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ORIGINAL RESEARCH

Resistance Training Improves Hyperglycemia and Dyslipidemia, Highly Prevalent Among Nonelderly, Nondiabetic, Chronically Disabled Stroke Patients

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Abstract

Objective: To test the effect of 8 weeks of lower body resistance training on hyperglycemia and dyslipidemia, which may be prevalent among nonelderly, nondiabetic, chronically disabled stroke patients.

Design: Randomized controlled study.

Setting: Outpatient clinics of rehabilitation centers.

Participants: Nonelderly, nondiabetic, chronically disabled stroke subjects (N=56) were enrolled and randomly assigned to an experimental group (n=28) and a control group (n=28).

Interventions: Lower body resistance training was performed by subjects in the experimental group 3 times a week for 8 weeks. The control group was given duration-matched stretch exercises.

Main Outcome Measures: Fasting glucose level, fasting insulin level, 2-hour blood glucose level during oral glucose tolerance test, homeostasis model assessment of insulin resistance (HOMA-IR), glycosylated hemoglobin (Hb A_{1c}), total triglyceride level, total cholesterol level, high-density lipoprotein (HDL) cholesterol level, low-density lipoprotein (LDL) cholesterol level, body mass index, lower limb muscle strength, and Fugl-Meyer motor score.

Results: Before the intervention, 34 subjects (60.7%) had hyperglycemia and 38 (67.9%) had dyslipidemia. Fifty-one subjects finished the study. Subjects in the experimental group (n=26) showed significant improvements in fasting insulin and 2-hour blood glucose levels; HOMA-IR; total cholesterol, HDL cholesterol, and LDL cholesterol levels; and muscle strength compared with control subjects (n=25) after the intervention ($P<.05$).

Conclusions: Resistance training may play a significant role in improving hyperglycemia and dyslipidemia, which are frequently present among nonelderly, nondiabetic, chronically disabled stroke patients.

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Hyperglycemia and dyslipidemia are closely associated with stroke morbidity and mortality.[1,2] The objectives of stroke rehabilitation training include recovery of functional independence, improvement of life quality, and prevention of recurrent vascular disease.[3] Although great efforts are made clinically to achieve functional independence, the correction of metabolic disorders with rehabilitation training or comprehensive management has received less attention.[4] This is because stroke subjects have motor function limitations that make performing high-intensity aerobic or resistance training difficult.[4,5] Rehabilitation training plays an important role in promoting functional recovery for stroke survivors; however, its role in regulating metabolic disorders for stroke patients has not been established. Our prior study[6] suggested that routine rehabilitation training has no effect on the glucose tolerance state of stroke survivors, indicating that routine rehabilitation training may be insufficient to improve metabolic disorders. Few studies have focused on the metabolic risk factors among chronic stroke

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patients who have finished comprehensive rehabilitation training. However, correction of metabolic disorders including hyperglycemia and dyslipidemia should be emphasized from the perspective of secondary vascular disease prevention. If hyperglycemia and dyslipidemia are still common after rehabilitation training, longer-term rehabilitation training consisting of resistance training or aerobic training is necessary, especially for nonelderly subjects.

Resistance training plays a significant role in regulating blood glucose and lipid metabolism among nonstroke subjects.[7,8] However, resistance training has not been widely used during stroke rehabilitation due to the difficulties disabled patients have performing it and the possible negative effects on muscle tone of the hemiplegic side. Recent studies have suggested that motor function could be increased after resistance training by chronic stroke patients,[9-11] and muscle properties such as muscle mass, which has a close association with blood glucose and lipid profiles,[12] could also be improved through the application of resistance training.[12] The study by Ivey and Ryan[13] also indicated that strength training may improve insulin sensitivity among stroke subjects. However, the efficacy of resistance training in improving hyperglycemia and dyslipidemia of stroke patients has not been documented. Randomized controlled studies on its application among nonelderly, nondiabetic, and chronically disabled stroke patients are absent.

Therefore, this study was designed (1) to determine the prevalence of hyperglycemia and dyslipidemia among nonelderly, nondiabetic, chronically disabled stroke patients who have finished routine rehabilitation training; and (2) to evaluate the effects of 8 weeks of lower body resistance training on these metabolic disorders. We hypothesized that hyperglycemia and dyslipidemia are prevalent among these patients and that these metabolic disorders could be improved by an 8-week lower body resistance training program.

Methods

Setting

The rehabilitation training and evaluation involved in this study were performed in the outpatient clinics of 2 hospital's rehabilitation centers.

Participants

Nonelderly (aged <60y), nondiabetic, chronically (defined as >6mo after stroke onset) disabled stroke patients who had completed conventional physical therapy were enrolled in this study. Baseline evaluations confirmed that they received at least 3 weeks of rehabilitation training and achieved basic functional independence with a Barthel Index score >60 (Barthel Index scores ranged from 0 to 100, with scores >60 indicating basic independence), while deficits in motor function, indicated by low Fugl-Meyer motor scores (scores <100), were still present. All the subjects in this study could walk independently with or without walking aids, while some patients had mild to moderate hemiparetic gait. Baseline evaluations excluded patients with diabetes, heart failure, unstable angina, dementia, and aphasia. The diagnosis of diabetes was confirmed by elevated blood glucose levels (fasting glucose level >7.0mmol/L or a blood glucose level >11.1mmol/L at 2h after a meal) on different days according to medical records and a baseline evaluation.

This study was approved by the ethics committees of the involved hospitals. The purpose, nature, and potential risks of this trial were fully explained, and all subjects provided their written, informed consent before participation. Subjects were free to withdraw at any time if they or their relatives requested.

List of abbreviations:

BMI body mass index
Hb A_{1c} glycosylated hemoglobin
HDL high-density lipoprotein
HOMA-IR homeostasis model assessment of insulin resistance
LDL low-density lipoprotein
OGTT oral glucose tolerance test
RM repetition maximum

Randomization

Subjects were randomly allocated to an experimental group or a control group. Sealed envelopes and a block sampling method were used to achieve an equal number of subjects in each group. The investigators were not blinded to group assignment; however, all the outcome assessors and therapists were blinded to baseline data and group assignment. Clinical parameters of all the subjects are shown in table 1.

Intervention protocols

Forty minutes of resistance training was provided to subjects in the experimental group 3 times a week for 8 weeks. During each training session, subjects were asked to perform 3 sets of 15 unilateral repetitions of the leg press, leg extension, and leg curl movements on the training machines.[a] The resistance was set at a level that would cause muscle failure between repetitions 10 and 12. Resistance was then gradually reduced until the completion of the full 15-repetition set. The training intensity and volume were determined according to the intervention in Ivey and Ryan's study,[13] and the tolerance of trained legs for subjects in this study. These training parameters were decided to provide a high training-volume and high-intensity training stimulis for maximal adaptations in trained muscles. The affected and unaffected legs were trained alternatively during each session to

Table 1 Clinical features of subjects

Characteristics	Experimental Group (n=28)	Control Group (n=28)
Age (y)	52.3±6.9	51.4±7.2
Sex (female/male)	15/13	19/9
Time since stroke onset (mo)	15±6.2	8±5.1
Stroke type		
Ischemia	19	18
Hemorrhage	9	10
Stroke site		
Cortex	12	10
Subcortical	15	16
Mixed	1	2
Stroke side (left/right)	11/17	13/15
History of hypertension	16	20

NOTE. Values are mean ± SD or n.