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Original research

The association between resistance exercise and cardiovascular disease risk in women

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ABSTRACT

Objectives: The objective of this study was to examine the association between resistance exercise and cardiovascular disease risk, independent of body composition, physical activity and aerobic capacity, in healthy women.
Design: A cross-sectional analysis including 7321 women with no history of heart disease, hypertension or diabetes was performed.
Methods: Participation in resistance exercise was self-reported and body weight and height was measured. A single cardiovascular disease risk score was established via factor analysis including percent body fat, mean arterial pressure, fasting glucose, total cholesterol and triglyceride levels. Physical activity level was determined based on questionnaire data and aerobic capacity was assessed via a maximal treadmill exercise test.
Results: Women reporting resistance exercise had lower total cardiovascular disease risk at any age. Specifically, resistance exercise was associated with lower body fat, fasting glucose and total cholesterol. The association between resistance exercise and cardiovascular disease risk, however, remained only in normal weight women after adjusting for physical activity and aerobic capacity.
Conclusion: Results of the present study underline the importance of resistance exercise as part of a healthy and active lifestyle in women across all ages. Our results suggest that resistance exercise may be particularly beneficial to independently improve cardiovascular disease risk profiles in women with normal weight. In overweight/obese women, total physical activity and aerobic capacity may have a stronger association with cardiovascular disease risk.

1. Introduction

Cardiovascular disease (CVD) is the leading cause of death in the United States with higher CVD mortality in women compared to men.[1,2] Regular physical activity (PA) has been shown to reduce CVD risk.[3] Due to the reduction of PA during activities of daily living over the past several decades,[4] exercise becomes an increasingly important component in achieving a sufficient amount of PA.

The benefits of aerobic exercise, consisting of continuous activation of large muscle groups, on CVD risk have been well documented.[5] Resistance exercise (RE) consists of repeated bouts of isolated muscle groups and, therefore, exerts different physiologic effects and health benefits than aerobic exercise. Previous research has shown positive effects of RE regarding musculoskeletal function and weight management.[6,7] An increase in muscle mass in response to RE, however, potentially affects various CVD risk factors as skeletal muscle is a major tissue regarding glucose and triglyceride metabolism.[8] For example, RE has been associated with a 23% risk reduction for coronary heart disease in men and improved endothelial function in men and women.[9,10] Furthermore, muscular strength, which is directly related to muscle mass, has been associated with a reduction in the incidence of metabolic syndrome in men,[11] as well as numerous other benefits on CVD risk factors and CVD prognosis.[12] Clinical and randomized controlled trials showed beneficial effects of RE on blood pressure but results

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on the effects of RE on blood lipid and glucose levels have been equivocal.[5,8,13]

Previous research, however, focused predominantly on at risk populations such as overweight or obese, individuals with metabolic syndrome and impaired glucose metabolism, or elderly. Further, most research considered specific risk factors separately rather than examining the association of RE and a composite CVD risk score. As currently less than 20% of U.S. women engage in regular RE,[14] more information on potential benefits of RE, beyond the well-established positive effects on the muscular-skeletal system, is needed. The purpose of the present study was to examine the association between overall CVD risk, as well as specific CVD risk factors, and RE independent of aerobic capacity or cardiorespiratory fitness (CRF) and PA in healthy women.

2. Methods

This cross-sectional analysis was done in a population of 7321 women from the Aerobics Center Longitudinal Study (ACLS) who had an examination between 1987 and 2007. The procedures used in the ACLS have been well-described previously.[15] Participants included in the study were between 20 and 90 years of age and with no history of heart disease, hypertension or diabetes. Participants provided written informed consent prior to data collection and the study was approved by the Cooper Institute Institutional Review Board.

Participants self-reported their participation in RE, including exercises using weight machines and free weights as well as calisthenics and other forms strength exercises. Specifically, women reported the frequency (times per week) and duration (min/session) of their current RE routine, which was used to calculate weekly engagement in RE.

Percent body fat (BF), mean arterial pressure (MAP), triglyceride, total cholesterol and fasting glucose levels were used as indicators for CVD risk with measurements taken after an overnight fast. BF was estimated by hydrostatic weighing in 30.7% of the participants. When hydrostatic weight measures were not available, 7-site skinfold measurements were used. Previous research showed a high correlation ($r = 0.94$) between these two methods and no significant difference in the estimation of BF by hydrostatic weighing and 7-site skinfold equations.[16,17] Resting blood pressure (mmHg) was measured according to standard procedures using a mercury sphygmomanometer and MAP was calculated [MAP = (2 * diastolic BP + systolic BP)/3]. Fasting triglyceride (mg/dL), total cholesterol (mg/dL) and glucose (mg/dL) levels were determined by automated techniques performed in the Cooper Clinic laboratory, which meets quality control standards of the Centers of Disease Control and Prevention Lipid Standardization Program.

Height and body weight were measured according to standard procedures by trained technicians. Body mass index (BMI) was calculated (kg/m^2) and used to differentiate between normal weight (BMI < 25) and overweight/obese women (BMI ≥ 25).

A PA index (PAI) was established based on a series of questions, which have been validated previously.[18,19] Specifically, participants reported their engagement in regular leisure PA during the past 3 months, including information on type, frequency, duration, and distance or time spent in the respective activity. PAI was subsequently determined as follows: high, those who walked or jogged more than 20 miles per week (PAI = 4); moderate, those who walked or jogged between 10 and 20 miles per week (PAI = 3); low, those who walked or jogged up to 10 miles per week (PAI = 2); other, those who participated in some other regular physical activity such as bicycling, swimming, racquet sports, and other strenuous sports, but not walking or jogging (PAI = 1); no regular activity (PAI = 0). Walking and jogging were chosen as the basis for the PAI because it was the most common activity for this population.

CRF was determined via a maximal exercise test using a modified Balke protocol. Participants started with a walking pace of 88 m/min at 0% incline. After 1 min the incline was increased to 2%, with an increase in 1% each subsequent minute until the 25th minute. If participants did not reach exhaustion at this point, the speed was increased by 5.4 m/min each minute while incline remained constant. Participants continued until volitional fatigue was reached with their peak performance reported as multiples of resting metabolic equivalent (MET).

Principal component factor analysis (PCA) was used to determine overall CVD risk, which explains more variance than a composite score based on the summation of measured variables. The CVD risk factor explained 39.46% of the total variance (Eigenvalue = 1.973). Specifically, factor loadings were 0.709 for triglycerides, 0.671 for total cholesterol, 0.456 for fasting glucose, 0.589 for MAP and 0.682 for BF.

Self-reported RE was initially categorized into 3 groups (none vs. 1–60 min/week vs. ≥60 min/week). As there were no differences in CVD risk between women reporting equal or more than 60 min/week of RE to those reporting less than 60 min/week of RE, subsequent analyses differentiated only between women reporting current engagement in RE and women not reporting any current RE.

Differences in total CVD risk and individual CVD risk components between these two groups were examined via ANCOVA in the total sample, initially adjusting for age and BMI. In a second analysis PA and CRF were included as additional covariates due to their well-established association with CVD risk. Further, the interaction between age and RE as well as body weight and RE was examined via 2-way ANCOVA. Cutpoints of 45 years and 55 years were used to stratify women by age and a BMI of 25 was used to differentiate between normal weight and overweight/obese. Bonferroni adjustment was used for the examination of main effects by age. In addition, each age and weight group was analyzed separately using the same analytical approach as for the total sample. All statistical analyses were carried out with SPSS® 21.0 (SPSS Inc., Chicago, IL, USA) using a significance level of $\alpha = 0.05$.

3. Results

Thirty-seven percent of the participating women reported current engagement in some type of RE, including calisthenics, free weights and weight machines, as well as other forms of RE. Descriptive characteristics of the study population are shown in Table 1. In the total sample, 29.1% of the women were classified as overweight or obese, with a higher prevalence of overweight/obesity in women not reporting RE (34.5% vs. 20.0%); PA and CRF were higher in women reporting engagement in RE, even after adjusting for age and BMI ($F_{PA}(1,7317) = 243.97$, $p < .001 F_{Fitness}(1,7317) = 778.30$, $p < .001$).

Using age and BMI as covariates, RE was associated with a significantly lower overall CVD risk ($F(1,7317) = 74.67$, $p < .001$). Specifically, lower levels of fasting glucose ($F(1,7317) = 7.32$, $p = .007$), total cholesterol ($F(1,7317) = 34.89$, $p < .001$) and BF ($F(1,7317) = 231.32$, $p < .001$) were observed in women reporting RE. No group difference was observed for MAP ($F(1,7317) = 0.83$, $p = .363$) and triglycerides ($F(1,7317) = 3.34$, $p = .068$). These results remained after additionally controlling for PA and CRF.

There was no significant interaction effect on total CVD risk between RE engagement and age, adjusting for BMI ($F(2,7314) = 1.05$, $p = .350$). Main effects for total CVD risk were significant for age ($F(2,7314) = 701.36$, $p < .001$) and RE ($F(1,7314) = 76.72$, $p < .001$). CVD risk increased with age, but was