2020, Volume 3 (Issue 4): 19 OPEN ACCESS

The Effects of a Six-Week Weight Loss Program on Body Composition and Muscular Strength and Endurance

Research Brief

Paul Stickles[1], Jamie M. Blose[1], Antonia Battaglino[1], Alexis Trumbetti[1], Jared James[1], Katie Cooper[1], Anna Schade[1], Melissa Reed, PhD[1], Selen Razon, PhD[1], Melissa A. Whidden, PhD[1]

[1]Department of Kinesiology, West Chester University, West Chester, PA USA

Abstract

Introduction: The purpose of this study was to investigate body composition and muscular strength and endurance adaptations with a six-week weight loss program.

Methods: Body fat, fat-free mass, waist and hip circumferences, resting metabolic rate, and muscular fitness were assessed before and after the six-week program in 40 middle-aged women.

Results: There was a significant reduction in body fat ($P < 0.001$) and waist and hip circumferences ($P < 0.01$) while there was an increase in fat-free mass ($P < 0.001$). There was a significant improvement in muscular strength in all muscle groups examined ($P < 0.01$) and an improvement in muscular endurance in forearm plank hold and wall taps for time. Resting metabolic rate did not change after the six-week weight loss program.

Conclusions: This weight loss program was effective in improving body composition while improving muscular strength and endurance. However, this combination of diet, exercise, and water consumption was not effective in changing resting metabolic rate. This study contributes to the necessity to create an exercise and diet program of optimal duration and intensity that is effective in altering body composition and improving muscular fitness while improving resting metabolic rate for the long-term maintenance of optimal body weight.

Key Words: Body Composition, Strength, Resting Metabolic Rate

Corresponding author: Melissa A. Whidden, mwhidden@wcupa.edu

Published December 9, 2020

Introduction

Obesity is escalating in the United States, as 42.5% of adults are obese[6]. The comorbidities and lingering conditions associated with obesity include but are not limited to, heart disease, stroke, type 2 diabetes, and cancer[6]. To evade these health problems and comorbidities, weight loss is crucial for individuals who carry excess weight. Exercise training and a balanced, healthy diet are essential factors of living a healthy lifestyle. Cardiovascular, skeletal muscle, and body composition changes are some of the countless adaptations linked with physical activity and healthy nutrition[16]. To encourage optimal body weight, group weight loss programs are becoming more popular due to their structured nature, as well as the sense of community and support that they provide. While some group weight loss programs are successful, others are not. It is important to determine the ideal qualities of a group weight loss program that result in successful weight loss but that also elicit other health benefits.

While body mass index (BMI) is a tool used by numerous fitness centers and gyms to track the weight status of their members and screen for potential weight problems, the measurement has numerous limitations. BMI does not consider age, sex, bone structure, or fat distribution and often, someone is misclassified as being overweight or obese[15]. Within a weight-loss program, it is important to measure

total body weight loss but body composition should never be ignored. The measurement of body fat percentage is a clearer indication of physical fitness because no matter how much someone weighs, a higher percentage of body fat results in a higher risk of developing obesity-related diseases[9]. Integrating both cardiovascular and resistance exercise into daily schedules while maintaining a healthy diet are some of the most effective ways to lose weight. Aerobic exercise stimulates the cardiovascular and pulmonary systems and results in improvements in heart and lung functioning as well as circulation[16]. Furthermore, cardiovascular exercise performed at 50% of VO_{2max} for 30 minutes or more is the best prescription for burning fat[16]. On the other hand, resistance training is beneficial for weight loss in that high-resistance weight training stimulates an increase in lean muscle mass[12]. An increase in lean muscle mass produces an increase in resting metabolic rate (RMR) or the number of calories burned at rest[5]. It has been shown that individuals with a higher percent of fat-free mass have a higher RMR and are able to maintain optimal body weight more efficiently than someone with a lower RMR[3]. Lastly, including a hypocaloric diet into an exercise program also contributes to weight loss due to the lack of consumed calories. The combination of both types of exercise and a hypocaloric diet increases health, fitness, and overall well-being.

The purpose of this study was to determine if a short-term, weight loss driven exercise program would improve measures of physical health beyond a reduction in total body weight. We examined a local gyms six-week 20-pound weight loss challenge to determine if the program was successful in improving body composition, resting metabolic rate, and muscular fitness in overweight, sedentary middle-aged women. We hypothesized that the six-week weight loss program would result in significant decreases in waist and hip circumferences and improve muscular strength and endurance but would not significantly change body fat percent, fat-free mass, or resting metabolic rate. The results of this study will further supplement the current literature by providing information about the health-related benefits of a short duration weight-loss program.

Methods

Participants

Forty female subjects (age 39.43 $\pm$ 10.4 years) from a local gym across six different six-week weight loss challenges spanning an entire year were included in this study. Each subject was required to meet all the inclusion criteria to be eligible to participate in this study. Subjects had to be over the age of 18 and had to complete all the prerequisite requirements of the local gym that sponsored this weight loss challenge. Women with a history of myocardial infarction or known cardiovascular disease were excluded from this study. If data that was collected prior to the six-week challenge appeared to present a risk factor for cardiovascular or metabolic disease, the subject was notified for their decision to continue or discontinue the six-week program at their own discretion. Data collection occurred pre- and post-six-week weight loss program. This study was conducted in compliance with the federal requirements for protection of human subjects and with the approval of West Chester University Institutional Review Board.

Six-Week Challenge Orientation

Prior to each six-week challenge, subjects were recruited via social media by a local gym to participate in a 20-pound weight loss program. Interested participants were asked to report to the gym two weeks prior to the start of each challenge for orientation. At orientation, details surrounding the weight-loss challenge, including food and water consumption and exercise expectations, were presented to the participants. Participants were encouraged to purchase a fitness tracker that measured heart rate so that exercise intensity could be monitored at class. At orientation, participants were also required to pay for the six-week program up front. If the participants attended 30 workouts over the six weeks, adhered to the diet, and successfully lost 20 pounds, then they would receive all their money back at the end of the challenge. Our research team attended every orientation to recruit subjects for our study. The subjects we recruited were required to report to our laboratory the weekend before their six-week challenge began so we could collect pre-program measurements. Our subjects were also asked to report back to our lab the day of their weigh-out by the local gym for post-program measurements.

Exercise Protocol

The exercise program took place at the local gym and was run entirely by coaches who were certified by the American Council on Exercise (ACE). A member of our research team was present at each workout but was only there to observe. Subjects were required to participate in five 50 minute workouts per week

for six weeks (30 workouts). If a subject missed a workout, they were excluded from our study. The local gym confirmed all 30 workouts for our subjects at the end of the six-week program. The workouts were moderate-to-high intensity, boot camp style sessions. Coaches continually monitored participants and knew when to push the participants harder in class as their heart rates were projected on TV monitors in the gym. Subjects chose from two upper body, two lower body, and two whole body workouts that were available weekly. Each workout began with a five-minute dynamic stretching warm-up. Upon completion, subjects then completed three moderate-to-high intensity circuits consisting of dumbbell, suspension training, and body weight exercises. Total physical movement of our subjects during each workout averaged around 35 minutes as some portion of each workout included coach demonstration and explanation of the exercises. During this time, the subjects were stationary. The difficulty of the program increased weekly; therefore, the structure and theme of the weekly workouts changed accordingly. The following is the workout schedule that was used for the circuits within the program: week 1: 3 rounds/1 minute, week 2: 4 rounds/45 seconds, week 3: 8 rounds/20 seconds, week 4: ladders, week 5: every minute on the minute, and week 6: as many repetitions, as possible. Each workout ended with a cool down. Subjects were encouraged to regularly check in and post on social media to boost morale and interact with other participants of the weight-loss challenge.

Diet Protocol

In addition to the exercise program, subjects were to follow a structured, calorie restrictive diet plan. The local gym provided participants with a list of approved proteins, carbohydrates, and vegetables to eat at orientation (Table 1). The participants were required to eat five to six meals per day and breakfast, lunch, and dinner had to include a protein, carbohydrate, and vegetable from the list. The other two to three snacks throughout the day were required to consist of only protein; a protein shake or protein snack. Participants were instructed to eat every two to three hours. The local gym strongly encouraged participants to keep a diet log for at least 1 week of the challenge, so that if problems arose with a lack of weight loss, coaches could adjust the participant's meal time consumption or suggest different options from the list. Our research team did not analyze the logs. Participant condiment usage was limited and they were instructed to drink a gallon of water per day.

Table 1: Approved Proteins, Carbohydrates, and Vegetables for the 6-Week Weight Loss Program

Protein	Carbohydrates	Vegetables
Eggs or Egg Substitute	Oatmeal	Broccoli
Chicken Breast	Quinoa	Brussel Sprouts
Turkey Breast	Brown Rice	Spinach
Tilapia	Sweet Potato	Kale
Halibut	Baked Potato	Celery
Buffalo	Ezekiel bread	Cucumber
Swordfish	Blackberries	Green Beans
Salmon	Raspberries	Cauliflower
Low-fat Cottage Cheese	Blueberries	Peppers
Crab	Strawberries	Mushrooms
Lobster	Yam	Lettuce
1% Lean Ground Turkey		Tomato
Tuna		Artichoke
Orange Roughly		Zucchini
Top Round Steak		Asparagus
Shrimp		
Top Sirloin Steak		
7% Lean Ground Beef		

Experimental Measures and Materials

Subjects were asked to fast overnight prior to pre- and post-program data collection sessions. After our subjects arrived at our lab, they were asked to sit quietly in an upright seated position for five minutes. RMR was then measured. Subjects were asked to breathe normally into a MedGem calorimeter (Microlife Medical Home Solutions, Inc., Golden, CO) for about ten minutes to determine the number of calories

burned at rest. Following RMR measurements, body composition was assessed. Waist and hip circumferences were measured via tape measure and recorded in inches. For the waist measurement, the tape measure was placed at the narrowest part of the waist just above the belly button and for the hip measurement, the tape measure was placed around the largest part of the hips or the widest part of the buttock. The same member of our research team measured all circumferences pre- and post-program to minimize variability. Height was measured via a stadiometer and weight was measured via a calibrated scale connected to the Bod Pod (COSMED USA, Inc., Chicago, IL). The Bod Pod was used to measure body composition via air displacement to differentiate between fat mass (BF%) and fat-free mass (FF%). Subjects wore skin-tight clothing, swim caps, and removed all jewelry before entering the Bod Pod. They sat in the Bod Pod as still as possible for about one minute while data was collected. A second measurement was conducted to ensure that the results were reliable. If the results of both trials differed greatly, a third trial in the Bod Pod was completed. Subjects then relocated to the fitness center in our facility so we could measure muscular strength and endurance. For pre-program measurements, a member of our research team clearly explained and demonstrated each exercise as our subjects were primarily sedentary and novice to resistance exercise training. The maximum amount of weight that each subject could lift for six repetitions was recorded for bicep curls, shoulder press, back squat, and Romanian dead lift. The same member of our research team measured muscular strength pre- and post-program to minimize variability. All subjects reached 6-RM within 3 trials with at least 2 minutes of rest in between each attempt. To test muscular endurance, four different exercises were completed for maximum time. These exercises included a forearm plank, six inches, high knees, and wall taps. Again, the same member of our research team measured muscular endurance pre- and post- program to minimize variability. They also clearly explained and demonstrated each exercise at the pre-program data collection as our subjects were novice to resistance exercise. All subjects were verbally encouraged during their tests. Subjects were given three minutes of rest in between each muscular endurance test. Upon completion of the data collection, subjects began their six-week weight loss program the next day. They returned to our lab after six weeks and followed the same procedures in the same order to collect post-program measurements.

Statistical Analysis

The average results of body composition, RMR, and muscular fitness across all six cohorts were calculated. Data is presented as means ± SEM. Paired t-tests were used to analyze differences between pre- and post-program measurements. Statistical significance was set at $P \leq 0.05$. Analyses were performed with the use of SPSS (version 25).

Results

Participant Characteristics

Six different cohorts of subjects completed the six-week challenge. Forty subjects out of 58 recruited completed the program as well as returned to West Chester University for post-program measurements. 9 subjects came from the February to April six-week challenge (22.5%), 10 subjects came from the April to June six-week challenge (25%), 5 subjects came from the June to July six-week challenge (12.5%), 7 subjects came from the July to September six-week challenge (17.5%), 4 subjects came from the September to October six-week challenge (10%), and 5 subjects came from the November to December six-week challenge (12.5%). BMI was analyzed in these subjects in a previous study and 87.5% of the subjects had a BMI greater than 24.9 and were classified as overweight, obese, or extremely obese prior to the 6-week program[4]. BMI values significantly decreased from 32.6 ± 1.1 pre-program to 31.1 ± 1.0 post program ($P < 0.01$)[4].

Body Composition Measurements

Total body weight (Pre: 192.2 ± 7.1 lbs., Post: 183.3 ± 6.6 lbs.; $P < 0.001$) and body fat percent (Pre: 39.0 ± 1.3%, Post: 36.6 ± 1.3%; $P < 0.001$) significantly decreased as percent fat-free mass (Pre: 61.0 ± 1.3%, Post: 63.4 ± 1.3%; $P < 0.001$) significantly increased. On average, our subjects lost 6.3% of their body fat and gained 3.9% fat-free mass. Resting metabolic rate (Pre: 1582.5 ± 48.8 kcal/day, Post: 1545.5 ± 42.8 kcal/day; $P = 0.36$) did not differ over the course of the six-week weight loss program.

Anthropometric Measurements

Waist circumference (Pre: 35.2 ± 0.9 in, Post: 34.1 ± 0.8 in; $P < 0.01$) and hip circumference (Pre: 45.0 ± 0.9 in, Post: 43.5 ± 0.9 in; $P < 0.001$) significantly decreased over the course of the six-week weight loss program. On average, our subjects lost 1 inch off their waist and hips.

Muscular Strength

Table 2 provides average muscular strength measurements for subjects from pre- to post-6-week weight loss program. Average 6-RM weight lifted in all four chosen exercises significantly increased following the 6-week weight loss program. 6-RM strength increased by 11.8% for shoulder press, 12.5% for bicep curls, 22.2% for back squat, and 17.4% for Romanian dead lift.

Table 2: 6-Repetition Maximum Weight Lifted Pre- and Post-6 Week Program

6-RM (lbs.)	Pre-Program	Post-Program	Significance
Shoulder Press	32 ± 1.7	36 ± 1.8	0.0003*
Bicep Curls	30 ± 1.3	34 ± 1.6	0.0006*
Back Squat	56 ± 6.3	70 ± 6.9	0.002*
Romanian Dead Lift	63 ± 6.2	75 ± 7.0	0.003*

Data are Means (rounded to the nearest whole number) ± SEM. * Indicates a significant increase from pre-program value ($P < 0.01$).

Muscular Endurance

Muscular endurance measures as represented by time to failure in seconds are shown in Table 3. No significant changes were seen in time to failure when our subjects performed six inches ($P = 0.35$) and high knees ($P = 0.20$). However, muscular endurance was significantly improved when our subjects performed forearm plank and wall taps, both performed until failure and measured in seconds.

Table 3: Muscular Endurance Values Pre- and Post-6 Week Program

Time to Failure (secs)	Pre-Program	Post-Program	Significance
Forearm plank	72 ± 5.5	90 ± 6.2	0.0000*
Six inches	70 ± 5.7	75 ± 5.4	0.35
High Knees	29 ± 2.3	31 ± 2.4	0.20
Wall Taps	17 ± 1.7	21 ± 2.0	0.005*

Data are Means (rounded to the nearest whole number) ± SEM. * Indicates a significant increase from pre-program value ($P < 0.01$).

Discussion

Main Findings

We hypothesized that this six-week weight loss challenge would result in changes in anthropometric measures and muscular fitness. Specifically, we expected to see a significant decrease in waist and hip circumference and an increase in muscular strength and endurance across different muscle groups. We did not expect to see significant improvements in body fat percent, fat-free mass percent, or RMR. This study is different than previously published literature, for it studied the physiological effects of a program prescribed to individuals looking to only lose total body weight by combining increased water consumption, daily caloric deficits, and short-duration exercise training. Our hypotheses were supported, as anthropometric measurements and muscular fitness improved significantly from pre- to post-six-week weight loss program.

Body Composition

According to ACSM, a body fat percentage for females above 32% is considered overweight[2]. A higher body fat percentage is correlated with an increased risk for metabolic and cardiovascular disease[2]. For females who carry excess weight, the first step to decrease their risk for comorbidities associated with obesity would be to lose weight. In this study, the female subjects were classified as overweight as their pre-program measurement for percent body fat was 39%. But losing weight is not easy, it requires commitment to a healthy diet and the time and motivation to exercise. Was this specific weight loss

program, that focused only on losing total body weight and financially driven, enough to change body composition in previously sedentary women? Surprisingly, body weight and percent body fat decreased as the percent of fat-free mass increased over the course of the 6-week weight loss program. The six-week weight loss program did more than help our female subjects lose total body weight, the program was sufficient to decrease body fat percent by 6.3%. This agrees with previous research in which hypocaloric dieting combined with increased water consumption and short-duration exercise training promoted weight loss[1,8]. Given that the exercises performed in this program were based heavily on body weight and/or low-resistance weight exercises, we did not expect to see a significant decrease in percent body fat and subsequent increase in fat-free mass in these subjects. We initially believed that the weight loss would primarily be due to a decrease in total body water versus a decrease in fat mass. While it has been shown that moderate cardiovascular exercise (50% of VO_{2max}) for at least 30 minutes is the most efficient for burning fat[16], the subjects in this study performed more resistance training exercises versus cardiovascular based exercises. Furthermore, upon closer examination of the workouts, coaches provided plenty of rest time in between each circuit to allow subjects to recover and listen to them explain and demonstrate the next set of exercises for the following circuit. So, when scrutinized further, the subjects in this study accumulated only 35 minutes of physical movement during each workout rather than a total of 50 minutes. With the lack of sustained cardiovascular exercise for 30 minutes of more within this exercise program, we believe that the hypocaloric diet was the primary contributing factor to the decrease in percent body fat. While this program was effective in improving body composition in a short time span, further research needs to be performed to see if this specific diet is sustainable for a long time as hypocaloric diets have been shown to be difficult maintain[10]. Furthermore, research needs to examine if continued adherence to this specific diet and exercise plan will continue to promote weight loss and improved body composition changes over time.

Anthropometric Measures

According to ACSM, a waist circumference above 35 inches for a female is considered overweight[2]. Again, the first step in preventing early death from diseases associated with obesity is weight loss. Our female subjects were classified as overweight prior to the six-week program as their pre-program waist circumference was 35.2 inches. Following the six-weight program, the female subjects lost 1 inch off their waist and their hips. The significant changes in anthropometric measurements are in accordance with research done by Kang et al. (2016) that found significant changes in body weight, body fat percentage, and waist circumferences after a twelve-week exercise program[11]. In many instances, changes in anthropometric measures are the first to be noticed by individuals trying to lose weight. When clothes fit better, it is an incentive to continue to take care of your health.

Resting Metabolic Rate

Resting metabolic rate accounts for 60–75% of total energy expenditure in sedentary people[7]. RMR plays a major role in determining energy balance and changes in weight[7]. Anything that increases RMR would facilitate weight loss and maintenance of weight loss. Unfortunately, we did not see any difference in RMR over the course of the six-week weight loss program. Pratley et al. (1994) found that a 16-week resistance training program increased resting metabolic rate by 7.7%[17]. However, the results of this study show a 2.4% decrease in RMR in participants after six weeks. We partially expected this result given the fact that our subjects were on a hypocaloric diet and did not perform significant high-resistance weight training. Factors such as the diet and duration and intensity of the exercise program may need to be manipulated to result in more substantial alterations in RMR to ensure the maintenance of optimal body weight for these participants.

Muscular Strength and Endurance

Four different exercises were used to test muscular strength, and the subjects' 6-RM significantly increased from pre- to post-program, indicating an improvement in muscular strength. These results were consistent with previous studies involving short-duration exercise programs and changes in muscular strength[13]. The significant improvements in muscular strength were likely the result of neural adaptations[16]. The exercise program was based on body weight and low-weight resistance exercises. While the coaches at the local gym, were required to push the participants harder and harder each week, most participants struggled with exercise technique. To prevent injury, most of the participants were instructed to use low weight and attempt to increase repetitions rather than to add weight to stimulate progressive overload. To continue to see improvements in muscular strength safely with this specific weight loss

program, more time should be spent up front working on exercise technique with the participants prior to the six-week challenge. Four exercises were also used to test muscular endurance, but only two of those exercises, forearm plank and wall taps, elicited statistically significant changes when comparing pre- to post-program values. Previous research has shown that short duration, low volume, whole-body interval training is beneficial in improving muscular endurance[14], and these findings agree with ours. We cannot explain why high knees nor six inches improved over the course of the six-week program except that perhaps we did not give our subjects enough rest time in between our data collection measurements. Of the four muscular endurance exercises, we felt that we would see the most improvement in high knees as a decrease in body weight should make it easier to move the whole body.

Limitations

There were several limitations readers should be aware of in the present study. First, the methods in which each variable were tested pre- and post-program were carefully planned and executed; however, the researchers were not involved in the exercise and diet protocols administered to the subjects. Food diaries and exercise logs were not required, so the subjects could have deviated from these program requirements, thus affecting the results of their weight loss program. While a member of our research team was present at each workout, we were simply there to observe and take notes. Second, no males were included in this study. This may limit the generalization of the results to the entire population. Third, while only women were included in this study, we did not keep track of their menstrual cycle and differences in menstrual cycle phases could have certainly impacted our body composition results. Fourth, the hypocaloric nature of the subjects' diet plan could be another limitation. While the subjects' caloric intakes were significantly decreased, and their total daily energy expenditures were increased compared to their lifestyle prior to the six-week challenge, there was variability in the amount of decreased caloric consumption across all subjects. In conjunction with the interval training, the diet could have contributed to the health-related changes that resulted from this weight loss program that may not have occurred if this program consisted of exercise alone. However, the ability to maintain the six-week nutritional plan for an extended period appears unrealistic, and this may impact the subjects' weight loss and health maintenance moving forward. The lack of improvement in RMR further suggests that maintenance of the weight loss may be hard to sustain.

Conclusions

The present study suggests that this specific weight loss program is effective in improving body composition, anthropometric measures and muscular strength and endurance. However, this specific combination of diet, exercise, and water consumption was not effective in producing significant changes in RMR. These findings provide evidence that this specific weight loss program is effective for individuals looking to lose weight, percent body fat and improve appearance. Furthermore, this weight loss program may be an excellent first step in promoting improvements in muscular strength and endurance in previously overweight women. More evidence is required to determine the factors of an optimal exercise and nutrition program that simultaneously improves body weight and RMR.

Media-Friendly Summary

The present study sought to determine if a six-week weight loss program that included a hypocaloric diet, excess water consumption, and a total of 30 moderate-high intensity exercise workouts, would result in significant improvements in body composition and muscular strength and endurance. The results of the present study show that a six-week weight loss program is beneficial for decreasing body fat percent, increasing fat-free mass, and improving whole body muscular strength and endurance. Unfortunately, a six-week weight loss program may not be sufficient to promote improvements in resting metabolic rate and the maintenance of a more optimal body weight.

Acknowledgements

The authors would like to thank the West Chester University Foundation for funding this study. Further, the authors would like to thank Legion Transformation Center for allowing us access to your members. All authors declare no conflict of interest over the outcomes of the study.

References

1. Alizadeh Z, Kordi R, Rostami M, Mansournia MA, Hosseinzadeh-Attar SJ, Fallah J. Comparison between the effects of continuous and intermittent aerobic exercise on weight loss and body fat percentage in overweight and obese women: a randomized controlled trial. *Inter J of Prevent Med.* 2013;4(8):881-888.
2. American College of Sports Medicine Guidelines for Exercise Testing & Prescription. 10th ed. Philadelphia, PA: Wolters Kluwer; 2018.
3. Apfelbaum MJ, Bestsarron J, Lacatis D. Effect of caloric restriction and excessive caloric intake on energy expenditure. *American Journal of Clinical Nutrition.* 1971;24:1405-1409.
4. Blose JM, Stickles P, Battaglino A, Trumbetti A, James J, Cooper K, et al. The effects of a six-week weight loss program on blood lipid profiles and cardiovascular health. *The Journal of Exercise and Nutrition.* 2020;3(4):16.
5. Byrne HK and Wilmore JH. The relationship of mode and intensity of training on resting metabolic rate in women. *International Journal of Sport Nutrition and Exercise Metabolism.* 2001;11(1):1-14.
6. Centers for Disease Control and Prevention. Prevalence of Obesity and Severe Obesity Among Adults: United States, 2017-2018. https://www.cdc.gov/nchs/products/databriefs/db360.htm. Accessed August 10, 2020.
7. Connolly J, Romano, Patruno M. Effects of dieting and exercise on resting metabolic rate and implications for weight management. *Family Practice.* 1999;16(2):196-201.
8. Dennis EA, Dengo AL, Comber DL, Flack KD, Savla J, Davy KP, Davy BM. Water consumption increases weight loss during a hypocaloric diet intervention in middle-aged and older adults. *Obesity.* 2010;18(2):300–307.
9. Gallagher D, Heymsfield SB, Heo M, Jebb SA, Murgatroyd PR, Sakamoto Y. Healthy percentage body fat ranges: guidelines based on body fat index. *American Journal of Clinical Nutrition.* 2000;72:694-701.
10. Greco M, Chiefari E, Montalcini T, Accattato F, Costanzo FS, Pujia A, Foti D, Brunetti A, Gulletta E. Early effects of a hypocaloric, Mediterranean diet on laboratory parameters in obese individuals. *Mediators of Inflammation.* 2014;750860.
11. Kang SJ, Kim E, Ko KJ. Effects of aerobic exercise on the resting heart rate, physical fitness, and arterial stiffness of female patients with metabolic syndrome. *Journal of Physical Therapy Science.* 2016;28(6):1764–1768.
12. MacIntosh BR, Gardiner PF, McComas AJ. *Skeletal Muscle: Form and Function.* 2nd ed. Champaign, IL: Human Kinetics; 2006.
13. Mangine GT, Hoffman JR., Gonzalez AM, Townsend JR., Wells AJ, Jajtner AR., et al. The effect of training volume and intensity on improvements in muscular strength and size in resistance-trained men. *Physiological Reports.* 2015;3(8):e12472.
14. McRae G, Payne A, Zelt JE, Scribbans TD, Jung ME, Little JP, Gurd BJ. Extremely low volume, whole-body aerobic resistance training improves aerobic fitness and muscular endurance in females. *Applied Physiology, Nutrition, and Metabolism.* 2012;37(6):1124-1131.
15. Okorodudu DO, Jumean MF, Montori VM, Romero-Corral A, Somers VK, Erwin PJ, Lopez-Jimenez F. Diagnostic performance of body mass index to identify obesity as defined by body adiposity: a systemic review and meta-analysis. *International Journal of Obesity (London).* 2010;34(5);791-799.
16. Powers SK, Howley ET. *Exercise Physiology: Theory and Application to Fitness and Performance.* 10th ed. New York, NY: McGraw-Hill Higher Education; 2018.
17. Pratley R, Nicklas B, Rubin M, Miller J, Smith A, Smith M, Hurley B, Goldberg A. Strength training increases resting metabolic rate and norepinephrine levels in healthy 50- to 65-year-old men. *Journal of Applied Physiology.* 1994;76(1):133-137.