill testing to an end-point of volitional fatigue or cardiopulmonary exercise intolerance. It is well-known that exercise intervention positively influences aerobic capacity and other physiological outcomes in patients with either stroke or CAD (4–7). To our knowledge, the present study is the first to show an effective exercise intervention for the enhancement of exercise capacity in patients with concomitant stroke and CAD, in light of significant improvements at both peak effort and AT $\dot{V}O_2$. Our findings indicated that the patients after stroke with prior CAD had statistically significant improvements in peak aerobic capacity, including increases in peak heart rate, peak $\dot{V}O_2$ and respiratory exchange ratio, similar to those of patients with either stroke or CAD alone in previous studies after the exercise intervention (6, 7).

Until now, only a few groups have investigated the influence of treadmill exercise training on the patients' ability to perform daily functions. In the present study, the patients' capacity to perform activities of daily living, as measured by the BI, was significantly improved after the exercise intervention. The application of an intensive task-oriented gait training program may be most conductive to locomotion learning (13). As anticipated, the patients had significant improvement in mobility-related activities, including transfers and ambulation, which were relevant to the task of treadmill exercise training. In addition, they gained the marked improvement on the items of self-care ability, including feeding, grooming, dressing, bowel control and toilet use. However, whether the improvement in aerobic capacity might contribute to the amelioration in daily functions by means of exercise training in patients after stroke with prior CAD should be investigated further.

Many investigators have mentioned that TC/HDL is an independent risk factor for patients with CAD, and as good as or better than apolipoprotein fractions in the prediction of cardiovascular events (14). In the current study, TC/HDL did significantly decrease after the exercise intervention. Furthermore, our study reported that the correlation between increased peak $\dot{V}O_2$ and decreased TC/HDL was significant by the results of Pearson correlation analysis. The possible causal relationship between these two variables needs to be investigated further.

The strengths of this study were the rigorous testing of exercise performance, execution of exercise training, and criteria for screening participants. However, our findings should be interpreted with caution because of the relatively small sample and the absence of a reference group. The possibility of a placebo effect or a selection bias cannot be ruled out. A randomized controlled study should be conducted to examine our findings further and to explore the possibility of generalizing the results to a large population.

In conclusion, our findings provided promising evidence of the beneficial effects of aerobic exercise intervention in patients after stroke with prior CAD. With a well-designed exercise protocol, patients' aerobic capacity, functional ability, and lipid profile can be improved significantly.

## ACKNOWLEDGEMENTS

This study was supported by a grant from the National Sciences Council (NSC93-2314-B-006-025), Taiwan, ROC. We are grateful to Dr Ing-Shiou Hwang for his comments on the manuscript.

## REFERENCES

1. American Heart Association. Fact sheet on stroke. Dallas: American Heart Association; 2002.
2. Di Pasquale G, Pinelli G, Grazi P, Andreoli A, Corbelli C, Manini GL, et al. Incidence of silent myocardial ischaemia in patients with cerebral ischaemia. Eur Heart J 1998; 9 (suppl N): 104–107.
3. Roth EJ. Heart disease in patients with stroke. Part II: impact and implications for rehabilitation. Arch Phys Med Rehabil 1994; 75: 94–101.
4. Potempa K, Lopez M, Braun LT, Szidon P, Fogg L. Tincknell T. Physiological outcomes of aerobic exercise training in hemiparetic stroke patients. Stroke 1995; 26: 101–105.
5. Macko RF, DeSouza CA, Tretter LD, Silver KH, Smith GV, Anderson PA, et al. Treadmill aerobic exercise training reduces the energy expenditure and cardiovascular demands of hemiparetic gait in chronic stroke patients: a preliminary report. Stroke 1997; 28: 326–330.
6. Macko RF, Smith GV, Dobrovolny CL, Sorkin JD, Goldberg AP, Silver KH. Treadmill training improves fitness reserve in chronic stroke patients. Arch Phys Med Rehabil 2001; 82: 879–884.
7. Wosornu D, Bedford D, Ballantyne D. A comparison of the effects of strength and aerobic exercise training on exercise capacity and lipids after coronary artery bypass surgery. Eur Heart J 1996; 17: 854–863.
8. Miller TD, Balady GJ, Fletcher GF. Exercise and its role in the prevention and rehabilitation of cardiovascular disease. Ann Behav Med 1997; 19: 220–229.
9. Roth EJ, Mueller K, Green D. Stroke rehabilitation outcome: impact of coronary artery disease. Stroke 1988; 19: 42–47.
10. Macko RF, Katzel LI, Yataco A, Tretter LD, DeSouza CA, Dengel DR, et al. Low velocity graded treadmill stress testing in hemiparetic stroke patients. Stroke 1997; 28: 988–992.
11. American College of Sports Medicine. Guidelines for exercise testing and prescription. New York: Lippincott Williams and Wilkins; 2000.
12. Beaver WL, Wasserman K, Whipp BJ. A new method for detecting anaerobic threshold by gas exchange. J Appl Physiol 1986; 60: 2020–2027.
13. Malouin F, Potvin M, Prevost J, Richards CL, Wood-Dauphinee S. Use of an intensive task-oriented gait training program in a series of patients with acute cerebrovascular accidents. Phys Ther 1992; 72: 781–789.
14. Ridker PM, Rifai N, Cook NR, Bradwin G, Buring JE. Non-HDL cholesterol, apolipoproteins A-I and B100, standard lipid measures, lipid ratios, and CRP as risk factors for cardiovascular disease in women. JAMA 2005; 294: 326–333.