

Health Care for Women International

ISSN: 0739-9332 (Print) 1096-4665 (Online) Journal homepage: https://www.tandfonline.com/loi/uhcw20

The Effects of Resistance Training on Cardiovascular Disease Risk Factors in Postmenopausal Women: A Randomized-Controlled Trial

Nihal Gelecek , Nursen İlçin , Sevgi Sevi Subaşi , Serap Acar , Namik Demir & Murat Örmen

To cite this article: Nihal Gelecek , Nursen İlçin , Sevgi Sevi Subaşi , Serap Acar , Namik Demir & Murat Örmen (2012) The Effects of Resistance Training on Cardiovascular Disease Risk Factors in Postmenopausal Women: A Randomized-Controlled Trial, Health Care for Women International, 33:12, 1072-1085, DOI: 10.1080/07399332.2011.645960

To link to this article: https://doi.org/10.1080/07399332.2011.645960

Published online: 15 Nov 2012.

Submit your article to this journal

Article views: 768

View related articles

Citing articles: 10 View citing articles

Full Terms & Conditions of access and use can be found at
https://www.tandfonline.com/action/journalInformation?journalCode=uhcw20

Health Care for Women International, 33:1072–1085, 2012
Copyright © Taylor & Francis Group, LLC
ISSN: 0739-9332 print / 1096-4665 online
DOI: 10.1080/07399332.2011.645960

Routledge
Taylor & Francis Group

The Effects of Resistance Training on Cardiovascular Disease Risk Factors in Postmenopausal Women: A Randomized-Controlled Trial

NIHAL GELECEK, NURSEN İLÇIN, SEVGI SEVI SUBAŞİ, and SERAP ACAR

School of Physical Therapy and Rehabilitation, Dokuz Eylül University, İzmir, Turkey

NAMIK DEMIR

Obstetric and Gynecology Department, Faculty of Medicine, Dokuz Eylül University, İzmir, Turkey

MURAT ÖRMEN

Biochemical Department, Faculty of Medicine, Dokuz Eylül University, İzmir, Turkey

Our aim was to determine the effects of resistance training on cardiovascular risk factors in postmenopausal women. Forty-five women were included in the study. Resistance exercises were done with an intensity of 60% of 1-Repetition Maximum, for 12 weeks. Heart rate, blood pressure, estimated peak VO_2, lipid profiles, and homocysteine levels were evaluated. There were significant time and group interactions for body mass index (p = .02), heart rate (p = .04), systolic blood pressure (p = .03), estimated mean peak VO_2 (p = .00), and total cholesterol (p = .00), but there were no interactions with other evaluated parameters. Resistance training has beneficial effects on particular cardiovascular risk factors in postmenopausal women.

Cardiovascular problems that increase during the postmenopausal period are global challenges that affect women's health in a negative way. The benefits

Received 14 February 2010; accepted 12 October 2011.

We thank the Department of Scientific Research Projects of Dokuz Eylül University for their financial support, and Pinar Akan, MD, and Gursoy Pala, MD, for their assistance.

Address corerspondnece to Nursen İlçin, School of Physical Therapy and Rehabilitation, Dokuz Eylül University, Inciralti, İzmir 35340, Turkey. E-mail: nursen.ozdemir@deu.edu.tr

of regular exercise for improving health and reducing the risk of developing cardiovascular disease (CVD) in postmenopausal women are well recognized (Earnest, Lavie, Blair, & Church, 2008; Maesta et al., 2007; Teoman, Ozcan, & Acar, 2004). Aerobic and combined (aerobic-resistance) training effects are investigated for modifing the CVD risk factors (Gelecek et al., 2007; Inaba, Obuchi, Arai, Satake, & Takahira, 2008; Riesco, Aubertin-Leheudre, Maltais, Audet, & Dionne, 2010; Shaw, Shaw, & Krasilshchikov, 2009). Its also found that resistance training had some benefits on improving particular cardiovascular parameters; however, there is a lack of studies demonstrating the effects of resistance training alone on the risk of CVD in postmenopausal women (Adams et al., 2006; Maesta et al., 2007; Nakata, Ohkawara, Okura, & Tanaka, 2008; Vona et al., 2009). Finding the effective intervention for reducing the CVD risk factors is not only highly important for the improvement of women's health but also will make a notable contribution to the related literature. If cardiovascular risks can be modified with resistance exercises, it would be helpful for guiding health professionals to encourage variety in the prescription of exercise and development of effective intervention programs to improve postmenopausal women's health.

Menopause is defined as an age-related decrease of, or loss of, ovarian estrogen production and secretion and also as the end of a woman's reproductive potential. The average age of occurrence is approximately 50 years in both European and U.S. women (Asikainen & Kukkonen-Harjula Kand Miilunpalo, 2004; Asikainen et al., 2006, Teoman et al., 2004). Menopause may induce a phase of decreased aerobic capacity, bone mineral density, and muscle strength. The risk of chronic diseases such as CVD and diabetes mellitus increases with menopause (Frank et al., 2005; Juca, Churc, Morss, Jordan, & Earnest, 2004; Maesta et al., 2007).

Cardiovascular disease (CVD) is the leading cause of death in women, and the risk of death caused by CVD in women markedly increases with the onset of menopause (Asikainen et al., 2006; Juca et al., 2004; Frank et al., 2005). Elevated plasma homocysteine levels and increased triglyceride (TG) and LDL-cholesterol (LDL-c) levels in blood have been identified as a risk factor for CVD (Hankey & Eikelboom, 1999; Kuller & Evans, 1998; Maesta et al., 2007). Several purported mechanisms for this association include the ability of homocysteine to promote endothelial cell injury, stimulate vascular smooth muscle cell growth, increase platelet adhesiveness, enhance LDL-c oxidation and deposition in the arterial wall, and directly activate the coagulation cascade (Kuller & Evans, 1998).

Researchers found that regular physical activity is beneficial for many aspects of health. These benefits include improved cardiovascular function with reduced risk of morbidity and mortality from cardiovascular heart disease, musculoskeletal function and changes to metabolic function, and enhanced psychological function affecting self-esteem, mood, memory and a reduction in stress (Church, Earnest, Skinner, & Blair, 2007; Francis, 1996;

Laughlin, 1999; Williams & Steward, 2009). Many exercise recommendations are also relevant to postmenopausal women for improving health. Exercise programs focus on aerobic, resistance training models, or combined programs (Asikainen et al., 2006; Asikainen & Kukkonen-Harjula Kand Miilunpalo, 2004; Francis, 1996; Inaba et al., 2008; Nakata et al., 2008; Orsatti, Nahas, Maesta, Nahas-Neto, & Burini, 2008; Teixeira et al., 2003; Teoman et al., 2004). Although aerobic and resistance training have similar benefits in physical fitness and health-related factors, resistance exercises improve muscle strength that would be helpful to accomplish daily leisure activities and tasks that require strength (Adams et al., 2006; Pollock et al., 2000).

Resistance training has long been accepted as a mean for developing and maintaining muscular strength, endurance, power and bone mineral density (Asikainen & Kukkonen-Harjula Kand Miilunpalo, 2004; Asikainen et al., 2006; Bea et al., 2009; Nakata et al., 2008; Orsatti et al., 2008; Pollock et al., 2000; Teıxeıra et al., 2003). For the last two decades, the American College of Sports Medicine (ACSM) has recognized resistance training as a significant component of a comprehensive fitness program to improve cardiovascular functions in adults of all ages (Orsatti et al., 2008; Pollock et al., 2000).

We hypothesized that resistance training alone would reduce cardiovascular risk factors in postmenopausal women. Thus, we aimed to determine the effects of resistance training on the particular risk factors for CVD in postmenopausal women.

METHOD

Fifty-one postmenopausal women were included in the study. The Medical Ethical Committee of Dokuz Eylul University approved the study, and all the subjects gave their written informed consent to participate in the study. Subjects, aged 44 through 65, were selected from amongst women who fit predetermined criteria. These women are regularly monitored by the Menopausal Clinic doctors of the Hospital of Faculty of Medicine.

Women with no surgical menopause, systolic blood pressure (SBP) $\leq$ 140 mmHg, diastolic blood pressure (DBP) $\leq$ 90 mmHg, and smoking fewer than 10 cigarettes a day were included the study. Exclusion criteria included using hormone replacement therapy, oral contraceptive, and/or vitamin B supplement; participating in regular physical activity for the last 6 months; having severe cardiovascular, metabolic, endocrine, and/or cancer disease history.

The study was completed with 45 nonsmoking women (resistance training group: "RT," $n = 24$; control group: "CT," $n = 21$) with the mean age of 53.16 ± 4.73 years, since four women did not attend the last measurements in the CT and two women quit the exercise program in the RT. At the baseline, body mass index (BMI), resting heart rate (HR), SBP, DBP, estimated mean

peak VO_2, lipid profiles, and plasma homocysteine level were evaluated. All tests were repeated in both groups after 12 weeks.

Our study was single blinded. A physiotherapist divided subjects into two groups consisting of the RT ($n = 26$) and nonexercise CT ($n = 25$) using the table of random numbers for the randomization process. Another physiotherapist evaluated the participants, and the third physiotherapist supervised the exercise program. The physiotherapist who collected the data and the exercise physiotherapist were blinded.

Women in RT did regular resistive exercises and women in CT did not do any exercises for 12 weeks. All participants were advised to keep their habitual diets, not to take any vitamins, especially vitamin B_6, vitamin B_{12}, or folate, and women in CT were asked not to change their activity levels during the study, which extended for 12 weeks. Maintaining of habitual dietary intake in both groups and weekly physical activity of the control group were monitored by phone interview at the end of each week. The phone interview consisted of two arms: (a) For both groups: "Did you change your habitual diet during this week? If yes, can you explain?" (b) For the control group: "Did you attain any sportive activity during this week? If yes, can you explain?" The answers were noted for each person.

Measurements

Laboratory assessments. The blood samples were collected between 8 a.m. and 9 a.m. following a 12-h overnight fast. Serum samples were used for routine biochemical analyses, and ethylenediaminetetraacetic acid (EDTA) samples were used for homocysteine measurements. Serum samples were centrifuged for 10 minutes at 3.000 rpm and separated on the day of collection. The EDTA samples were stored on ice for a maximum of 10–20 minutes, and centrifuged for 10 minutes at 4°C, 4.000 rpm. The plasma fractions were kept at −20°C for 3 months until the measurements were taken. Plasma homocysteine levels were measured by the competitive immunoassay method (Intra-assay CV % = 0.98%, Inter-assay CV % = 1.60%; DPC Immulite, Los Angeles, USA; Gelecek et al., 2007). Total cholesterol (Total-c), TG, HDL-cholesterol (HDL-c), amd LDL-c levels were measured with the colorimetric/enzymatic method in a chemistry auto analyzer (Roche, DP Moduler System, Tokyo, Japan). When the triglyceride level was lower than 400 mg/dL, LDL-c was calculated using the Friedewald formulae: {Total-c} − {(TG/5) + HDL-c} (Maesta et al., 2007). All methods were controlled daily by an internal quality system and were certified by the NEQAS external quality control system.

6-Minute Walk Test. A 6-Minute Walk Test (MWT) was used to estimate mean peak VO_2. The test was performed indoors on a hard and flat surfaced circular walking corridor of 200 meters. During the 6-MWT, participants were instructed to walk as quickly as possible without running for 6 minutes, the

distance covered was measured in meters, and peak oxygen consumption was indirectly calculated by the formula. The following formula was used for estimated mean peak VO_2 (ml min^{-1} kg^{-1}): 0.2×distance (m) − 0.191 × age (year) − 0.07 × weight (kg) + 0.09 × height (cm) 0.26 × Rate Pressure Product (RPP) ($\times 10^{-3}$) + 2.45, where RPP = HR × SBP × 10^{-3} (Cahalin, Mathier, Semigran, William, & DiSalvo, 1996). Resting HR (beats/min) was measured using manual palpation on the left radial artery for 30 seconds; SBP and DBP (mmHg) were measured on the upper right arm over the brachial artery using a standard mercury sphygmomanometer after 10 minutes rest for the first measurement. Then the measurement was repeated immediately after 6-MWT. All the measurements were performed with the same procedure in both groups (Pickering et al., 2005).

Exercise Protocol

The subjects performed resistance exercises three times a week for 12 weeks. Resistance training included the 5-minute warm-up period, resistive exercise training, and 5-minute cool-down period. Warm-up and cool-down periods included treadmill walking at constant speed and inclination, as well as stretching exercises. For the resistance training, the exercise physiotherapist, who supervised the exercise sessions, measured 1-repetetion maximum (1-RM: the maximum load that can be lifted one time throughout a complete range of motion) for every subject at the beginning of the 12-week training program, and then the subjects performed two sets of 8–12 repetitions at 60% of 1-RM (Maesta et al., 2007; Vincent, Braith, Bottiglieri, Vincent, & Lowenthal, 2003; Vincent, Bourguignon, & Vincent, 2006) for 2 weeks. Exercises were progressed with gradually increasing repetition numbers of 60% of 1-RM started from 8 repetitions and ending with 12 repetitions in each 2-week period. Exercise physiotherapist measured new 1-RMs for every subject at the beginning of the each two-week period. The program consisted of 10 muscle-including upper extremities (biceps and triceps), lower extremities (thigh and calf), and trunk (chest, back, abdominal) in the resistive program for a total of 50–60 minutes of exercise under the physiotherapist's supervision. Rest breaks between series and exercise ranged from 30 seconds (s) to 1 minute and the participants were advised to perform a concentric contraction about for 3–5s and an eccentric contraction for 2s during the training session. The resistance exercises were applied using free weights and resistance machines (Maesta et al., 2007; Vincent et al., 2003; Vincent et al., 2006). Upper extremity and lower extremity muscle exercises were performed using free weights; trunk muscles exercises were performed using resistance machines. The same physiotherapist filled out an adherence chart for each exercise session. More than 91.7% attendance at the overall resistance training sessions was accepted for the exercise consistency.

Statistical Analysis

All variables were put into a database within the SPSS 11.0 data management system and analyzed. All variables were normally distributed. Therefore, arithmetic mean and standard deviation were used for descriptive statistics. Additionally, percentages and the absolute changes between the measurements at the baseline and 12 weeks later were demonstrated. To determine whether the groups were homogeneous in descriptive and anthropometric characteristics, the Mann Whitney-U test was administered because the number of the participants in both groups was nonparametric ($n < 30$) and they normally distributed. Two-way analysis of variance (ANOVA) with repeated measures with time (within) and groups (between) as factors was used to test for the time-by-exercise effect on BMI, HR, blood pressure, estimated peak VO_2, lipid profile, and Hcy levels. When significant changes were observed in the ANOVA test, Tukey's post hoc test was applied to locate the source of significant difference; $p < .05$ was regarded as significant.

RESULTS

The data were obtained from 45 participants (RT = 24, CT = 21). There were no significant differences for any demographic variables between RT and CT at the baseline ($p > .05$). Table 1 illustrates the comparison of demographic data of the groups. During 12 weeks we determined that the habitual dietary intakes of all the participants were maintained. Moreover, participants in the CT did not join any regular physical activity during this period. The mean adherence of the participants of the RT to the total training sessions was 95.8%.

After 12 weeks, it was found that BMI decreased in women in the RT, whereas it increased in women in the CT. A significant time-by-group interaction for BMI values ($F = 5.927$, $p = .019$) and no significant time effect ($F = 1.164$, $p = .287$) was found according to the repeated measures from the ANOVA test. Further post-hoc analysis revealed differences in the

TABLE 1 Descriptive and Anthropometric Characteristics of the Participants

Variable	RT * ($n = 24$)	CT * ($n = 19$)	p
Age (years)	54.33 ± 5.3 (45–60)	51.80 ± 3.65 (44–59)	.094
Height (cm)	157.82 ± 05 (146–168)	158.14 ± 0.61 (147–170)	.918
Body mass (kg)	69.66 ± 9.11 (53–90)	68.02 ± 9.92 (52–88)	.538

All values are means and standart deviations, $p < .05$.
*RT: Resistance training group, CT: Control group.

TABLE 2 Changes in BMI, HR, SBP, DBP, and Peak VO_2 in RT and CT Groups

Variable	RT†	CT†
Body mass index (kg/m^2)		
Pre	28.00 ± 3.7	27.17 ± 3.50
Post	27.70 ± 3.62*	27.28 ± 3.53
Δ	−0.29 ± 0.72	0.11 ± 0.29
HR†† (beat/min)		
Pre	80.08 ± 7.92	77.76 ± 8.36
Post	78.41 ± 6.04*	80.47 ± 12.31*
Δ	−1.66 ± 3.76	2.71 ± 9.61
DBP†† (mmHg)		
Pre	70.00 ± 9.44	72.38 ± 9.03
Post	70.20 ± 8.64	73.80 ± 7.56
Δ	0.20 ± 3.12	1.42 ± 3.21
SBP†† (mmHg)		
Pre	111.87 ± 11.11	112.61 ± 14.88
Post	108.12 ± 8.68*	113.09 ± 13.27
Δ	−3.75 ± 6.46	0.47 ± 6.50
E-Peak VO_2 (ml/min/kg)		
Pre	19.98 ± 1.99	18.92 ± 1.40
Post	22.50 ± 2.29*	19.29 ± 1.52
Δ	2.52 ± 1.34	0.37 ± 1.37

All values are means and standart deviations.
*$p < .05$ compared with pretest.
†RT: Resistance training group, CT: Control group, E-Peak VO_2: Estimated mean peak VO_2.
††HR: Heart rate, DBP: Diastolic blood pressure, SBP: Systolic blood pressure.

effectiveness of RC in reducing BMI ($p = .009$; Table 2). The two-way interactions of group x time were significant for HR ($F = 4.249$, $p = .045$), SBP ($F = 4.758$, $p = .035$). The RT participants' HR and SBP decreased significantly ($p = .045$, $p = .023$, respectively) at the end of 12 weeks, whereas DBP did not change in either group (Table 2), although estimated mean peak VO_2 was significantly altered after 12 weeks ($F = 28.086$, $p = .001$). Furthermore, estimated mean peak VO_2 increased in the RT compared with the CT ($p = .000$; Table 2).

According to the results of the two-way ANOVA analysis, there was significant time-by-group interactions for Total-c ($F = 9.118$, $p = .004$) and TG ($F = 4.289$, $p = .044$) levels. Additionally, there was a time effect for TG level ($F = 8.431$, $p = .006$). The RT had significant decreases in Total-c level ($p = .045$) after resistance training (Table 3). There was a 7.25 reduction for the Total-c level percentile in RT, and CT increased by 2.43 %. This reduction for Total-c level in RT was higher than the percentage of biological variation of the Total-c level (http://www.westgard.com/biodatabase1.htm).

The changes in HDL-c ($F = 0.275$, $p = .157$), LDL-c ($F = 3.422$, $p = .071$) and homocysteine ($F = 0.377$, $p = .543$) were not statistically different between the two groups, and there was no time effect for these parameters ($p > .05$; Table 3).

TABLE 3 Changes in Blood Assessments in RT Group and CT Group

Variable	RT†	CT†
Triglyceride (mg/dL)		
Pre	174.33 ± 65.73	164.57 ± 57.05
Post	149.58 ± 53.64	160.42 ± 46.17
Δ	−24.75 ± 34.13	−4.14 ± 32.31
	(11.55% ± 21.52)	(1.09% ± 21.31)
Total-c†† (mg/dL)		
Pre	213.41 ± 38.36	219.33 ± 43.60
Post	198.25 ± 43.4*	225.00 ± 51.83
Δ	−15.16 ± 22.03	5.66 ± 24.24
	(7.25% ± 9.56)	(2.43% ± 10.53)
HDL-c†† (mg/dL)		
Pre	50.75 ± 11.82	60.19 ± 13.71
Post	52.08 ± 10.39	57.28 ± 9.08
Δ	1.33 ± 8.59	−2.90 ± 11.11
	(4.35% ± 15.12)	(2.15% ± 16.33)
LDL-c ††(mg/dL)		
Pre	134.91 ± 31.28	133.14 ± 34.80
Post	126.04 ± 32.09	136.47 ± 46.05
Δ	−8.87 ± 20.74	3.33 ± 23.50
	(6.09% ± 14.87)	(1.60% ± 17.11)
Hcy †† (μmol/L)		
Pre	8.83 ± 2.91	10.28 ± 2.69
Post	8.38 ± 2.75	10.18 ± 3.12
Δ	−0.45 ± 1.79	−0.09 ± 2.10
	(3.46% ± 15.63)	(0.22% ± 17.47)

All values are means and standart deviations.

*$p < .05$ compared to pretest.

†RT: Resistance training group, CT: Control group.

††Total-c: Total cholesterol, HDL-c: HDL cholesterol, LDL-c: LDL cholesterol, Hcy: Homocysteine.

DISCUSSION

We investigated whether a 12-week resistance training program alone may have an influence on particular risk factors for CVD in postmenopausal women. We found that BMI, HR, SBP, and Total-c levels decreased, and estimated mean peak VO_2 improved. However DBP, LDL-c, HDL-c, and plasma homocysteine levels did not change after resistance training.

The benefits of regular exercises on chronic diseases have been recognized (Asikainen et al., 2004; Earnest et al., 2008; Pollock et al., 2000). Aerobic and aerobic-resistance combined training effects are well discussed in terms of modifing the CVD risk factors including improvement of endothelial function, body composition, and lipid profile (Gelecek et al., 2007; Inaba et al., 2008; Riesco et al., 2010; Shaw et al., 2009). Both aerobic and resistance training have similar effects on modifiable risk factors; moreover, resistance exercises improve muscle strength, which would be helpful to accomplish activities of daily living and tasks that require strength (Adams et al., 2006; Pollock et al., 2000). It is mentioned that the aerobic exercises seem

not to improve people's perception that they can undertake heavy work, whereas resistance training improved self-efficacy scores for strength-related tasks (Adams et al., 2006). Furthermore, our participants' adherence to the resistance training sessions was high. The possible reason for the greater exercise adherence may be due to our training design, as all sessions were performed as group exercises under supervision. We recommend supervised resistance exercise training to modify particular risk factors in postmenopausal women.

Resistance training is accepted to increase muscular strength, endurance, and bone mineral density (Asikainen et al., 2004; Asikainen et al., 2006; Nakata et al., 2008). Resistance training has benefits on cardiovascular parameters in terms of improvements in peak oxygen uptake, stroke volume, cardiac output, DBP, and oxidative stress; however, data are still lacking about the benefits of resistance exercises alone on CVD risk factors on postmenopausal women (Adams et al., 2006; Maesta et al., 2007; Nakata et al., 2008; Vona et al., 2009). In our study, we investigated whether resistance exercises would be an alternative choice for training programs designed to reduce CVD risks in postmenopausal women.

Increased BMI, which is associated with numerous health problems predictive of increased risk of CVD and other chronic diseases, is well known in women at menopause (Lemoine et al., 2007). Pollock and colleagues (2000) found that combined resistance-aerobic training or resistance exercise with diet restriction may increase weight loss compared with resistance training alone. Bouchard and colleagues (2009) found similar results in obese older women. In the present study, BMI decreased after 3 months resistance training alone while sustaining normal dietary habits without caloric restriction. This finding can be explained with some possible mechanisms. Although aerobic exercises are mostly considered calorie burners, resistance exercises assist the body in expending calories via increasing the lean body mass and basal metabolism. In other words, resistance exercises are potential exercises for stimulation of the metabolic rate and fat oxidation after the activity and increasing total energy expenditure chronically (Pollock et al., 2000).

The authors found that increased resting HR is associated with the high risk of CVD in sedentary postmenopausal woman (Earnest et al., 2008; Juca et al., 2004). Dixon and colleagues (1992) indicated that reduced resting HR may be associated with an improvement in the neuron-regulatory aspects of cardiac regulation through the sinoatrial node. Earnest and colleagues (2008) pointed out that exercise might decrease blood pressure by causing vascular remodeling, altering sympathetic nerve activity and decreasing the sensitivity of blood vessels to vasoconstrictor endothelin −1. An other possible mechanism for reduced peripheral vascular resistance is vasodilatation in metabolically active skeletal muscle related to mediated nitric oxide (NO) and other endothelium-dependent and independent mediators (Brett, Jiang, Turner, Ritter, & Chowienczyk, 2006). In the present study resistance training

increased estimated mean peak oxygen uptake and decreased HR and SBP, similar to the effects of aerobic training. This result may be due to the NO release and related vasodilatation in the blood vessels. Additionally, Vona and colleagues (2009) declared that the exercise intensity may play an important role for stimulation of NO release. It is known that high-intensity exercises increased oxidative stress while moderate aerobic exercises increased endothelium dependent vasodilatation (Vona, 2009). Generally researchers reported that RT exercises at an intensity of 50%–80% of 1-RM improve lipid profiles, lower hydroperoxides, Hcy levels, and proinflammatory cytokines in adults (Pollock et al., 2000; Prestes et al., 2009; Vincent et al., 2006). We used moderate resistance training (60% 1-RM) and we found improvements in cardiac functions that may be related to the following mechanisms.

Good physical condition prevents CVD and decreases mortality and morbidity rates (Asikainen & Kukkonen-Harjula Kand Miilunpalo, 2004). Peak VO_2 is a commonly accepted indicator of physical condition (Lemoine et al., 2007). It is usually suggested that resistance exercises may improve peak oxygen uptake levels lesser than the exercise training, which consists of aerobic components (Pollock et al., 2000). According to our six MWT results, however, estimated mean peak VO_2 improved in postmenopausal women via 3 months resistance training. This improvement may be due to increased maximal voluntary contraction of the skeletal muscles after resistance training and a lesser need of effort for the same workload for a specific activity (ACSM, 1998).

Szapary, Bloedon, & Foster (2003) and Puglisi and colleagues (2008) declared that regular exercise may decrease the risk for CVD by decreasing cholesterol and TG and increasing HDL-c. In our study TG values did not change, while total-c level decreased after 12 weeks resistance training and the decrease was higher than the percentage of biological variation of the Total-c. These results bring into mind that resistance training has positive effects on the lipid profile that might be related to reducing the inflammation by less inflammatory cytokines with regular exercise as Puglisi and colleagues (2008) pointed out in their study.

Homocysteine is also accepted as an independent risk factor for CVD (Gelecek et al., 2007; Hankey & Eikelboom, 1999; Kuller & Evans, 1998). There is evidence that elevated homocysteine levels may cause toxicity by such mechanisms as oxidative stress and endothelial damage (Mcanulty et al., 2005; Siri, Verhoef, & Kok, 1998). Homocysteine metabolism is predominantly driven by several B-complex cofactors (Kuller & Evans, 1998; Siri et al., 1998). Thus, folic acid and vitamin B_{12} levels of the participants were controlled with blood analysis. In the beginning of the study, these parameters, which are the key factors for homocysteine metabolism, were normative and remained the same at the end of the study. We can suggest, therefore, that our results show the effect of exercise on homocysteine levels independent of the essential factors act in homocysteine metabolism. Researchers also

pointed out that physical activity may affect the homocysteine level (Duncan et al., 2004; Okura et al., 2006). Several authors focused on the aerobic training (Duncan et al., 2004; Gelecek et al., 2007; Okura et al., 2006), whereas only two researchers investigated the effect of resistance training on homocysteine levels according to the best of our knowledge. They reported significant reductions in serum levels of homocysteine after resistance exercise training in the elderly (Vincent et al., 2003; Vincent et al., 2006). In this study, plasma homocysteine levels did not change with resistance exercises in the present study despite 12 weeks of physical activity. The reason for these results could be that we were studying subjects with normative homocysteine levels and unchanged B-complex cofactors.

CONCLUSION

Three months of moderate intensity resistance training alone improved BMI, HR, SBP, estimated mean peak VO_2, and total cholesterol levels. These results point out that resistance training alone has positive effects on particular risks of CVD in postmenopausal women. In conclusion, supervised resistance exercises have a high level of adherence, and resistance exercises alone could be effective as an important nonpharmacological intervention to modify cardiovascular risks similar to aerobic or multiexercises programs and could help to guide health professionals to encourage variety in the prescription of exercise in order to generalize the development of effective intervention programs in postmenopausal women. Future studies need to be designed with a larger sample and also postmenopausal women who already have cardiac risks, in order to fully understand the scope.

REFERENCES

Adams, J., Cline, M. S., Reed, M., Masters, A., Ehlke, K., & Hartman, J. (2006). Importance of resistance training for patients after cardiac event. *Proceeding (Baylor University Medical Center)*, *19*, 246–248.

American College of Sports Medicine (ACSM) Position Stand. (1998). The recommended quantity and quality of exercise for developing and maintaining cardiorespiratory and muscular fitness, and flexibility in healthy adults. *Medicine & Science in Sports & Exercise*, *30*, 975–991.

Asikainen, T. M., & Kukkonen-Harjula Kand Miilunpalo, S. (2004). Exercise for health for early postmenopausal women. A systematic review of randomised controlled trials. *Sports Medicine*, *34*, 753–778.

Asikainen, T. M., Suni, J. H., Pasanen, M. E., Oja, P., Rinne, M. B., Miilunpalo, S. I., . . . Vuori, I. M. (2006). Effect of brisk walking in 1 or 2 daily bouts and moderate resistance training on lower-extremity muscle strength, balance, and walking performance in women who recently went through menopause: A randomized, controlled trial. *Physical Therapy*, *86*, 912–924.

Bea, J. W., Cussler, E. C., Going, S. B., Blew, R. M., Metcalfe, L. L., & Lohman, T. G. (2009). Resistance training predicts six-year body composition change in postmenopausal women. *Medicine & Science in Sports & Exercise*, *42*, 1286–1295.

Bouchard, D. R., Soucy, L., Sénéchal, M., Dionne, I. J., & Brochu, M. (2009). Impact of resistance training with or without caloric restriction on physical capacity in obese older women. *Menopause*, *16*, 66–72.

Brett, S. E., Jiang, B. Y., Turner, C., Ritter, J. M., & Chowienczyk, P. J. (2006). Elevation of plasma homocysteine by methionine loading increases the diastolic blood pressure response to exercise. *Journal of Hypertension*, *24*, 1985–1989.

Cahalin, L. P., Mathier, M. A., Semigran, M. J., William, G., & DiSalvo, T. G. (1996). The six-minute walk test predicts peak oxygen uptake and survival in patients with advanced heart failure. *Chest*, *110*, 325–332.

Church, T. S., Earnest, C. P., Skinner, J. S., & Blair, S. N. (2007). Effects of different doses of physical activity on cardiorespiratory fitness among sedentary, overweight or obese postmenopausal women with elevated blood pressure: A randomized controlled trial. *Journal of the American Medical Assocation*, *16, 297*, 2081–2091.

Dixon, E. M., Kamath, M. V., McCartney, N., & Fallen, E. L. (1992). Neural regulation of heart rate variability in endurance athletes and sedentary controls. *Cardiovascular Research*, *26*, 713–719.

Duncan, G. E., Perri, M. G., Anton, S. D., Limacher, M. C., Martin, A. D., Lowenthal, D. T., . . . Stacpoole, P. W. (2004). Effects of exercise on emerging and traditional cardiovascular risk factors. *Preventive Medicine*, *39*, 894–902.

Earnest, C. P., Lavie, C. J., Blair, S. N., & Church, T. S. (2008). Heart rate variability characteristics in sedentary postmenopausal women following six months of exercise training: The DREW study. *PLoS ONE*, *3*(6), e2288.

Francis, K. T. (1996). Physical activity in the prevention of cardiovascular disease. *Physical Therapy*, *7*, 456–468.

Frank, L. L., Sorensen, B. E., Yasui, Y., Tworoger, S. S., Schwartz, R. S., Ulrich, C. M., . . . McTiernan, A. (2005). Effects of exercise on metabolic risk variables in overweight postmenopausal women: A randomized clinical trial. *Obesity Research*, *13*, 615–625.

Gelecek, N., Teoman, N., Ozdirenc, M., Pınar, L., Akan, P., Bediz, C., & Kozan, O. (2007). Influences of acute and chronic aerobic exercise on the plasma homocysteine level. *Annals of Nutrition and Metabolism*, *51*, 53–58.

Hankey, G. J., & Eikelboom, J. W. (1999). Homocysteine and vascular disease. *Lancet*, *354*, 407–413.

Inaba, Y., Obuchi, S., Arai, T., Satake, K., & Takahira, N. (2008). The long-term effects of progressive resistance training on health-related quality in older adults. *Journal of Physiological Anthropology*, *27*, 57–61.

Juca, R., Churc, T. S., Morss, G. M., Jordan, A. N., & Earnest, C. P. (2004). Eight weeks of moderate-exercise training increases heart rate variability in sedentary postmenopausal women. *American Heart Journal*, *147*, 8–14.

Kuller, L. H., & Evans, R. W. (1998). Homocysteine, vitamins, and cardiovascular disease. *Circulation*, *98*, 196–199.

Laughlin, M. H. (1999). Cardiovascular response to exercise. *American Journal of Physiology*, *277*, 244–259.

Lemoine, S., Rossell, N., Drapeau, V., Poulain, M., Garnier, S., Sanguignol, F., & Mauriège, P. (2007). Effect of weight reduction on quality of life and eating behaviors in obese women. *Menopause*, *14*, 432–440.

Maesta, N., Nahas, E. A. P., Nahas-Neto, J., Orsatti, F. L., Fernandes, C. E., Traiman, P., & Burini, R. C. (2007). Effects of soy protein and resistance exercise on body composition and blood lipids in postmenopausal women. *Maturitas*, *56*, 350–358.

Mcanulty, S. R., Mcanulty, L. S., Nieman, D. C., Morrow, J. D., Shooter, L. A., Holmes, S., … Henson, D. A. (2005). Effect of alpha-tocopherol supplementation on plasma homocysteine and oxidative stress in highly trained athletes before and after exhaustive exercise. *Journal of Nutritional Biochemistry*, *16*, 530–537.

Nakata, Y., Ohkawara, K., Okura, T. D., & Tanaka, K. (2008). Effects of additional resistance training during diet-induced weight loss on bone mineral density in overweight premenopausal women. *Journal of Bone and Mineral Metabolism*, *26*, 172–177.

Okura, T., Rankinen, T., Gagnon, J., Lussier-Cacan, S., Davignon, J., Leon, A. S., Rao, D. C., … Bouchard, C. (2006). Effect of regular exercise on homocysteine concentrations. *The HERITAGE Family Study*, *98*, 394–401.

Orsatti, F. L., Nahas, E. A., Maesta, N., Nahas-Neto, J., & Burini, R. C. (2008). Plasma hormones, muscle mass and strength in resistance-trained postmenopausal women. *Maturitas*, *59*, 394–404.

Pickering, T. G., Hall, J. E., Appel, L. J., Falkner, B. E., Graves, J., Hill, M. N., … Roccella, E. J. (2005). Recommendations for blood pressure measurement in humans and experimental animals: Part 1: Blood pressure measurement in humans: A statement for professionals from the Subcommittee of Professional and Public Education of the American Heart Association Council on High Blood Pressure Research. *Hypertension*, *45*, 142–161.

Pollock, M. L., Franklin, B. A., Balady, G. J., Chaitman, B. L., Fleg, J. L., Fletcher, B., Limacher, M., Piña, I. L., Stein, R. A., Williams, M., & Bazzarre, T. (2000). 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*, *101*, 828–833.

Prestes, J., Shiguemoto, G., Botero, J. P., Frollini, A., Dias, R., Leite, R., … Perez, S. (2009). Effects of resistance training on resistin, leptin, cytokines, and muscle force in elderly post-menopausal women. *Journal of Sports Science*, *27*, 1607–1615.

Puglisi, M. J., Vaishnav, U., Shrestha, S., Torres-Gonzalez, M., Wood, R. J., Volek, J. S., & Fernandez, M. L. (2008). Raisins and additional walking have distinct effects on plasma lipids and inflammatory cytokines. *Lipids in Health and Disease*, *16*, 7–14.

Riesco, E., Aubertin-Leheudre, M., Maltais, M. L., Audet, M., & Dionne, I. J. (2010). Synergic effect of phytoestrogens and exercise training on cardiovascular risk profile in exercise-responder postmenopausal women: A pilot study. *Menopause*, *17*(5), 1–5.

Shaw, I., Shaw, B. S., & Krasilshchikov, O. (2009). Comparison of aerobic and combined aerobic and resistance training on low-density lipoprotein cholesterol concentrations in men. *Cardiovascular Journal of Africa*, *20*, 290–295.

Siri, P. W., Verhoef, P., & Kok, F. J. (1998). Vitamins B6, B12, and folate: Association with plasma total homocysteine and risk of coronary atherosclerosis. *Journal of the American College of Nutrition*, *17*, 435–441.

Szapary, P. O., Bloedon, L. T., & Foster, G. D. (2003) Physical activity and its effects on lipids. *Current Cardiology Reports*, *5*, 488–492.

Teixeira, P. J., Going, S. B., Houtkooper, L. B., Metcalfe, L. L., Blew, R. M., Flint-Wagner, H. G., . . . Lohman, T. G. (2003). Resistance training in postmenopausal women with and without hormone therapy. *Medicine & Science in Sports & Exercise*, *35*, 555–562.

Teoman, N., Ozcan, A., & Acar, B. (2004). The effect of exercise on physical fitness and quality of life in postmenopausal women. *Maturitas*, *20*, 71–77.

Vincent, H. K., Bourguignon, C., & Vincent, K. R. (2006). Resistance training lowers exercise-induced oxidative stress and homocysteine levels in overweight and obese older adults. *Obesity*, *14*, 1921–1930.

Vincent, K. R., Braith, R. W., Bottiglieri, T., Vincent, H. K., & Lowenthal, D. T. (2003). Homocysteine and lipoprotein levels following resistance training in older adults. *Preventive Cardiology*, *6*, 197–203.

Vona, M., Codeluppi, G. M., Iannino, T., Ferrari, E., Bogousslavsky, J., & von Segesser, L. K. (2009). Effects of different types of exercise training followed by detraining on endothelium-dependent dilation in patients with recent myocardial infarction. *Circulation*, *31, 119*, 1601–1608.

Williams, M. A., & Steward, K. J. (2009). Impact of strength and resistance training on cardiovascular disease risk factors and outcomes in older adults. *Clinics in Geriatric Medicine*, *25*, 703–714.