Effect of Low-Intensity Ergometer Aerobic Training on Glucose Tolerance in Severely Impaired Nondiabetic Stroke Patients

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Objective: To investigate whether low-intensity ergometer aerobic training has beneficial effect on glucose tolerance in nondiabetic patients with severely impaired stroke. *Methods:* Fifty-four severely impaired stroke survivors were recruited and randomly assigned to the experimental group and control group. They have no diabetes history with fasting plasma glucose less than 7 mmol/L. Both groups participated in a 6-week rehabilitation training program with low-intensity ergometer aerobic training added only in the experimental group 3 times per week. Primary outcome variables were fasting glucose, fasting insulin, 2-hour glucose, and homeostasis model assessment–insulin resistance (HOMA-IR) in oral glucose tolerance test before and after intervention. *Results:* Before intervention, 36 of 54 (66.7%) were diagnosed with impaired glucose status or diabetic glucose tolerance totally. The average 2-hour plasma glucose level was 9.14 ± 1.39 mmol/L. After intervention, aerobic training significantly improved fasting insulin (from 8.51 ± 2.01 μU/mL to 7.11 ± 2.02 μU/mL), 2-hour glucose level (from 9.13 ± 1.14 mmol/L to 7.22 ± 1.23 mmol/L), and HOMA-IR (from 1.62 ± 1.01 to 1.29 ± .79) in the intervention group compared with the control group ($P < .05$). Aerobic training also significantly improved their glucose tolerance state ($P < .05$). *Conclusions:* Preliminary findings suggest that abnormal glucose tolerance may be highly present among severely impaired nondiabetic stroke patients and low-intensity ergometer aerobic training may have beneficial role in improving glucose tolerance. **Key Words:** Effect—low-intensity ergometer aerobic training—severely impaired nondiabetic stroke patients—glucose tolerance.

Inroduction

High prevalence of abnormal glucose tolerance status was reported among stroke survivors in previous studies. For example, Ivey et al[1] showed that among all the stroke survivors, more than 80% have abnormal higher plasma glucose level. In another study, Kernan et al[2] found that more than 50% nondiabetic stroke subjects were diagnosed with impaired glucose status (IGT) or diabetic glucose tolerance (DGT). Abnormal glucose tolerance,

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always ignored among subjects with normal fasting glucose, was closely related with first and recurrent stroke.[3] It was reported that IGT and DGT are each associated with an increased risk for incident vascular disease, vascular disease mortality, and all-cause mortality.[4-6]

Aerobic training could be used effectively to improve fitness and cardiovascular risks.[7,8] Several recent studies have also proved its role among stroke patients.[9,10] Yet, most studies focus on functional recovery and fitness improvement.[11,12] The effect on hyperglycemia was less investigated, especially among severely impaired stroke hemiplegia.

Our study concentrates on severely compromised nondiabetic stroke survivors. We studied the role of low-intensity ergometer aerobic training in improving glucose tolerance state. Our hypothesis was that low-intensity ergometer aerobic training could be well tolerated to improve glucose metabolism among severely affected nondiabetic stroke survivors.

Materials and Methods

Subjects

Subjects in this study were recruited from rehabilitation center of the First Affiliated Hospital of Nanjing Medical University in eastern China. In this large rehabilitation center, stroke patients participated in a comprehensive rehabilitation program including physiotherapy, occupational therapy, acupuncture, and speech therapy according to individual needs. The hospital and university ethics committees approved the trial, and patients gave written informed consent authorized by the hospital. They were free to withdraw from this trial at any time if they or their relatives requested.

Inclusion criteria were as follows: 1-6 months post-stroke confirmed by computed tomography or magnetic resonance imaging scan; age over 45 years; severely impaired with the affected leg marked 3 or less on the 7-point Chedoke–Mcmaster Stroke Assessment scale[13]; unable to walk even with walk aids; the unaffected leg can move against normal resistance; fasting glucose level less than 7 mmol/L; no physician diagnosed diabetes according to history and medical records (outcomes in fasting glucose, oral glucose tolerance test [OGTT], or hemoglobin A1c) in stroke unit or neurology department; never using medications that may significantly alter heart rate and blood glucose level; and able to understand the purpose and content of the study.

Exclusion criteria include signs and symptoms of subarachnoid hemorrhage, transient ischemic attack, severe cerebral oedema, O_2 dependence, angima, unstable cardiac conditions, peripheral arterial occlusive disease, abnormal high fever, severe pneumonia, high blood pressure over 200/110 mm Hg, dementia, aphasia operationally defined as incapacity to follow 2-point commands, untreated major depression, and other medical conditions that precluded participation in exercise training.

During baseline assessment, subject may also be excluded from the study if they could not produce enough power output in exercise test or they were diagnosed as diabetes by OGTT and given insulin or oral drugs to treat it.

Randomization

The subjects were randomly allocated to the experimental group or control group. Each subject was given an envelope containing 2 cards and was instructed to blindly draw 1 card on each occasion. The investigators were not blinded to group assignment; however, all the outcome assessors and therapists involved were blinded to baseline data and group assignment.

Rehabilitation Training

Both groups exercised 5 d/wk for 6 weeks. On every training day, they will receive routine exercise program comprising three 40-minute sessions of physical training, two 15-minute occupational training, one 30-minute acupuncture or traditional Chinese manipulation, and one 30-minute physical agents therapy. One 40-minute physical training was replaced by low-intensity ergometer aerobic training 3 d/wk in the experimental group. Prior works have demonstrated that routine rehabilitation training for severely affected stroke survivors provide little aerobic stimulus.[14,15]

Exercise Test and Aerobic Training

Adapted symptom-limited graded exercise test (Appendix 1) was performed before aerobic training to collect peak heart rate. Our prior study has proved its feasibility in severely impaired stroke patients, and in this study, a random sample of 10 eligible subjects were tested twice at the entry to program. As a result, they finished the test at the same workload and for the same reason (test–retest percentage agreement = 100%). The peak heart rate was defined as the highest observed during the exercise test.

Low-intensity ergometer aerobic training (Appendix 2) was performed 3 times per week for 6 weeks. The same ergometer was used while patients also sit on his wheelchair. The targeted intensity training time was 30 minutes, and the intensity was determined according to Karvonen equation[16,17]: target heart rate = ((peak heart rate in the exercise test − resting heart rate) × 50%-70%) + resting heart rate. There was 1 additional therapist in help who will correct patient's wrong compensatory movement, keep patients in good posture, encourage the use of affected leg verbally, and monitor training intensity to ensure treatment fidelity. Cardiac monitor or heart rate belt will be used during aerobic training, and the