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# 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 (CVD) 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 CVD 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 CVD risk at any age. Specifically, resistance exercise was associated with lower body fat, fasting glucose and total cholesterol. The association between resistance exercise and CVD risk, however, remained only in normal weight women after adjusting for physical activity and aerobic capacity.

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**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 CVD risk profiles in women with normal weight. In overweight/obese women, total physical activity and aerobic capacity may have a stronger association with CVD risk.

**Keywords**

strength training; body composition; blood glucose; cholesterol; blood pressure; adipose tissue

## 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 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.

## 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 minute the incline was increased to 2%, with an increase in 1% each subsequent minute until the 25$^{th}$ 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 $\alpha = 0.05$.

## 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 consistently lower with engagement in RE. Regarding different components contributing to CVD risk, significant interaction effects occurred for triglycerides ($F(2, 7314)=4.25$, $p=.014$) and BF ($F(2, 7314)=9.89$, $p<.001$), with the difference in BF between exercise groups being more pronounced in younger women, while the association between triglyceride levels and RE became more pronounced with increasing age. Significant main effects for age occurred for all individual risk factors ($F(2, 7314) \geq 55.91$, $p<.001$), with increasing values with higher age. Main effects for RE were significantly lower fasting glucose ($F(1, 7314)=10.47$, $p=.001$), triglycerides ($F(1, 7314)=8.38$, $p=.004$), total cholesterol ($F(1, 7314)=43.16$, $p<.001$) and BF ($F(1, 7314)=155.81$, $p<.001$). Additionally adjusting for CRF and PA did not affect these results, except for fasting glucose, which was no longer significantly different across age groups.

No interaction effect for weight category and RE was observed for total CVD risk, adjusting for age ($F(1, 7316)=.067$, $p=.796$) but significant main effects were observed for weight ($F(1, 7315)=2150.69$, $p<.001$) and RE ($F(1, 7315)=74.08$, $p<.001$). There was a significant interaction effect for BF ($F(1, 7315)=11.01$, $p=.001$), with a larger effect of RE in normal weight subjects. Significant main effects for weight were observed in all individual CVD risk components ($F(1, 7316) \geq 137.33$, $p<.001$), with higher values in overweight/obese women. Additionally, controlling for CRF and PA did not affect these results.

Adjusting for BMI and age, a significant difference across RE groups was observed for total CVD risk in each age group ($F_{20–44}(1, 3462)=36.45$, $p<.001$; $F_{45–55}(1, 2606)=22.98$, $p<.001$; $F_{\geq 56}(1, 1241)=19.66$, $p<.001$). Specifically, total cholesterol and BF were lower with RE in every age group ($F_{TC} \geq 6.51$, $p \leq .011$; $F_{BF} \geq 18.72$, $p<.001$) (Table 2). In older women (≥ 56 years), triglyceride levels also differed significantly ($F(1, 1241)=4.70$, $p=.030$). After additionally adjusting for PA and CRF, total CVD risk and BF remained significantly lower with RE in all age groups.

Total CVD risk was significantly lower with RE in both normal weight and overweight/obese women ($F_{NW}(1, 5185)=69.63$, $p<.001$; $F_{OW/OB}(1, 2128)=6.95$, $p=.008$). Total cholesterol and BF were significantly lower with RE in both weight groups ($F_{TC} \geq 5.43$, $p \leq .020$; $F_{BF} \geq 18.98$, $p<.001$) (Table 3). In normal weight subjects, RE was further associated with lower fasting glucose levels ($F(1, 5185)=5.95$, $p=.015$). After additionally adjusting for CRF and PA, significant differences between exercise groups remained only in normal weight women.

## Discussion

Results of the present study suggest that RE is associated with CVD risk, independent of leisure-time PA and CRF. Specifically, RE was associated with a lower BF, as well as lower levels of cholesterol, triglycerides and blood glucose. As expected, CVD risk was higher in older women, however, there were differences in BF and total cholesterol between those that performed RE and those that did not, across all age groups. Women aged 56 years and older also displayed lower triglyceride levels with RE, underlining the potential benefits of this type of exercise in older women. The present study further suggested benefits of RE across different weight categories. The association between RE and CVD risk, however, seems to be stronger in normal weight women, while CRF and PAI may be of greater importance regarding CVD risk in overweight/obese women.

Despite growing evidence on the positive effects of RE on chronic disease risk and well-being,[20,21] aerobic exercise continues to be the primary focus of exercise prescription.[6] A loss of muscle mass and quality of skeletal muscle, however, has been identified as a key factor contributing to an increased CVD risk, particularly in elderly.[22] A reduction in PA levels with increasing age contributes to the loss of skeletal muscle mass, and it has been shown that skeletal muscle maintains plasticity and capacity for hypertrophy into older ages given appropriate stimuli.[20] More attention, therefore, should be paid to the potential benefits of RE regarding CVD risk. Consistent with results of the present study, positive effects of RE on body composition, visceral adipose tissue, glucose and triglyceride levels have been shown in training studies; results on the effects of RE on cholesterol levels, on the other hand, were inconsistent.[13,22] The lack of conclusive evidence on the association between RE and lipid levels has been attributed to the generally healthy cholesterol levels prior to exercise interventions.[8] Further, a longer duration of engagement in RE may be necessary in order to observe significant changes in cholesterol levels. Previous research relied predominantly on intervention studies lasting between 1 and 12 months following general guidelines for RE with 2 to 3 training sessions per week.[13] Prior engagement in RE in the population of this study was on average 37 months (results not shown), which may have resulted in more pronounced effects.

In contrast to previous studies,[13,22,23] the present results did not show an association between RE and blood pressure. The lack of significant differences in MAP between exercise groups may have been due to a broader definition of RE, including calisthenics, compared to training studies as differences in RE protocols may affect the cardiovascular system differently.[8] Particularly isometric RE has been shown to reduce blood pressure in hypertensive and normotensive adults [13,23] and, thus, has been suggested as non-pharmacological treatment to lower blood pressure.[24] The exact mechanisms of RE explaining the positive effects on blood pressure, however, remain to be determined. Recent research suggests an increase in resistance vessel endothelial function and antioxidant concentrations, but these studies did not have sufficient power to assess possible mechanistic pathways.[23]

There is also some evidence on a positive effect of RE on CRF,[13] which has been accepted as important protective aspect in CVD risk reduction.[15] The impact of RE on CRF, however, may be limited to participants with low initial CRF and has not been consistently demonstrated.[25] Nevertheless, this may partially explain the lack of significant results regarding the association between CVD risk factors and RE after controlling for CRF in overweight/obese participants in the present study. It is possible that RE had a more pronounced effect on CRF in overweight/obese women due to their lower CRF. It has also been argued that the implementation of RE may be necessary prior to the start of an aerobic exercise program in obese adults in order to induce positive changes in body composition, which would subsequently facilitate participation in continuous exercise.[26] Participation in RE is considered to be safe and Stensvold et al. did not report any problems with RE in adults with metabolic syndrome.[9] Additionally, RE may help with motivation and adherence to an exercise program as improvements in muscular strength occur generally faster than changes in CRF in response to aerobic exercise.[27] In order to reduce CVD risk, a higher threshold for improvement in muscle quality or muscular strength, however, may be needed.[26] Nevertheless, a home-based RE program has been shown to elicit favorable changes in markers of cardiovascular and metabolic diseases in an elderly population.[28]

Valid information on exercise intensity was not available in the present study. The variety of exercise types being considered as RE, however, may strengthen the results, as exercises such as calisthenics were considered as resistance training. This may also explain the higher prevalence of resistance exercisers in the study population compared to the US population.[14] Another concern was the lack of dietary information. Study participants reporting RE may have an overall healthier lifestyle and consume a healthier diet, which could affect their CVD risk. The homogeneity of the sample, consisting of primarily Caucasian women with a middle-to-high socio-economic background may mitigate dietary effects, but it does limit the generalizability of the results. Further, the cross-sectional design of the study does not allow establishing causality but findings of the present study utilizing a large cohort with a wide age range are generally consistent with previous training studies.[8,29] The inclusion of PA level and CRF as confounding variables, along with various physiologic measures contributing to CVD risk and the utilization of a combined CVD risk score further support the claim for an independent association between RE and CVD risk in generally healthy women.

## Conclusion

Most likely, a combination of aerobic and RE will provide the largest health benefits. The inverse association between engagement in RE and overall CVD risk, independent of total PA and CRF indicates that benefits of regular RE go beyond the well-established effects on muscular strength, bone mineral density and functional capacity. Such information may help with the promotion of regular RE, which has been identified as a national health perspective.[30] More research, however, is needed to clarify the dose-response relationship between RE and various health related outcomes, including CVD risk, in order to refine current exercise and PA recommendations.

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## References

1. Lloyd-Jones D, Adams RJ, Brown TM, et al. Heart disease and stroke statistics--2010 update: a report from the American Heart Association. Circulation. 2010; 121(7):e46–e215. [PubMed: 20019324]
2. Heidenreich PA, Trogdon JG, Khavjou OA, et al. Forecasting the future of cardiovascular disease in the United States: a policy statement from the American Heart Association. Circulation. 2011; 123(8):933–944. [PubMed: 21262990]
3. Löllgen H. Importance and evidence of regular physical activity for prevention and treatment of diseases. Dtsch Med Wochenschr. 2013; 138(44):2253–2259. [PubMed: 24150703]
4. Archer E, Shook RP, Thomas DM, et al. 45-Year trends in women’s use of time and household management energy expenditure. PLoS One. 2013; 8(2):e56620. [PubMed: 23437187]

5. Pattyn N, Cornelissen VA, Eshghi SR, et al. The effect of exercise on the cardiovascular risk factors constituting the metabolic syndrome: a meta-analysis of controlled trials. Sports Med. 2013; 43(2):121–133. [PubMed: 23329606]
6. Williams MA, Haskell WL, Ades PA, et al. Resistance exercise in individuals with and without cardiovascular disease: 2007 update: a scientific statement from the American Heart Association Council on Clinical Cardiology and Council on Nutrition, Physical Activity, and Metabolism. Circulation. 2007; 116(5):572–584. [PubMed: 17638929]
7. Pollock ML, Franklin BA, Balady GJ, et al. AHA Science Advisory. Resistance exercise in individuals with and without cardiovascular disease: benefits, rationale, safety, and prescription: An advisory from the Committee on Exercise, Rehabilitation, and Prevention, Council on Clinical Cardiology, American Heart Association; Position paper endorsed by the American College of Sports Medicine. Circulation. 2000; 101(7):828–833. [PubMed: 10683360]
8. Braith RW, Stewart KJ. Resistance exercise training: its role in the prevention of cardiovascular disease. Circulation. 2006; 113(22):2642–2650. [PubMed: 16754812]
9. Stensvold D, Tjønna AE, Skaug EA, et al. Strength training versus aerobic interval training to modify risk factors of metabolic syndrome. J Appl Physiol (1985). 2010; 108(4):804–810. [PubMed: 20093665]
10. Tanasescu M, Leitzmann MF, Rimm EB, et al. Exercise type and intensity in relation to coronary heart disease in men. JAMA. 2002; 288(16):1994–2000. [PubMed: 12387651]
11. Jurca R, Lamonte MJ, Barlow CE, et al. Association of muscular strength with incidence of metabolic syndrome in men. Med Sci Sports Exerc. 2005; 37(11):1849–1855. [PubMed: 16286852]
12. Artero EG, Lee DC, Lavie CJ, et al. Effects of muscular strength on cardiovascular risk factors and prognosis. J Cardiopulm Rehabil Prev. 2012; 32(6):351–358. [PubMed: 22885613]
13. Cornelissen VA, Fagard RH, Coeckelberghs E, et al. Impact of resistance training on blood pressure and other cardiovascular risk factors: a meta-analysis of randomized, controlled trials. Hypertension. 2011; 58(5):950–958. [PubMed: 21896934]
14. Centers for Disease Control and Prevention. Trends in strength training--United States, 1998–2004. MMWR Morb Mortal Wkly Rep. 2006; 55(28):769–772. [PubMed: 16855525]
15. Blair SN, Kohl HW, Paffenbarger RS, et al. Physical fitness and all-cause mortality. A prospective study of healthy men and women. JAMA. 1989; 262(17):2395–2401. [PubMed: 2795824]
16. Hortobágyi T, Israel RG, Houmard JA, et al. Comparison of body composition assessment by hydrodensitometry, skinfolds, and multiple site near-infrared spectrophotometry. Eur J Clin Nutr. 1992; 46(3):205–211. [PubMed: 1559525]
17. Fogelholm M, van Marken Lichtenbelt W. Comparison of body composition methods: a literature analysis. Eur J Clin Nutr. 1997; 51(8):495–503. [PubMed: 11248873]
18. Blair SN, Kannel WB, Kohl HW, et al. Surrogate measures of physical activity and physical fitness. Evidence for sedentary traits of resting tachycardia, obesity, and low vital capacity. Am J Epidemiol. 1989; 129(6):1145–1156. [PubMed: 2729253]
19. Banada J, Hutto B, Feeney A, et al. Comparing physical activity measures in a diverse group of midlife and older adults. Med Sci Sports Exerc. 2010; 42(12):2251–2257. [PubMed: 20421836]
20. Banz WJ, Maher MA, Thompson WG, et al. Effects of resistance versus aerobic training on coronary artery disease risk factors. Exp Biol Med (Maywood). 2003; 228(4):434–440. [PubMed: 12671188]
21. Schjerve IE, Tyldum GA, Tjønna AE, et al. Both aerobic endurance and strength training programmes improve cardiovascular health in obese adults. Clin Sci (Lond). 2008; 115(9):283–293. [PubMed: 18338980]
22. Strasser B, Siebert U, Schobersberger W. Resistance training in the treatment of the metabolic syndrome: a systematic review and meta-analysis of the effect of resistance training on metabolic clustering in patients with abnormal glucose metabolism. Sports Med. 2010; 40(5):397–415. [PubMed: 20433212]
23. Carlson DJ, Dieberg G, Hess NC, et al. Isometric Exercise Training for Blood Pressure Management: A Systematic Review and Meta-analysis. Mayo Clin Proc. 2014; 89(3):327–334. [PubMed: 24582191]

24. Brook RD, Appel LJ, Rubenfire M, et al. Beyond medications and diet: alternative approaches to lowering blood pressure: a scientific statement from the american heart association. Hypertension. 2013; 61(6):1360–1383. [PubMed: 23608661]
25. Johannsen NM, Swift DL, Lavie CJ, et al. Categorical analysis of the impact of aerobic and resistance exercise training, alone and in combination, on cardiorespiratory fitness levels in patients with type 2 diabetes: results from the HART-D study. Diabetes Care. 2013; 36(10):3305–3312. [PubMed: 23877979]
26. Hornbuckle LM, Liu PY, Ilich JZ, et al. Effects of resistance training and walking on cardiovascular disease risk in African-American women. Med Sci Sports Exerc. 2012; 44(3):525–533. [PubMed: 21778912]
27. Conley M, Rozenek R. Health aspects of resistance exercise and training. Strength and Conditioning Journal. 2001; 23:9–23.
28. Williams AD, Almond J, Ahuja KD, et al. Cardiovascular and metabolic effects of community based resistance training in an older population. J Sci Med Sport. 2011; 14(4):331–337. [PubMed: 21441068]
29. Kelley GA, Kelley KS. Impact of progressive resistance training on lipids and lipoproteins in adults: a meta-analysis of randomized controlled trials. Prev Med. 2009; 48(1):9–19. [PubMed: 19013187]
30. US Department of Health and Human Services. With understanding and improving health and objectives for improving health. 2. Vol. 2. Washington, DC: US Government Printing Office; 2000. Healthy people 2010.

## Practical Implications

- Engagement in resistance exercise reduces cardiovascular disease (CVD) risk in women independent of leisure physical activity level and aerobic fitness.
- Engagement in resistance exercise reduces cardiovascular disease risk at all ages.
- The effect of resistance exercise on CVD risk is more pronounced in normal weight compared to overweight women.
- The benefits of resistance exercise warrant an inclusion of resistance exercise in health-related exercise programs.

**Table 1**

Descriptive characteristics of the sample. Values are Mean±SD.

| | No Resist Ex (N=4596) | Resist Ex < 60 min/ week (N=599) | Resist Ex ≥ 60 min/ week (N=2126) | Total Sample (N=7321) |
|---|---|---|---|---|
| Age (yrs) * | 46.1 ± 10.3 | 44.5 ± 9.8 | 44.3 ± 10.1 | 45.5 ± 10.2 |
| Height (cm) | 164.5 ± 6.3 | 164.8 ± 6.0 | 164.9 ± 6.2 | 164.7 ± 6.2 |
| Weight (kg) * | 66.1 ± 12.9 | 62.3 ± 10.7 | 62.3 ± 10.4 | 64.7 ± 12.2 |
| BMI (kg/m$^2$) * | 24.4 ± 4.6 | 22.9 ± 3.7 | 22.9 ± 3.5 | 23.8 ± 4.3 |
| Percent body fat (%) * | 28.0 ± 6.6 | 24.7 ± 6.5 | 24.3 ± 6.7 | 26.6 ± 6.9 |
| Mean arterial pressure (mmHg) * | 89.5 ± 10.6 | 88.1 ± 9.6 | 88.2 ± 10.0 | 89.0 ± 10.4 |
| Triglycerides (mg/dL) * | 101.8 ± 66.6 | 92.3 ± 80.7 | 89.4 ± 50.0 | 97.4 ± 63.9 |
| Fasting glucose (mg/dL) * | 94.0 ± 14.9 | 92.3 ± 12.2 | 91.8 ± 10.6 | 93.22 ± 13.6 |
| Total cholesterol (mg/dL) * | 202.4 ± 39.0 | 194.6 ± 35.8 | 192.7 ± 35.0 | 199.0 ± 37.9 |
| Aerobic capacity (METs) * | 9.33 ± 1.93 | 10.76 ± 2.05 | 10.89 ± 2.08 | 9.90 ± 2.12 |

*sig. difference between no resistance exercise and both resistance exercise groups (p≤0.01)

**Table 2**

CVD risk components by engagement in resistance exercise, across different age groups. Values are Mean±SD, adjusted for age and BMI.

| | 20–44 years | | 45–55 years | | ≥ 56 years | |
|---|---|---|---|---|---|---|
| | **No Resist Ex N=2073** | **Resist Ex N=1393** | **No Resist Ex N=1642** | **Resist Ex N=968** | **No Resist Ex N=881** | **Resist Ex N=364** |
| Fasting Glucose (mg/dL) | 91.7 ± 13.2 | 90.8 ± 13.4 | 94.1 ± 11.8 | 93.7 ± 11.8 | 97.6 ± 16.0 | 95.7 ± 16.0 |
| Total Cholesterol (mg/dL) [a,b,c] | 187.6 ± 33.2 | 183.6 ± 33.2 | 208.5 ± 35.3 | 202.2 ± 35.2 | 221.8 ± 37.7 | 215.8 ± 37.8 |
| Triglycerides (mg/dL) [c,d] | 84.7 ± 54.2 | 84.8 ± 54.5 | 104.7 ± 60.0 | 100.8 ± 60.4 | 123.3 ± 68.9 | 114.0 ± 68.9 |
| Mean Arterial Pressure (mmHg) | 85.8 ± 8.2 | 86.2 ± 8.6 | 90.5 ± 10.1 | 90.8 ± 10.3 | 94.6 ± 10.7 | 94.0 ± 10.7 |
| Percent body fat (%) [a,b,c] | 25.8 ± 4.6 | 23.6 ± 4.9 | 28.4 ± 4.5 | 27.0 ± 4.4 | 29.3 ± 4.5 | 28.1 ± 4.4 |

[a] sig. difference between groups in women 20–44 years of age (p<0.01)

[b] sig. difference between groups in women 45–55 years of age (p<0.01)

[c] sig. difference between groups in women above 56 years of age (p<0.01)

[d] sig. difference between groups in women above 56 years of age (p<0.05)

## Table 3

CVD risk components by exercise groups, separately for normal weight and overweight/obese women. Values are Mean±SD. adjusted for age and BMI.

| | Normal Weight (N=5189) | | Overweight/Obese (N=2132) | |
|---|---|---|---|---|
| | **No Resist Ex N=3011** | **Resist Ex N=2178** | **No Resist Ex N=1585** | **Resist Ex N=547** |
| Fasting Glucose (mg/dL) [a] | 91.9 ± 10.4 | 91.2 ± 10.3 | 97.6 ± 18.3 | 96.1 ± 18.2 |
| Total Cholesterol (mg/dL) [a,b] | 196.5 ± 33.5 | 191.6 ± 33.1 | 211.0 ± 37.8 | 206.7 ± 37.9 |
| Triglycerides (mg/dL) | 85.6 ± 45.0 | 83.7 ± 44.8 | 129.2 ± 83.6 | 125.1 ± 84.2 |
| Mean Arterial Pressure (mmHg) | 87.2 ± 9.3 | 87.3 ± 9.3 | 93.2 ± 9.6 | 93.8 ± 9.6 |
| Percent body fat (%) [a,b] | 24.6 ± 4.4 | 22.8 ± 4.2 | 33.7 ± 4.4 | 32.8 ± 4.2 |

[a] sig. difference between exercise groups in normal weight women ($p<0.05$)

[b] sig. difference between exercise groups in overweight/obese women ($p<0.05$)