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ORIGINAL RESEARCH

Following the Physical Activity Guidelines for Adults With Spinal Cord Injury for 16 Weeks Does Not Improve Vascular Health: A Randomized Controlled Trial

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Abstract

Objective: To evaluate the effects of following the physical activity guidelines (PAG) for adults with spinal cord injury (SCI) for 16 weeks.
Design: Randomized controlled trial.
Setting: Community exercise program.
Participants: Individuals with SCI (N=23; neurological level of injury, C3−T11; American Spinal Injury Association Impairment Scale A−C; time postinjury, 12.0±9.9y; age, 41.4±11.6y).
Interventions: Participants were randomly assigned to PAG training (n=12) or active control (n=11) groups. PAG training involved ≥20 minutes of moderate-vigorous aerobic exercise (rating of perceived exertion 3−6 on 10-point scale) and 3×10 repetitions of upper-body strengthening exercises (50%−70% 1 repetition maximum) 2 times per week. The control group maintained existing physical activity levels with no guidance on training intensity.
Main Outcome Measures: Outcome measures were obtained pre- and postintervention. Vascular health indicators included arterial stiffness via carotid distensibility and pulse wave velocity, and endothelial function via flow-mediated-dilation. Fasted blood samples were analyzed for markers of cardiovascular disease (CVD) risk. Body composition was assessed via anthropometrics and with dual-energy x-ray absorptiometry.
Results: Twenty-one individuals completed the intervention (PAG=12, control=9). Group-by-time interactions were observed for whole-body mass (P=.03), whole-body fat (P=.04), visceral adipose tissue (P=.04), and carotid artery distensibility (P=.05), suggesting maintained body composition and carotid stiffness in the PAG group concurrent with declines in the control group. No changes were found in any other outcome measure.
Conclusions: While 16 weeks of adherence to the PAG in adults with SCI is insufficient to improve many markers of CVD risk, it may prevent declines in others. The PAG should continue to be promoted as a means to increase physical fitness and maintain body composition in individuals with SCI, but changes may be needed to achieve other health outcomes.
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Regular physical activity decreases the risk of cardiovascular disease (CVD)[1]; monitoring both traditional and novel CVD risk factors may provide a more comprehensive assessment of the impact of different exercise training interventions. Traditional risk factors for CVD that define characteristics of metabolic syndrome include abdominal obesity, elevated triglycerides, low high-density lipoprotein cholesterol, high blood pressure, and elevated fasting glucose.[2]

Blood biomarkers of CVD risk include insulin resistance, a proinflammatory state (ie, interleukin [IL]-6, tumor necrosis factor [TNF]-α), a prothrombotic state (ie, plasminogen activator inhibitor-1 [PAI-1]), and altered serum adipokine secretion (ie, leptin,

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adiponectin).[3,4] All these biomarkers are secreted from adipose tissue,[5,6] and some evidence exists regarding the effects of exercise on these blood biomarkers in able-bodied persons.[7]

Novel risk factors for CVD include indicators of vascular health such as arterial stiffness and endothelial function.[8] Arterial stiffness is a strong independent risk factor for CVD.[9] Impaired endothelial function is an early step in the pathophysiology of atherosclerosis and has been associated with an increased incidence of cardiac events.[10] Growing evidence in the able-bodied literature suggests that exercise training exerts direct changes on blood vessels that result in measureable changes in vascular health.[8]

Individuals with spinal cord injury (SCI) are at increased risk for CVD as a result of an altered etiology of cardiovascular risk, altered autonomic regulation, and a blunted cardiovascular response to exercise postinjury.[11] Physical activity guidelines for able-bodied individuals may not be appropriate for individuals with SCI; the Canadian physical activity guidelines (PAG) for adults with SCI were released in 2011 to address this need.[12] While limited literature exists regarding the impact of exercise interventions on multiple risk factors for CVD in persons with SCI, strong evidence exists regarding the effects of exercise on fitness outcomes after SCI.[13] A recent randomized controlled trial[14] run in parallel with the present study reported that adherence to 16 weeks of the PAG improves peak oxygen consumption and muscle strength. The objective of the present study was to determine the effects of implementing the PAG on CVD risk factors.

Methods

Participants

This parallel-group randomized controlled trial was part of a larger study examining additional outcomes[14]; participants were individuals with chronic SCI (≥1y postinjury) aged 18 to 65 years. Exclusion criteria included any progressive loss of neurologic function within the previous 6 months. Data collection and implementation of the intervention took place at McMaster University in Hamilton, Ontario, Canada. The study procedures were approved by the Hamilton Health Sciences Research Ethics Committee, and all of the participants gave written informed consent.

List of abbreviations:

BA	**brachial artery**
CVD	**cardiovascular disease**
FES	**functional electrical stimulation**
FMD	**flow-mediated dilation**
HbA1c	**glycosylated hemoglobin**
IL	**interleukin**
IMT	**intima media thickness**
NTG	**nitroglycerin**
PAG	**physical activity guidelines**
PAI-1	**plasminogen inhibitor-1**
PWV	**pulse wave velocity**
SCI	**spinal cord injury**
SFA	**superficial femoral artery**
TNF	**tumor necrosis factor**
VAT	**visceral adipose tissue**
WLR	**wall-to-lumen ratio**

Randomization

After baseline testing, participants were randomly assigned to PAG training or active control using GraphPad software.[a] Active control was selected because of ethical considerations regarding withholding exercise from a clinical population.[15]

Intervention

The PAG group attended supervised exercise training sessions twice weekly for 16 weeks (32 sessions) for 60 minutes per session. Training was progressive and involved at least 20 minutes of moderate-vigorous aerobic exercise (rating of perceived exertion 3–6 on a 10-point scale) and 3×10 repetitions (50%–70% 1 repetition maximum) of resistance exercises for major upper-body muscle groups.[14] Participants randomly assigned to the control group were asked to maintain existing physical activity levels and were provided no guidance on training intensity.

Assessments

Participant demographic and injury-related characteristics, the presence or history of chronic conditions (ie, high blood pressure, diabetes, heart disease, arthritis, etc), and information on current medications were obtained via self-report. Participants were asked to empty their bladder before assessments, and refrained from alcohol and caffeine for ≥12 hours and exercise for a minimum of 24 hours before testing. Medications and vitamins were kept constant throughout the study, except for nitroglycerin (NTG), which was withheld on testing days. Assessments were conducted in a quiet, temperature-controlled room (22°C–24°C).

Blood biomarkers

Blood glucose control (glycosylated hemoglobin [HbA1c]), lipids (triglycerides, total cholesterol, low-density lipoprotein cholesterol, high-density lipoprotein cholesterol, total cholesterol/high-density lipoprotein cholesterol), fasting insulin, adipokines (leptin, adiponectin), proinflammatory markers (IL-6, TNF-α), and prothrombotic markers (PAI-1) were measured from a blood sample taken after a 12-hour fast. HbA1c and lipids were sent to a blood clinic for analysis. Serum insulin, leptin, IL-6, and TNF-α were analyzed in-house on a 4-plex luminex plate and run in duplicate; they were measured in picograms per milliliter, and a 5-parameter curve-fitting analysis was used. Serum adiponectin and PAI-1 were analyzed in-house on a 2-plex luminex plate and run in duplicate; they were measured in picograms per milliliter, and a best-fitting analysis was used.

Body composition

Basic anthropometric measures of mass (kg) (Detecto BRW-1000 Digital Bariatric Wheelchair Scale[b]), length (m), body mass index (kg/m^2), and waist circumference (cm) were determined.[16] Whole-body fat (kg, %), whole-body lean (kg), and visceral adipose tissue (VAT) (kg, %) were determined using dual-energy x-ray absorptiometry (Hologic QDR-4500A[c]).[16]

Arterial structure and function

After the blood draw, participants lay supine for 10 to 15 minutes. Heart rate (model ML123[d]) and blood pressure (FMS MIDI[e]) were monitored continuously. Carotid pulse pressure (mmHg),