DOI: 10.5114/pm.2016.58770

Menopause Rev 2016; 15(1): 26-31

ORIGINAL PAPER

Effect of resistance training with elements of stretching on body composition and quality of life in postmenopausal women

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Abstract

Introduction: Physical activity in elderly persons contributes to prevention and treatment of chronic disease and, through its influence on the musculoskeletal system, increases physical capability and improves mental function.

Aim of the study was to assess the effect of resistance training with elements of stretching on body composition and quality of life in women of postmenopausal age.

Material and methods: Thirty-eight postmenopausal women aged 62.5 ±5.8 years were randomly divided into two groups. One group participated in an 8-week training program (60 minutes, twice weekly; 4 MET [metabolic equivalent] 2 hours/week). The second group performed no training. A comparison was made of body composition and quality of life (SF-36 Health Survey) prior to and after 8 weeks of training.

Results: In the training group, after 8 weeks there was a significant reduction in body fat (in %; $p = 0.028$), and an increase in fat-free mass (in %; $p = 0.025$) and total body water (in %; $p = 0.021$), which indicates increased muscle mass. Furthermore, there were statistically significant differences in the assessment of quality of life in physical (role-physical [RP], bodily pain [BP], general health [GH] scales; $p < 0.005$) and mental health (vitality [VT] scale; $p = 0.05$). In the non-exercising group no changes were observed in features examined in the initial and final test.

Conclusions: Resistance training with elements of stretching in postmenopausal women improved body composition to achieve a reduction in risk factors associated with excess fatty tissue and muscle mass deficiency. It raises the quality of life in terms of both physical and mental function.

Key words: exercise training, body composition, physical health, mental health, elderly women.

Introduction

Changes in body composition (BC) accompanying the ageing process involve a reduction in muscle mass and increase in body fat (BF), which is subject to redistribution and assumes a rather centralized position [1, 2]. It has been shown that after the age of 50, we lose muscle at a rate of approximately 1-2% annually [3]. Research has shown that the limiting of physical ability in the elderly is more closely associated with excess BF than deficiency in fat-free mass (FFM) [4]. Physical activity (PA) may significantly delay or reduce the effects of ageing on the organism, and guidelines concerning PA constitute a priority in the activities of the World Health Organization. It has been shown that lack of PA causes an increased risk of cardiovascular disease, type-2 diabetes, some cancers, osteoporosis, obesity, and depression [5]. Among the various forms of PA recommended for women over 50 years of age, resistance training (RT) has become particularly significant, despite being considered, until recently, within the male domain. It has been shown that women participating in the same well-prepared strength training programs as men can enjoy benefits such as increased FFM, reduced BF, and improved quality of life [6, 7]. Resistance training is generally recommended as part of an exercise scheme for older persons [8]. The most recent research suggests that RT in adults leads to prevention and treatment of chronic illness, and through its influence on the musculoskeletal system causes an improvement in physical and mental health [9]. Participation in a well-designed RT program by older persons does not only cause increased muscle mass and strength, but also prevents falls, reduces sensitivity to pain, improves glucose tolerance and insulin sensitivity, increases bone density and basal metabolic rate, reduces the risk of circulatory system disease, leads to maintenance of physical condition, and improves quality of life through the reduction of negative emotional states [9-12]. Despite these data, the effects of RT on the physical functioning of the or-

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Submitted: 08.12.2014
Accepted: 20.08.2015

ganism in older persons is not fully known. The results of some research indicate only a slight improvement in function following RT, despite the great positive results of such training on muscle strength [13, 14].

In light of these data, the aim of this study is to assess the effect of 8 weeks of RT, with elements of stretching, on body composition and quality of life in women of postmenopausal age.

Material and methods

Subjects

The study included 38 healthy women between the ages of 50 and 76 years, average age 62.5 ±5.8 years. There were no medical contraindications to participation in moderate PA. Based on careful medical history, we excluded patients with circulatory insufficiency and chronic diseases according to Kowalski and Mejer [15]. The women were divided randomly into two groups (G1 and G2) of 19 persons. Group G1 participated in an RT program with elements of stretching lasting 8 weeks (Table I). Group G2 was the control group, not participating in any form of PA. From the group of women who commenced training, 13 women systematically participated in classes, and for these women we have full comparative data. The subject women declared a lack of participation in regular RT for a period of six months prior to commencement of the study. Furthermore, they were committed to maintaining their current level of PA during the day, independently of the exercises completed within the program. The women in group G1 were familiarized with the principles of safe exercise in a gym. The women in groups G1 and G2 did not differ statistically significantly in terms of age, height or body mass, waist circumference or body mass index (BMI) or waist-hip ratio (WHR), or body composition parameters (Table II). The training program was conducted over 8 weeks, twice weekly for 60 minutes, and included exercise of moderate intensity, defined as 4 MET (metabolic equivalent) on the basis of "Compendium of physical activities" according to Ainsworth *et al.* [16]. 1 MET corresponds to oxygen consumption at rest, and in regard to body weight, is 3.5 ml · kg^{-1} · min^{-1}. The women in group G1 performed physical effort requiring energy expenditure of approximately 4 MET · 2 hours/week. The study was conducted in two stages – preliminary examinations, prior to training, and after eight weeks of training. These included anthropometric measurements, body composition measurements, and assessment of quality of life. Permission to conduct the study was received from the Polish local Commission for Ethics at the University School of Physical Education in Wroclaw 2014. All research participants had to provide written consent in order to participate in the project.

Exercise training program

Stationary form, endurance-strength training for muscle groups is shown in Table I. Work was performed in aerobic zones. The internal resistance training included 25 repetitions (very low load). The training was led by a qualified instructor. Training stages: 1) warm up to music (15 min), including various forms of aerobic exercise such as marching, basic fitness steps mixed with breathing exercises. The aim of this was to raise the body temperature and stimulate the organism in preparation for effort. The intensity of the warm up was at the level of 55-80% VO_{2max}; 2) endurance-strength exercises with the body's own resistance, dumbbells (1 kg on each side) and large exercise ball (35 min), two series of maximum 25 repetitions for each exercise; this stage comprised 12 exercise types for selected muscle groups; 3) stretching of main muscle groups used in the exercises (10 min), two series of 20 seconds for each side; included 9 types of exercise for selected muscle groups (Table I).

Anthropometric measurements

Measurements were taken of body mass, body height, waist circumference (at the largest narrowing in the trunk at the waist) and hips (through the buttocks); BMI was calculated (body mass [kg]/body height [m^2]) and WHR (waist circumference [cm]/hip circumference [cm]). Body composition assessment was performed with the bioimpedance method (BIA) – STA/BIA RJL – Akern 101/S tetrapolarna version (Italy); the following BC component percentages were analyzed: body fat (BF), fat-free mass (FFM), total body water (TBW) and body cell mass (BCM).

Quality of life

This was measured using the Short Form Health Survey (SF-36). Permission was obtained from QualityMetric Incorporated for using the Polish version questionnaire (IQOLA SF-36v2 Standard, Poland). The

Tab. I. Characteristics of training

Twice weekly, 60 minutes		
Resistance training:		Muscle groups: m. quadriceps femoris mm. adductores m. gluteus maximus m. gluteus medius mm. dorsi mm. femoris posteriori mm. flexoris genus m.m. membri superioris m. pectoralis major mm. abdominis
Number of series	2 series	
Number of repetitions	25 repetitions	
Stretching:		
Number of series	2 series	
Duration of exercise	20 s	

Tab. II. Effects of resistance training with elements of stretching on anthropometric and body composition features in postmenopausal women

Variables	G1 (n = 13)		G2 (n = 19)	
	Baseline	Eight weeks	Baseline	Eight weeks
Age (years)	62.7 (6.8)		62.4 ±5.2	
Height (cm)	159.3 (7.4)		159.4 ±6.9	
Weight (kg)	69.5 (10.5)	69.2 (11.6)	68.5 (10.9)	68.5 (11.4)
Waist (cm)	88.6 (11.2)	88.0 (12.1)	84.4 (9.5)	84.4 (9.8)
Hips (cm)	104.1 (8.1)	102.3 (8.1)*	103.7 (7.8)	102.7 (7.2)
BMI (kg/m^2)	27.5 (4.4)	27.3 (4.7)	27.0 (4.4)	27.0 (4.7)
WHR	0.85 (0.1)	0.86 (0.1)	0.81 (0.1)	0.82 (0.1)
BF (%)	34.4 (4.6)	33.3 (5.0)*	32.6 (4.5)	32.6 (4.4)
FFM (%)	65.6 (4.6)	66.7 (5.0)*	67.4 (4.5)	67.5 (4.4)
TBW (%)	47.2 (4.8)	48.3 (5.2)*	48.9 (4.6)	49.0 (4.5)
BCM (%)	34.8 (5.9)	34.9 (5.7)	34.5 (2.5)	34.5 (2.5)

G1 – exercising group; G2 – non-exercising group; BMI – body mass index; WHR – waist-hip ratio; values are expressed as mean (±SD); *p < 0.05, Wilcoxon signed-rank test to compare two dependent variables, for comparison between baseline and after eight weeks of resistance training with elements of stretching

questionnaire contains 36 questions which allow comparison of subjects in 8 dimensions of quality of life: physical functioning (PF), role-physical (RP), bodily pain (BP), general health (GH), vitality (VT), social functioning (SF), emotional role functioning (RE) and mental health (MH). In each category, questions are marked on a scale of 0 to 100 points, where a greater points value corresponds to better quality of life. Furthermore, two indicators were compared: physical component summary (PCS) and mental component summary (MCS) [17].

Statistical analysis

Statistical analysis was performed using the Statistica 10.0. software. The data presented in the text and tables of the study are expressed as mean values ± standard deviation (SD). The difference between two samples of independent variables (groups G1 and G2) was examined with the Mann-Whitney U test. The significance of the differences between the mean values for dependent variables (prior to and following training) was analyzed with the Wilcoxon test. To assess the strength of the correlation between anthropometric features and body composition parameters and quality of life, the Spearman rank correlation coefficient (R) was calculated. A value of p < 0.05 was considered statistically significant.

Results

Prior to commencement of the program, in 38.5% of class participants G1 36.8% of subjects in G2 presented BMI within normal values (BMI < 25 kg/m^2), 30.7% of subjects in G1 and 31.6% in G2 presented excess weight (BMI 25-29.9 kg/m^2), 30.8% of subjects in G1 and 31.6% in G2 were found to be obese (BMI ≥ 30 kg/m^2). In the total group of women (G1 and G2) a statistically significant correlation was found between BMI, waist and hip circumference and quality of life assessment (Table III). Lower point scores, and thus worse quality of life in the physical perception of health measured in categories of PF, BP and GH and PCS were observed in women with greater body mass, high BMI indicators and greater waist and hip circumference (R = from –0.43 to –0.61, p < 0.05). Similar interdependencies occurred between examined BC features and subjective assessment of health (Table III). High physical fitness in terms of PF, BP and GH was observed in women with higher FFM and BCM (R = from 0.37 to 0.57, p < 0.05). Physical component summary was observed to be higher in women with lower fat measurements (R = –0.46, p < 0.05) with greater FFM and BCM in body composition (R = from 0.41 to 0.47, p < 0.05). Physical functioning and PCS were positively correlated with greater organism hydration (R = from 0.41 to 0.51, p < 0.05). The subject group of women presented no significant correlation between BC parameters and mental function.

In G1 participation in RT caused statistically significant changes in BC parameters without an influence on body mass and mean BMI values (Table II). After 8 weeks of training there was a significant reduction in BF (p = 0.03), and increase in FFM (p = 0.02) and TBW (p = 0.02), which indicated increased muscle mass. Among the examined anthropometric features, there

Tab. III. Relationship between baseline quality of life and baseline anthropometric and body composition features in postmenopausal women (all participants, *n* = 38)

Variables	SF-36 Scale									
	PF	RP	BP	GH	VT	SF	RE	MH	PCS	MCS
Weight (kg)	–0.50*	–0.13	–0.26	–0.35	–0.11	–0.13	–0.09	0.15	–0.43*	0.03
Waist (cm)	–0.47*	–0.13	–0.13	–0.46*	–0.27	–0.27	–0.12	0.01	–0.44*	–0.10
Hips (cm)	–0.59*	–0.17	–0.43*	–0.48*	–0.16	–0.23	–0.22	0.09	–0.61*	0.00
BMI (kg/m^2)	–0.60*	–0.18	–0.32	–0.46*	–0.13	–0.27	–0.18	0.13	–0.52*	0.02
WHR	–0.12	–0.13	–0.04	–0.27	–0.27	–0.23	–0.06	–0.10	–0.12	–0.22
BF (%)	–0.56*	–0.17	–0.38*	–0.38*	–0.38	–0.27	–0.32	0.11	–0.46*	–0.08
FFM (%)	0.57*	0.17	0.40*	0.39*	0.07	0.28	0.32	–0.09	0.47*	0.09
TBW (%)	0.51*	0.11	0.34	0.34	0.04	0.21	0.26	–0.11	0.41*	0.05
BCM (%)	0.51*	0.10	0.19	0.37*	–0.07	0.24	0.18	–0.18	0.41*	–0.08

BMI – body mass index; WHR – waist-hip ratio; BF – body fat; FFM – fat-free mass; TBW – total body water; BCM – body cell mass; PF – physical functioning; RP – role-physical; BP – bodily pain; GH – general health; VT – vitality; SF – social functioning; RE – role-emotional; MH – mental health; PCS – physical component summary; MCS – mental component summary
*$p < 0.05$, Spearman rank correlation coefficient (R)

was a reduction only in hip circumference ($p = 0.02$), which did not cause a change in distribution of fatty tissue expressed as WHR (p insignificant). Furthermore, in G1 under the influence of RT, a statistically significance difference was observed in the assessment of quality of life in four of the eight scales (Table IV, Fig. 1). In the dimension of physical health there was a statistically significant improvement in quality of life in the categories RP ($p = 0.03$), BP ($p = 0.02$) and GH ($p = 0.01$), with no significant change in PF. In the dimension of mental health, there was an increase in point scores for VT ($p = 0.05$), but no significant difference was observed in the remaining emotional-social categories constituting this dimension i.e. SF, RE and MH. In the non-exercising group G2 no statistically significant changes were observed in body composition features or subjective assessment of quality of life between the initial and final examinations.

Discussion

Resistance training has a positive influence on biochemical and BC features in elderly persons [11, 18] and is recommended for persons in this age group to com-

Tab. IV. Influence of resistance training with elements of stretching on quality of life in postmenopausal women

SF-36 Scale	G1 (*n* = 13)		G2 (*n* = 19)	
	Baseline	Eight weeks	Baseline	Eight weeks
PF	81.2 (10.2)	84.6 (10.7)	78.8 (19.5)	82.1 (18.4)
RP	76.9 (27.9)	100.0 (0.0)*	77.9 (39.4)	86.8 (29.5)
BP	56.4 (20.7)	72.4 (19.1)*	64.5 (21.6)	72.4 (21.9)
GH	56.4 (23.9)	71.7 (19.2)*	58.1 (13.6)	60.9 (15.8)
VT	69.2 (18.5)	80.4 (17.1)*	60.6 (21.4)	64.7 (19.9)
SF	82.8 (22.6)	88.5 (18.0)	86.0 (17.6)	79.4 (27.9)
RE	71.8 (35.6)	87.2 (32.0)	74.5 (40.0)	84.3 (29.2)
MH	76.3 (18.3)	80.3 (18.0)	70.6 (13.7)	72.9 (16.1)
PCS	44.9 (6.4)	50.7 (5.4)*	45.7 (7.7)	49.0 (7.7)
MCS	51.4 (10.5)	54.4 (10.1)	49.8 (8.6)	49.7 (9.8)

G1 – exercising group; G2 – non-exercising group; PF – physical functioning; RP – role-physical; BP – bodily pain; GH – general health; VT – vitality; SF – social functioning; RE – role-emotional; MH – mental health; PCS – physical component summary; MCS – mental component summary; values are mean ±SD; *$p < 0.05$, Wilcoxon signed-rank test to compare two dependent variables, for comparison between baseline and after eight weeks of training

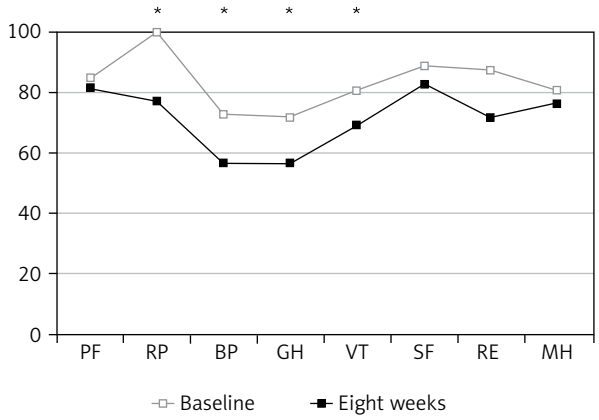

Fig. 1. Quality of life (SF-36 score; out of 100) before and after training in postmenopausal women. PF – physical functioning; RP – role-physical; BP – bodily pain; GH – general health; VT – vitality; SF – social functioning; RE – role-emotional; MH – mental health, *$p < 0.05$

plement programs for control of mass [19]. The results of the present study conducted on a group of women over the age of 50 years confirm the benefits resulting from participation in RT. The observed changes in BC after eight weeks of training concerned the reduction in BF and increase in muscle mass, the result of which was statistically significant changes in body hydration. However, the exercise program did not result in significant effects on weight and BMI. A review of the literature provides a variety of data concerning the influence of RT on BC in postmenopausal women. Ivey *et al.* [20] did not find any increase in FFM in younger or older women participating in 9-week RT. The longer, 12-week RT program conducted by Lyndon *et al.* [18] caused a significant increase in FFM and reduction in FM only in men over the age of 50 years, while no changes in BC were observed in women. However, studies by Bouchard *et al.* [6] have shown after 12 weeks of RT training a significant decrease in body weight, BM, and BMI in obese postmenopausal women. The research by Velthuis *et al.* [7] showed that in postmenopausal women a 12-month exercise program combining aerobic and muscle strength training did not affect body weight but positively influenced BC – reduced BF and increased FFM. Lemmer *et al.* [21], after 24 weeks of RT, observed a significant increase in FFM in younger and older women, although these changes were greater in the younger group. Similar research by Dionne *et al.* [22] indicated a fall in body mass and significant increase in FFM in younger women, and only a non-significant increase after 24 weeks of RT in women over the age of 55 years, without an effect on body mass and FM. A statistically significant difference in abdominal fatty tissue was found in women over the age of 60 years, following 25-week participation in RT, three times a week for 45 minutes [23]. The cited differences in the results of these studies may be a consequence of the varied durations of the programs and sessions, loads applied and numbers of repetitions in each series.

The current findings show that reconstruction of BC in the direction of reduced BF and increased FFM under the influence of RT may be expected in healthy postmenopausal women, with the above intensity of exercise, combined with rational nutrition and positive motivation from the instructor. A permanent effect involving reduction in body mass and FM was observed by Bea *et al.* [24] in women over the age of 50 years, who participated in RT with elements of stretching, three times per week for six years.

Many studies have shown a significant relationship between PA and general perception of health as well as physical and mental function in women over the age of 55 [e.g. 25-27]. With a beneficial influence primarily on muscle mass, bone mass and fatty tissue mass, RT creates the conditions for improved quality of life in postmenopausal women [28]. Meta-analysis results [29] indicate that RT, especially at a higher intensity, is efficient in improving muscle strength in older persons, and may be considered a feasible strategy for prevention of general muscle weakening accompanying the ageing process. Galvão and Taaffe [30] observed a significant improvement in muscle function and physical fitness in men and women over the age of 60 years, following 20 weeks of RT, twice per week, with maximum intensity of eight repetitions. Some authors indicate that a significant improvement in psycho-social function in overweight or obese women is, in the majority of cases, related to reduction in body mass [31]. In this study, over 60% of the women presented a deviation from correct body mass (BMI > 25). Participation in RT did not cause a significant change in their mean values for body mass or BMI. However, the women did achieve greater point scores in comparison with the pre-training period for both physical and mental function. It should be noted that physical function in the pre-training period was significantly correlated with BC parameters. Improved function in dimensions of life was decided by lower FM and higher FFM, and as concerns anthropometric features, lower body mass, waist and hip circumference, and BMI. Similar dependencies have been described by other researchers [e.g. 32, 33].

Among the various forms of physical activity, RT is not widely used as therapeutic intervention in the treatment of menopause [28]. In light of the findings of the present study, RT may be a good strategy in modeling BC with the aim of preventing the occurrence of undesired changes and risk of chronic illness in the 50+ female population.

Conclusions

Eight-week participation in resistance training with elements of stretching leads to remodeling of the body

composition in the direction of reduced risk factors associated with excess body fat. Resistance training raises quality of life in women of advanced age, and above all in the dimension of physical function (SF-36 scales: RP, BP, GH and PCS), but also in the mental dimension (VT scale). Exercise at a gym can be recommended as a form of health training for women over the age of 50, which breaks the stereotype for participant age.

Study limitations

The work is limited by a small sample size, and at this stage of the study cannot be generalized. This study, however, could be a pilot study for designing a more robust one. In the future the effects of the RT will be judged separately in groups of women with normal body weight and with overweight and obesity. However, the preliminary research results showed that even a relatively short period of RT training causes expected changes in body composition and quality of life in postmenopausal women.

Disclosure

Authors report no conflict of interest.

References

1. Goodpaster BH, Park SW, Harris TB, et al. The loss of skeletal muscle strength, mass, and quality in older adults: the health, aging, and body composition study. J Gerontol A Biol Sci Med Sci 2006; 61: 1059-1064.
2. Kuk JL, Saunders TJ, Davidson LE, Ross R. Age-related changes in total and regional fat distribution. Ageing Res Rev 2009; 8: 339-348.
3. Marcell TJ. Sarcopenia: causes, consequences, and preventions. J Gerontol A Biol Sci Med Sci 2003; 58A: 911-916.
4. Sternfeld B, Ngo L, Satariano WA, Tager IB. Associations of body composition with physical performance and self-reported functional limitation in elderly men and women. Am J Epidemiol 2001; 156: 110-121.
5. Lee IM, Shiroma EJ, Lobelo F, et al. Effect of physical inactivity on major non-communicable diseases worldwide: an analysis of burden of disease and life expectancy. Lancet 2012; 380: 219-229.
6. Bouchard DR, Soucy L, Sénéchal M, et al. Impact of resistance training with or without caloric restriction on physical capacity in obese older women. Menopause 2009; 16: 66-72.
7. Velthuis MJ, Schuit AJ, Peeters PH, Monninkhof EM. Exercise program affects body composition but not weight in postmenopausal women. Menopause 2009; 16: 777-784.
8. American College of Sports Medicine. ACSM's guidelines for exercise testing and prescription (6th ed.). MD: Wolters Kluwer, Baltimore 2000.
9. Ciccolo JT, Carr LJ, Krupel KL, et al. The role of resistance training in the prevention and treatment of chronic disease. Am J Lifestyle Med 2010; 4: 293-308.
10. Leenders M, Verdijk LB, van der Hoeven L, et al. Elderly men and women benefit equally from prolonged resistance-type exercise training. J Gerontol A Biol Sci Med Sci 2013; 68: 769-779.
11. Tan S, Li W, Wang J. Effects of six months of combined aerobic and resistance training for elderly patients with a long history of type 2 diabetes. J Sport Sci Med 2012; 11: 495-501.
12. Latham N, Bennett D, Stretton C, et al. Systematic review of progressive resistance strength training in older adults. J Gerontol 2004; 59: M48-M61.
13. Yavari A, Najafipoor F, Aliasgarzadeh A, et al. Effect of aerobic exercise, resistance training or combined training on glycaemic control and cardio-vascular risk factors in patients with type 2 diabetes. Biol Sport 2012; 29: 135-143.
14. Steib S, Schoene D, Pfeifer K. Dose-response relationship of resistance training in older adults: a meta-analysis. Med Sci Sports Exerc 2010; 42: 902-914.
15. Kowalski J, Mejer A. Regularna aktywność fizyczna – receptą na długie życie. Kwartalnik Ortopedyczny 2012; 3: 398-407.
16. Ainsworth BE, Haskell WL, Herrmann SD, et al. Compendium of physical activities: a second update of codes and MET values. Med Sci Sports Exerc 2011; 43: 1575-1581.
17. Ware JE Jr, Sherbourne CD. The MOS 36-item short-form health survey (SF-36). I. Conceptual framework and item selection. Med Care 1992; 30: 473-483.
18. Joseph LJ, Davey SL, Evans WJ, Campbell WW. Differential effect of resistance training on the body composition and liporotein-lipid profile in older men and women. Metabolism 1999; 48: 1474-1480.
19. Campbell WW, Crim MC, Young VR, Evans WJ. Increased energy requirements and changes in body composition with resistance training in older adults. Am J Clin Nutr 1994; 60: 167-175.
20. Ivey FM, Roth SM, Ferrell RE, et al. Effects of age, gender, and myostatin genotype on the hypertrophic response to heavy resistance strength training. J Gerontol A Biol Sci Med Sci 2000; 55: M641-M648.
21. Lemmer JT, Ivey FM, Ryan AS, et al. Effect of strength training on resting metabolic rate and physical activity: age and gender comparisons. Med Sci Sports Exerc 2001; 33: 532-541.
22. Dionne IJ, Mélançon MO, Brochu M, et al. Age-related differences in metabolic adaptations following resistance training in women. Exp Gerontol 2004; 39: 133-138.
23. Hunter GR, Bryan DR, Wetzstein CJ, et al. Resistance training and intra-abdominal adipose tissue in older men and women. Med Sci Sports Exerc 2002; 34: 1023-1028.
24. Bea JW, Cussler EC, Going SB, et al. Resistance training predicts 6-yr body composition change in postmenopausal women. Med Sci Sports Exerc 2010; 42: 1286-1295.
25. Koltyn KF. The association between physical activity and quality of life in older women. Womens Health Issues 2001; 11: 471-480.
26. Martin CK, Church TS, Thompson AM, et al. Exercise dose and quality of life: a randomized controlled trial. Arch Intern Med 2009; 169: 269-278.
27. Bouchard DR, Soucy L, Sénéchal M, et al. Changes in objective and self-reported measures of physical capacity after an intervention in obese older women. J Women Aging 2010; 22: 34-46.
28. Leite RD, Prestes J, Pereira GB, et al. Menopause: highlighting the effects of resistance training. Int J Sports Med 2010; 31: 761-767.
29. Peterson MD, Rhea MR, Sen A, Gordon PM. Resistance exercise for muscular strength in older adults: a meta-analysis. Ageing Res Rev 2010; 9: 226-237.
30. Galvão DA, Taaffe DR. Resistance exercise dosage in older adults: single-versus multiset effects on physical performance and body composition. J Am Geriatr Soc 2005; 53: 2090-2097.
31. Messier C, Tsiakas M, Gagnon M, Desrochers A. Effect of age and glucoregulation on cognitive performance. J Clin Exp Neuropsychol 2010; 32: 809-821.
32. Villareal DT, Banks M, Siener C, et al. Physical frailty and body composition in obese elderly men and women. Obes Res 2004; 12: 913-920.
33. Lebrun CE, van der Schouw YT, de Jong FH, et al. Relations between body composition, functional and hormonal parameters and quality of life in healthy postmenopausal women. Maturitas 2006; 55: 82-92.