Anthropometric and cardiovascular responses to hypertrophic resistance training in postmenopausal women

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Abstract

Objective: Menopause induces a phase of decreased physical fitness and altered body composition characterized by increased total and abdominal fat and reduced lean mass. It is, however, inconclusive which specific resistance training (RT) subtypes can reverse these deleterious changes in postmenopausal women.

Methods: Thirty-seven postmenopausal women were randomized to a 6-week nonexercising control group (n = 18) or hypertrophic RT group (n = 19) that engaged in two 40-minute sessions weekly using three sets of 12 repetitions at 67% to 85% one-repetition maximum for 10 whole-body exercises.

Results: RT significantly improved resting heart rate (69.05 ± 11.19-63.80 ± 4.94 bpm, P = 0.017), systolic blood pressure (125.85 ± 4.86-124.05 ± 3.98 mm Hg, P < 0.0001), diastolic blood pressure (81.20 ± 7.50-77.90 ± 6.85 mm Hg, P < 0.0001), rate-pressure product (8,712.40 ± 1,408.21-7,952.90 ± 782.72, P = 0.003), blood glucose concentration (6.06 ± 0.52-5.70 ± 0.52 mmol/L, P = 0.009), fat mass (21.53 ± 7.07-19.75 ± 6.40 kg, P = 0.001), percentage body fat (30.66% ± 5.08%-25.49% ± 9.89%, P = 0.026), body mass index (24.50 ± 3.85-24.27 ± 4.04 kg/m², P = 0.050), waist circumference (80.04 ± 8.57-73.19 ± 18.44 cm, P = 0.045), sum of skinfolds (22.91 ± 6.05-20.72 ± 5.26 mm, P < 0.0001), upper-body muscle strength (20.12 ± 5.65-23.77 ± 7.10 kg, P < 0.0001), and lower-body (16.28 ± 5.47-16.44 ± 5.62 kg, P = 0.001) muscle strength.

Conclusions: A 6-week hypertrophic RT program, performed even twice weekly, produces substantial simultaneous improvements in multiple anthropometric, cardiovascular, and muscle strength variables in postmenopausal women. This program can be recommended for inclusion in any exercise training regime or as an adjunct lifestyle approach in combination with other treatments in postmenopausal women.

Key Words: Exercise – Menopause – Strength training – Weight training.

The average age of occurrence of menopause is approximately 50 years in both European and US women.1-3 Menopause is defined as an age-related decrease of, or loss of, ovarian estrogen production and secretion, and signals the end of a woman’s reproductive potential. Consequently, menopause may induce a phase of decreased bone mineral density, cardiorespiratory fitness, and muscle strength, all of which increase the risk for the development of chronic diseases.4,5

Adults who do not perform regular resistance exercise lose approximately 0.46 kg of muscle mass per year from the age of 50 years. Furthermore, sedentary individuals can have a 50% reduction in type II muscle fibers, the fibers responsible for high levels of strength, by the age of 80 years.6 This age-related muscle loss and weakness is further exacerbated by a reduction of the sex hormone estrogen,7 with studies suggesting that the decreased muscular strength observed in women over the age of 50 years being related to the lack of estrogen resulting from menopause.7

The normal aging process also involves several additional changes in body composition, including a progressive reduction in connective tissue and fatty tissue replacement. These changes in body composition are compounded by increasingly reduced levels of habitual physical activity, and a reduced basal metabolic rate (due to muscle tissue loss), which further contributes to the worsening of cardiorespiratory fitness and quality of life.6

In postmenopausal women, the additional decline in estrogen levels leads to an even further and deleterious increase in total and abdominal fat, which is itself a risk factor not only for the development of a multitude of diseases, but also for the further development of obesity-associated insulin resistance.7 Even when controlling for age and body mass index (BMI), postmenopausal women, however, have been found to display a greater prevalence of abdominal obesity, elevated fasting glucose concentrations, and hypertension during the 10 to 14 years after menopause.1-3 These changes have resulted in postmenopause status becoming an independent risk factor for developing a multitude of chronic diseases, such as type II diabetes and dyslipidaemia.8

Research has previously shown that resistance training (RT) can safely and effectively be incorporated into training...
programs for older women.9 In this regard, RT is used by many populations as a method of inducing muscular strength, preventing injuries, and maintaining a healthy lifestyle.10 Studies have shown that RT performed three times a week may decrease the metabolic syndrome Z-score, with a decrease in fasting glucose, improvements in body composition and muscle strength.11 Resistance training has also been found to decrease total cholesterol (TC), low-density lipoprotein cholesterol, and non-high-density lipoprotein cholesterol concentrations.12,13 Despite aerobic training’s popularity, both aerobic and RT have been seen to diminish the risk factors for chronic diseases,14,15 although the latter is under-researched,16 especially in postmenopausal women. Although limited, research has demonstrated that RT may retard the development of sarcopenia, and increase mitochondrial capacity in postmenopausal muscle.17

In addition, although it is typically believed that high resistive loads are best to increase muscular strength and lower resistive loads are best to increase muscular endurance, it is this oversimplification of RT program design that has denigrated RT in its applications.18 This is because RT can take the guise of, inter alia, strength training, power training, hypertrophy training, and muscular strength training. As such, it is crucial for research to determine the efficacy of the different subtypes of RT as they may have different and unique impacts on health promotion in different populations.18 For this purpose, it is essential to determine if hypertrophy-specific RT will have a positive effect on anthropometric and cardiovascular parameters in an attempt to limit the expansion of lifestyle-related diseases in postmenopausal women at particular risk for developing such diseases.

METHODS

Participants and study design

A sample of 37 postmenopausal women, aged 50 to 79 years, was randomly assigned using a random numbers table to either a 6-week hypertrophy RT group (RTG) (n = 19) or a nonexercising control group (CON) (n = 18) to eliminate causal relationships19 (Table 1). Participants were recruited using flyers and posters that were distributed throughout the local community to sample from numerous geographical locations, socioeconomic statuses, and ethnicities in an attempt to increase ecological validity/generalizability. To ensure allocation concealment as to prevent the foreknowledge of group assignment, participants were informed privately of their group allocation subsequent to the completion of all evaluations. Furthermore, none of the RTG and CON participants interacted during the experimental period and were not evaluated on the same days to further conceal group assignments. Observer variation was accounted for by ensuring that all evaluations pre- and posttest were conducted by the same technician. In addition, all equipment was maintained and calibrated according to manufacturer guidelines.

The RTG participants engaged in two, nonconsecutive, 40-minute sessions weekly, whereas the CON participants were required to not participate in any structured exercise for the duration of the 6-week program. Participants from both groups were previously sedentary for 6 months, were advised to adhere to their normal dietary habits, and were required not to take any nutritional supplements that could have an influence on the tested variables. Postmenopause status was confirmed from the respective attending physician with the women having to be at least 12 months postmenopausal and continuously using or not using hormone therapy for more than 12 months. The onset of menopause was defined as the date of the last menstrual period with a serum follicle-stimulating hormone value more than 50 IU/L. Any participants that did not meet these criteria were excluded from participation in the study. Before participation in the study, all women provided written informed consent, and underwent a screening history and physical examination. The present study was approved by the Institutional Review Board at the University of Johannesburg, South Africa (REC-01-177-2015) and was conducted in the spirit of the Declaration of Helsinki. All participants underwent an identical battery of tests before and after the 6-week intervention period. All participants were evaluated by the same technician in the postabsorptive state after an 8-hour fasting period before all testing procedures.

### Cardiovascular measures

Resting blood pressure (RBP) and resting heart rate (RHR) were measured in a seated position after a 5-minute rest with the ausculatory method, according to the standards established by the American College of Sports Medicine, using a sphygmomanometer and stethoscope.20 Each participant’s RHR was measured in a seated position by means of a telemetry strap placed around the waist and linked to HR monitor providing the measurement in beats per minute (bpm).20 In addition to each participant’s RBP and RHR, these parameters were used to calculate resting rate-pressure product (RRPP). RRPP was calculated as the product of RHR and resting systolic blood pressure (RSBP).20 Capillary finger prick blood glucose concentration and TC were sampled pre- and posttest after an 8-hour fast and analyzed as per the Reflotron system (Roche Products Pty Ltd, Randburg, South Africa) requirements. The Reflotron system uses a within-series precision with an SD of less than 0.2% reflectance. The electronics of the Reflotron system ensured, by a compensation procedure, that mains-frequency synchronous or persistent interference such as extraneous light or zero currents and ultrasound or diathermy equipment (≥2 metres away) did not influence the tests. A measurement accuracy of ±0.5% was achieved.

### Table 1. Baseline participant characteristics

<table>
<thead>
<tr>
<th></th>
<th>Resistance training group (RTG) (n = 19)</th>
<th>Nonexercising control group (CON) (n = 18)</th>
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<tbody>
<tr>
<td>Age, y</td>
<td>60.44 ± 5.34</td>
<td>57.74 ± 2.83</td>
</tr>
<tr>
<td>Body mass, kg</td>
<td>67.78 ± 11.77</td>
<td>68.64 ± 8.16</td>
</tr>
<tr>
<td>BMI, kg/m²</td>
<td>26.11 ± 3.14</td>
<td>24.50 ± 3.85</td>
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</table>

Values are means ± SD. BMI, body mass index.
reflectance was attained with the Reflotron system. A reference procedure used by the Reflotron system eliminated errors caused by differing component tolerances or aging. The Reflotron system uses strictly selected light-emitting diodes with wavelengths centered on 567, 642, and 951 nm serving as light sources. The Reflotron system controlled all functions of the test such as the performance of the test, temperature control, automatic calibration, and evaluation of the reflectance measurements, including calculation of the result of a fully automated microprocessor-controlled reflectance photometer. The reliability of the tests has previously been confirmed.21 Cardiorespiratory evaluations (VO2max) were measured using the 6-minute walk test.20 Participants were required to walk for 6 minutes as fast as possible on a level surface, and their HR recorded once the 6 minutes had expired. VO2max was then calculated by using the regression equation: VO2max (0.02 \times \text{distance [m]} - (0.19 \times \text{age [y]}) - (0.07 \times \text{body mass [kg]}) + (0.09 \times \text{stature [cm]}) + (0.26 \times \text{RRPP [x \times 10^{-5}]})) + 2.45.20

**Anthropometric measures**

Measurements of body mass (BM) in kilograms, stature in meters, waist circumference (WC) in centimeters, hip circumference (HC) in centimeters, and sum of skinfolds (SKF) in millimeters were carried out according to the methods proposed by the International Society for the Advancement of Kinanthropometry.22 BM was measured in kilograms on a calibrated medical scale (Trojan, BSA16056v, Duteck Industrial Co. Ltd, Taiwan), whereas stature was measured to the nearest millimeter, using a standardized stadiometer (Seca Stadiometer, 216, Seca). Participants were required to wear minimal clothing and no shoes, whereas the same technician completed these tests. BMI was calculated by dividing the participant’s BM (kg) by stature squared (m²), and expressed as kilograms per square meter (kg/m²).23 WC measurements were measured to the nearest millimeter using a nondistensible measuring tape (MyoTape Body Tape Measure, Accufit). These measurements were taken at the narrowest part of the abdomen: above the umbilicus and below the xiphoid process.24 HC measurements were taken at the maximal circumference of buttocks and were measured to the nearest centimeter using a nondistensible measuring tape (MyoTape Body Tape Measure, Accufit). Waist-to-hip ratio (WHR) was determined by dividing the WC by the HC (WC [cm] divided by HC [cm]).23 To calculate the SKF, skinfold (triceps, biceps, subscapular, supra-iliac, abdomen, anterior thigh, chest, and midaxillary) measurements were taken on the right side of the body using a Harpenden skinfold calliper (Harpenden, HSB-BI, ATICO Medical Pvt. Ltd, United Kingdom).25 Percentage body fat (PBF) was calculated from information obtained from seven skinfold measurements by using the following equation: Body density (Db) (g/cc) = 1.097 – 0.00046971 (sum of seven skinfolds in millimeters [Σ]) + 0.00000056 (Σ)² – 0.0012828 (age).20 Fat mass (FM) was calculated by multiplying BM by fat percentage, and was divided by 100 to get a percentage (BM multiplied by [fat percentage divided by 100]), whereas lean mass (LM) was calculated by subtracting the FM from the BM.23

**Muscle strength measures**

Muscular strength measurements were obtained by the 4 to 6 repetitions maximum (RM) submaximal strength test for the upper and lower body. The following equation was used to calculate the final results: 24.62 + (1.12 × BM) + (5.09 × number of repetitions). Upper-body muscular strength was determined by performing shoulder presses, whereas lower-body muscular strength was determined by performing a standard leg press.

**Treatment protocol**

Participants in the RTG participated in two, nonconsecutive, 40-minute hypertrophy-specific RT sessions each week for 6 weeks. All sessions commenced with a 5-minute warm-up of walking (HR < 100 bpm), followed by mobility exercises including arm circles, shoulder rotations, and hip circles completed for three sets at 10 repetitions.26 The RTG participants used 3 sets of 12 repetitions at 67% to 85% 1-RM for dumbbell presses, machine lateral rows, machine latissimus dorsi pulldowns, abdominal curls, dumbbell pelvic lifts, machine leg presses, barbell squats, machine hip adduction, machine hip abduction, and machine standing calf raises, with 30 to 90 seconds rest allowed between each set.27 The training program was concluded by completing a cool-down, which included a 5-minute walk (HR < 100 bpm), followed by stretching of the biceps, shoulder, quadriceps, and calves for two sets held for 10 seconds on both sides.26 The CON were instructed not to engage in any structured physical activity and maintain their normal activity during the 6-week period.

**Statistical procedure**

Data were analyzed using commercial software (Statistical Package for Social Sciences Version 20, Chicago, IL). Standard statistical methods were used for the calculation of the means and SDs. Heterogeneity or homogeneity was determined using independent t tests at pretest, whereas pre- and posttest comparisons within groups were performed using paired t tests. Alpha levels were set at P ≤ 0.05 for establishing statistical significance.

**RESULTS**

After randomization, the RTG and CON were found to be homogenous at pretest in terms of their RHR (P = 0.535), RSBP (P = 0.461), resting diastolic blood pressure (RDBP) (P = 0.610), RRPP (P = 0.659), blood glucose concentration (P = 0.021), TC (P = 0.889), BM (P = 0.792), BMI (P = 0.158), WC (P = 0.364), HC (P = 0.141), WHR (P = 0.286), LM (P = 0.591), FM (P = 0.856), PBF (P = 0.706), and \(\sum\text{SKF} = 0.882\), but were heterogeneous for VO2max \(P = 0.008\) with the RTG beginning the study with significantly \(P \leq 0.05\) greater mean VO2max levels (Table 2).
TABLE 2. Effect of hypertrophic resistance training on anthropometric and cardiovascular measures in postmenopausal women

<table>
<thead>
<tr>
<th></th>
<th>Resistance training group (RTG) (n = 19)</th>
<th>Nonexercising control group (CON) (n = 18)</th>
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<tbody>
<tr>
<td>Cardiovascular measures</td>
<td>Pretest</td>
<td>Posttest</td>
</tr>
<tr>
<td>RHR, bpm</td>
<td>69.05 ± 11.19</td>
<td>63.80 ± 4.94a</td>
</tr>
<tr>
<td>RSBP, mm Hg</td>
<td>125.85 ± 4.86</td>
<td>124.05 ± 3.98a</td>
</tr>
<tr>
<td>RDBP, mm Hg</td>
<td>81.20 ± 7.50</td>
<td>77.90 ± 6.85a</td>
</tr>
<tr>
<td>RRPP</td>
<td>8,712.40 ± 1,408.21</td>
<td>7,952.90 ± 782.72</td>
</tr>
<tr>
<td>Glucose, mmol/L⁻¹</td>
<td>6.06 ± 0.52</td>
<td>5.70 ± 0.52a</td>
</tr>
<tr>
<td>TC, mmol/L</td>
<td>5.55 ± 0.91</td>
<td>5.64 ± 0.10</td>
</tr>
<tr>
<td>V02max, mL/(kg·min)</td>
<td>16.14 ± 2.83</td>
<td>16.83 ± 2.81</td>
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<tr>
<td>Anthropometric measures</td>
<td></td>
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</tr>
<tr>
<td>BM, kg</td>
<td>67.78 ± 11.77</td>
<td>67.395 ± 12.02</td>
</tr>
<tr>
<td>BMI, kg/m²</td>
<td>24.50 ± 3.85</td>
<td>24.27 ± 4.04a</td>
</tr>
<tr>
<td>WC, cm</td>
<td>80.04 ± 8.57</td>
<td>73.19 ± 18.44a</td>
</tr>
<tr>
<td>HC, cm</td>
<td>101.24 ± 11.55</td>
<td>94.42 ± 26.24</td>
</tr>
<tr>
<td>WHR</td>
<td>0.80 ± 0.04</td>
<td>0.77 ± 0.05</td>
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<tr>
<td>LM, kg</td>
<td>46.55 ± 5.72</td>
<td>47.70 ± 6.58</td>
</tr>
<tr>
<td>PBF, %</td>
<td>34.66 ± 5.08</td>
<td>25.49 ± 9.89a</td>
</tr>
<tr>
<td>∑SKF, mm</td>
<td>22.91 ± 6.05</td>
<td>20.72 ± 5.26a</td>
</tr>
<tr>
<td>Muscular strength measures</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upper-body 1-RM, kg</td>
<td>20.12 ± 5.65</td>
<td>23.77 ± 7.10a</td>
</tr>
<tr>
<td>Lower-body 1-RM, kg</td>
<td>16.28 ± 5.47</td>
<td>16.44 ± 5.62a</td>
</tr>
</tbody>
</table>

Values are means ± SD.

∑SKF, sum of skinfolds; 1-RM, one-repetition maximum; BM, body mass; BMI, body mass index; bpm, beats per minute; FM, fat mass; HC, hip circumference; LM, lean mass; PBF, percentage body fat; RDBP, resting diastolic blood pressure; RHR, resting heart rate; RRPP, resting rate-pressure product; RSBP, resting systolic blood pressure; TC, total cholesterol; V02max, cardiorespiratory fitness; WC, waist circumference; WHR, waist-to-hip ratio.

aP < 0.05 within-group compared with pretest.
bP < 0.05 RTG difference compared with CON.

Cardiovascular measures

Six weeks of hypertrophy RT resulted in significant (P < 0.05) changes in RHR (P = 0.017), RSBP (P < 0.001), RDBP (P < 0.001), RRPP (P = 0.003), and blood glucose concentration (P = 0.009). No significant changes were, however, observed in TC (P = 0.554) and V02max (P = 0.145). The CON were found to have no significant alterations in RHR (P = 0.601), RSBP (P = 0.578), RDBP (P = 0.716), RRPP (P = 0.750), blood glucose concentration (P = 0.711), TC (P = 0.165), and V02max (P = 0.626).

Anthropometric measures

After the 6-week intervention, the RTG were found to have significant (P < 0.05) changes in WC (P = 0.045), FM (P = 0.001), PBF (P = 0.026), BMI (P = 0.050), ∑SKF (P = 0.0001) from pre- to posttest. No significant changes were, however, observed in BM (P = 0.151), HC (P = 0.225), WHR (P = 0.066), and LM (P = 0.106). In turn, the CON were found to have no significant alterations in BM (P = 0.776), BMI (P = 0.946), WC (P = 0.285), HC (P = 0.235), WHR (P = 0.781), LM (P = 0.342), FM (P = 0.858), PBF (P = 0.128), and ∑SKF (P < 0.0001) from pre- to posttest.

Muscular strength measures

Six weeks of hypertrophy RT resulted in significant (P < 0.05) changes in upper-body 1-RM (P < 0.0001) and lower-body 1-RM (P = 0.001). In turn, the CON were found to have no significant alterations in upper-body 1-RM (P = 0.038) and lower-body 1-RM (P = 0.406).

DISCUSSION

Menopause induces several deleterious changes in physical fitness. Such changes include decreased cardiorespiratory fitness, decreased muscular strength, and altered body composition characterized by decreased bone mineral density, decreased LM, increased total and abdominal fat, and reduced LM, all of which increase the risk for the development of chronic diseases.\(^4\)\(^5\) As such, there is a dire need to halt or even reverse these negative changes in postmenopausal women using scientifically proven population/condition-specific exercise regimes. In this regard, research in this area has often focused on aerobic modalities of exercise training; however, RT may have a wealth of unique benefits over those of aerobic training, such as an increased strength and LM,\(^1\)\(^9\) that at least warrants its inclusion in any exercise regime for postmenopausal women. Research has shown that RT can safely be incorporated into exercise programs and nonpharmacological treatment regimens for older women,\(^2\) and this mode of training is already used in many populations as a method of increasing muscular strength, preventing injuries, and maintaining a healthy lifestyle.\(^1\)\(^9\) Because several subtypes of RT exist, each with their own potential impacts on health and specifically anthropometric and cardiovascular parameters, it is, however, crucial for research to determine the efficacy of each of the subtypes of RT on health promotion in different populations in an attempt to limit the expansion of lifestyle-related diseases.

For this purpose, this randomized controlled trial investigated the impact of 6 weeks of two, hypertrophy-specific,
WEIGHT TRAINING IN POSTMENOPAUSAL WOMEN

nonconsecutive, whole-body, 40-minute sessions weekly using three sets of 12 repetitions at 67% to 85% 1-RM for dumbbell presses, lateral rows, lattissimus dorsi pulldowns, curl-ups, pelvic lifts, leg presses, squats, hip adduction, hip abduction, and calf raises in previously sedentary postmenopausal women. The present study demonstrated that a 6-week hypertrophy RT program not only improved five of the nine measured anthropometric measures (ie, FM, PBF, BMI, WC, and SKF), but also resulted in improvements in five of the seven measured cardiovascular measures (ie, RHR, RSBP, RDBP, RRPP, and fasting blood glucose concentration) in postmenopausal women. Regarding cardiovascular measures, the positive changes in RHR, RSBP, RDBP, RRPP, and fasting blood glucose concentration in postmenopausal women after RT are previously supported in literature using elastic bands and aquatic RT, but not in postmenopausal women after 8 weeks of 3 days weekly RT consisting of three sets of eight repetitions at 80% of 10RM of leg press, bench press, knee extension, knee flexion, and lattissimus dorsi pulldowns. Although the mechanism explaining RT’s effect on cardiovascular measures is generally unknown, resistance exercise may have an influence in decreasing blood pressure by causing vascular remodeling, altering sympathetic nerve activity, and decreasing the sensitivity of blood vessels to vasoconstrictor endothelin. Even though the present study and that of previous studies found favorable changes in blood glucose concentrations in postmenopausal women after a period of RT, our study showed no change in cholesterol concentrations which is similar to previous studies examining the effects of RT in postmenopausal women. These findings add to the variable RT responses in blood chemistry parameters found previously in literature that confirms that there is no definitive RT regime that will consistently yield definitive changes in specific blood chemistry measures.

Although the present study failed to elicit significant changes in cardiorespiratory fitness, the results of this study and those of previous studies suppose that the volume of the RT protocol used largely determines whether or not a significant change occurs in cardiorespiratory fitness. This is because previous studies using longer program durations, such as the 24-week study of Brentano et al and 3-month study of Pollock et al, have found significant improvements in cardiorespiratory fitness after RT in postmenopausal women. It is unequivocal that aerobic modes of training are superior to those of resistance modes of exercise at improving cardiorespiratory fitness, however RT can in some instances, but not in this study, improve cardiorespiratory fitness as a result of increased maximal voluntary contraction of the skeletal muscles after RT, and the decreased need for an increased effort for the same workload for a specific activity.

An increased total fatness, and especially abdominal fat deposition, is associated with a greater risk for a variety of health problems and metabolic disturbances. Although it is commonly accepted that aerobic training induces alterations in total adiposity, RT may have other advantages on body fat distribution. Importantly, the present study demonstrated improvements in measures of total adiposity (ie, FM, PBF, BMI, and SKF) and abdominal adiposity (ie, WC). Similar findings of decreases in FM have previously been found in postmenopausal women, after 1-year of RT at six to eight repetitions at 70% to 80% 1-RM, three times weekly. In that study, not the present, postmenopausal women were, however, found to have an increased lean soft tissue. As the intensity of that study and the present was similar (70%-80% 1-RM vs 67%-85% 1-RM, respectively), as were the type and number of exercises (8 whole body exercises vs 10 whole body exercises, respectively), these contradictory findings may indicate that exercise duration (60-75 min/d vs 40 min/d, respectively), program duration (1-y vs 6 wk, respectively), and/or frequency (three times weekly vs two times weekly, respectively) may prove essential to increase LM in this population. Further evidence that the optimal RT prescription may require longer program duration is the previous finding that 24 weeks of RT using aquatic RT or elastic bands resulted in significant decreases in FM, LM, BMI, and WC, whereas an 8-week study failed to alter BM, WHR, BMI, and PBF. The decrease in BMI in the present study is significant in that an increased BMI is associated with numerous health problems and is predictive of an increased risk of cardiovascular disease and other chronic diseases. This increased risk arising from BMI then exponentially increases the risk of developing such diseases in postmenopausal women already at risk. Although not the case in this study, it is, however, important to note that BMI and BM as an indirect measure of body fatness should be used with caution in individuals engaging in RT, especially hypertrophic RT programs. This is because the hypertrophy that is common after this mode of training often arises due to an increase LM, and not FM, may result in an unchanged, an even and increased BM and/or BMI.

CONCLUSIONS

The hypertrophic RT program used in this study produced significant improvements in five of the seven measured cardiovascular measures (ie, RHR, RSBP, RDBP, RRPP, and fasting blood glucose concentration), five of the nine measured anthropometric measures (ie, FM, PBF, BMI, WC, and SKF) and upper- and lower-body muscle strength simultaneously in postmenopausal women, but failed to produce significant changes in TC, cardiorespiratory fitness, BM, HC, WHR, and LM. Therefore, we conclude that a short-duration hypertrophic RT program performed even twice weekly can be recommended to be included in any exercise training regime or solely as an adjunct lifestyle approach either in the initial stages of a progressive RT program or in combination with other treatments in postmenopausal women. Findings of these and previous studies suggest that a longer duration (in terms of session and/or program) and/or more frequent RT (days/week) and/or other subtypes of RT (ie, strength, power, and/or muscular endurance) may be required to evoke significant additional changes in TC, \( VO_{2}\text{max} \), BM, HC, WHR, and LM.

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REFERENCES


