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Research article

MIXED RESISTANCE TRAINING IMPROVES STRENGTH AND ANTHROPOLOGICAL CHARACTERISTICS IN YOUNG FEMALE ADULTS

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Abstract. *This study aimed to investigate the effects of ten weeks of mixed resistance training on isometric force parameters and anthropological characteristics in young female adults. Fifty-two participants (22.61 ± 1.86 years) were randomized into either the mixed resistance training (MRT; n = 25) or control group (CON; n = 27). Anthropological parameters were body mass, body fat percentage, skinfolds (triceps, tight, abdominal), while force parameters were the isometric force of hand flexors, upper-body flexors and extensors, and knee extensors (both legs). The MRT group was engaged in mixed resistance training consisting of four weeks of muscular endurance resistance training (ERT) followed by six weeks of traditional resistance training (TRT) three times per week. The CON group did not exercise. A two-way repeated measures ANOVA was used to determine the effects of programs on strength and anthropological characteristics. A significant group x time interaction was found for body fat (p < 0.001), waist-hip ratio (p = 0.001), triceps skinfold (p < 0.001), abdominal skinfold (p = 0.001), isometric force of right-hand flexors (p = 0.001), and isometric force of upper-body flexors (p = 0.002). No interaction was observed for body weight, thigh skinfold, isometric force of left-hand flexors, the isometric force of upper-body extensors, and isometric force of knee extensors. Mixed resistance training represents a valid training method to improve anthropological characteristics, but its role in isometric force was not fully confirmed in untrained females.*

Key words: *Strength Training, Body Weight, Force, Females*

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INTRODUCTION

Physical activity has many health benefits (Bauman, 2004; Bogataj, Pajek, Ponikvar, Hadžić, & Pajek, 2020; Brady et al., 2016; Hyde, Conroy, Pincus, & Ram, 2011), and it has become an interesting research topic having in mind that inactivity is one of the main risk factors for disease development (Deslandes et al., 2009). It has been demonstrated that physical activity enhances brain plasticity and cognitive functioning (Colcombe et al., 2006; Kramer & Erickson, 2007).

To date, numerous studies were conducted on the effects of aerobic training, resistance training, and combined (aerobic + resistance) training (Orcy, Dias, Seus, Barcellos, & Bohlke, 2012; Wilson et al., 2012; Zambom-Ferraresi et al., 2015). Adding resistance training to aerobic training has resulted in better muscular strength, cardiovascular fitness, mobility, functional status, and VO_{2peak} (Fisher et al., 2013; Marzolini et al., 2018; Villareal et al., 2017; Zambom-Ferraresi et al., 2015). Moreover, participation in resistance training has been associated with reduced central adiposity and unhealthy gain (Artero et al., 2014), cardiovascular and metabolic diseases (Artero et al., 2011; Benson, Torode, & Fiatarone Singh, 2006; Shaibi et al., 2006), increased skeletal health (Vicente-Rodríguez et al., 2008), and aerobic fitness (Faigenbaum et al., 2009). The literature investigating resistance training supports its implementation into the daily physical activity of the young, adult, and senior populations (Kraemer, Ratamess, & French, 2002). However, it was demonstrated that females generally choose to engage more in solely aerobic exercise with the motive to lose weight (Craft, Carroll, & Lustyk, 2014).

Older females engaged in resistance training can gain various physiological benefits, including muscle strength and blood pressure decrease (Silva et al., 2017), along with an increase in functional capacity and quality of life (Ramírez-Campillo et al., 2014). In young females, this type of training is an effective method to enhance jumping performance (Lesinski, Prieske, & Granacher, 2016), as well as self-efficacy (LeCheminant et al., 2014) and mineral density (Zhao, Zhao, & Xu, 2015).

In conjunction with the physiological benefits of resistance training, there are also various psychological benefits for females who practice resistance training. Among them are better self-esteem, improvements in self-concept, body image, emotional well-being, and reduction in anxiety (Tucker & Maxwell, 1992). Considering the number of benefits linked to resistance training, more females should engage in a resistance training program.

It was shown that older men have a similar ability as younger ones to increase muscle power following a periodized mixed resistance training (Newton et al., 2002). This was confirmed in females after 13 weeks of submaximal training, showing progress at the same rate as younger women (Mata, Oliver, Jagim, & Jones, 2016). This research in males and females confirmed that neural adaptation is the primary goal of resistance training programs in order to increase force and power in women across the age spectrum.

Designing a training program that will show maximum effects and allow a person to achieve the optimal benefits is important. Although resistance training has been shown to improve fitness and health status, there is still a considerable debate regarding the optimal ordering of different modes of exercise within an exercise program. Given the fact that only a few studies exist regarding mixed models in females, there is a need to determine the effects mixed resistance training has on specific outcomes (i.e., isometric force and anthropological characteristics). Moreover, little research exists on the impact of solely resistance training on isometric strength and anthropological characteristics in females. Therefore, the purpose of this study was to determine the effects of mixed resistance training on isometric strength parameters and anthropological characteristics in young adult females.

METHODS

Study Design

Anthropological characteristics measurement and force testing were undertaken at the Provincial Institute for Sport in Novi Sad, Serbia. The aim was to test the effects of a 10-week mixed neuromuscular resistance training intervention on isometric force parameters and anthropological characteristics. Pre-tests and post-tests were conducted on two consecutive days, before and after the 10-week treatment period. Participants from the mixed resistance training (MRT) group performed four weeks of muscular endurance resistance training (ERT) followed by six weeks of traditional resistance training (TRT). The control (CON) group did not exercise or use any training intervention during a period of 10 weeks.

Participants

A total of 52 healthy females (age 22.61 ± 1.86 years; height 167.88 ± 5.61 cm; weight 60.22 ± 8.61 kg) were recruited to participate in the study. The participants were selected based on the following criteria: no prior history of lower limb injuries in the past nine months, and no history of resistance or endurance training. Finally, the participants were randomly divided into either the MRT group (n = 25) or the CON group (n = 27). Age, height, weight and BMI data across participants are presented in Table 1, with no significant differences found between the groups at baseline ($p > 0.05$). Written consent and participant assent were provided before initiating the study in accordance with the Novi Sad University Human Research Ethics Committee guidelines (ethical approval number: 234/2020).

Table 1 Characteristics of the participants

	MRT	CON
Age (years)	23.04 ± 1.98	22.22 ± 1.69
Body Height (cm)	166.13 ± 5.13	169.51 ± 5.64
Body Weight (kg)	58.78 ± 7.78	61.56 ± 9.25
BMI (kg/m^2)	21.29 ± 2.58	21.42 ± 3.03

Note: Data is presented as mean ± SD

Abbreviations: MRT - mixed neuromuscular resistance training group, CON - control group

Testing Procedures – Isometric Force Assessment

The testing was done at the Provincial Institute for Sport in Novi Sad, Serbia, on a dynamometric apparatus, and was performed in accordance with basic measuring protocols. It took place in the morning when the temperature was 18–21°C and the relative humidity was 40–60%. All the participants were tested immediately before the beginning of their training season. Isometric muscle force was measured by a dynamometer, manufactured by the Nikola Tesla Electrical-technical Institute in Belgrade, Serbia. The assessment consisted of 3 phases: resting period, workload period, and recovery period. Each measurement was taken three times, and the best attempt was recorded and saved for subsequent analyses. Five topologically defined tests of isometric muscle force were applied: (a) isometric force of right-hand flexors, (b) isometric force of left-hand flexors; (c) isometric force of upper-body flexors; (d) isometric force of upper-body extensors; and (e) isometric force of knee extensors (both legs). The assessment protocol used in this study has been described by Doder, Babiak, Janjić, & Doder (2012).

Testing Procedures – Anthropological Characteristics Assessment

Height and weight were measured in minimal clothing and barefoot. Height was measured to the nearest 0.1 cm with the use of a stadiometer (SECA Instruments Ltd, Hamburg, Germany). Bodyweight and body fat percentage were determined using an InBody230 (InBody Co. Ltd, Cerritos, CA, USA) with the bioelectrical impedance method. BMI was calculated as follows: BMI= (Weight in kilograms)/(Height in meters)^2. InBody230 is a reliable device in men and women as indicated by high intraclass correlation coefficients for relative values - body fat ($\geq$0.98) and a low standard error of measurement (McLester, Nickerson, Kliszczewicz, & McLester, 2018). Before the measurement, the participants were asked to excrete, refrain from drinking excessive amounts of water, and not change their typical breakfast patterns.

Three skinfolds (thigh, triceps, abdomen) were examined for thickness on the right side of the body. Skinfold measurements were taken with a precision of 0.1 mm using a pre-calibrated Harpenden skinfold caliper (Harpenden, West Sussex, UK) according to procedures described by Eston & Reilly (2009).

Waist circumference (WC) was taken at the level between the lowest rib margin and hips. Hip circumference (HC) was taken at the level of the maximum body width below the waist. Waist and hip circumference was measured twice with a precision of 0.1 cm with a constant tension of non-elastic tape (*Waist Circumference and Waist-Hip Ratio: Report of a WHO Expert Consultation*, 2011). Furthermore, the waist-to-hip ratio (WHR) was calculated by dividing the WC with the HC using the same units of measurements for both.

Training Program

Muscular Endurance Resistance Training (ERT)

Before training, the participants underwent 10 repetition maximum (RM) testing to determine individual initial training loads for each exercise. Repetition maximum testing was consistent with recognized guidelines as established by the National Strength and Conditioning Association (Baechle & Earle, 2008). The ERT program consisted of 3 supervised sessions a week over a four-week period. This period presented the process of familiarization with exercise and training routine. Each resistance training session consisted of four sets of 15 repetitions at ~60% of 1RM with 60 seconds of rest between sets and 180 seconds of rest between exercises with the slow cadence of execution. If an individual was able to complete four sets of 15 repetitions after two weeks (6 training sessions), the training weight was increased by 2 to 4% to compensate for any strength gains (Haff & Triplett, 2015; Ratamess & Kraemer, 2004) in the last week of ERT program. During five weeks of ERT, the exercises performed were: squats, lunges, the bench press, leg raises, the hyperextension bench, knee extension, hamstring curl, leg adductions, leg abductions, lat pulldowns, rowing torso, biceps curls, triceps extension, and the butterfly bench. All routines were directly supervised and lasted approximately 50 min, including the warm-up, dynamic neuromuscular stabilization (DNS) basic movements according to the DNS approach (Frank, Kobesova, & Kolar, 2013), basic breathing exercises, and a cool-down period.

Traditional Resistance Training (TRT)

All participants started their training with six weeks of TRT. During the six-week period participants performed TRT which consisted of 3 sets of 8 to 12 repetitions at ~60% 1RM with 80s breaks between sets. The time between the exercises was extended to about 120s, given the extra time needed to set up the equipment for the subsequent resistance exercise. The repetitions were performed up to the point of momentary concentric failure, i.e. the inability to perform another concentric repetition while maintaining the correct form with the cadence of the repetitions was performed in a controlled manner with a concentric action of about 1s and an eccentric action of about 2s. The TRT protocol consisted of seven exercises per session targeting all major muscle groups of the body. This protocol uses some recommendations for training that include large muscle group exercises before small muscle group exercises; multiple-joint exercises before single-joint exercises or rotation of upper and lower body exercises. The exercises performed were: the bench press, flat barbell, inclined bench press, barbell military press, overhead press, wide grip lateral pulldown, seated cable row, barbell back squat, machine leg press and unilateral machine leg extension, squats (additional weights), lunges (additional weights), bicep curls, triceps extension, and the butterfly bench. These exercises were selected on the basis of their common involvement in strength training type programs (Baechle & Earle, 2008; Coburn & Malek, 2012). An attempt was made to gradually increase the weekly lifted loads to ensure that the test participants trained with as much resistance as possible within the limits of the target repetition range. All exercises were directly supervised by the research team to ensure the correct performance of each exercise. The training session lasted approximately 70 minutes, including the warm-up phase, core DNS movements according to the DNS approach (Frank et al., 2013), accompanied by breathing exercises, and the cool-down phase. All participants trained three times a week with at least one day of rest between sessions. To avoid confusion, the test persons were instructed not to perform any additional anaerobic resistance training or high-intensity anaerobic training during the entire duration of the study.

Statistical Analysis

Descriptive statistics were calculated for age, height and body mass. The distribution of the raw data sets was checked with the Kolmogorov-Smirnov test and showed that all data had a normal distribution. A two-way repeated measures ANOVA was used to determine the effects of programs on strength and anthropological characteristics. In addition, we tested the simple main effect of time to detect changes from before and after the tests in MRT and CON. The effect size (ES) of each variable was tested using Cohen's d within each group and classified as follows: 0.2 was defined as trivial; 0.2-0.6 was defined as small; 0.6-1.2 was defined as moderate; 1.2-2.0 was defined as large; 2.0 was defined as very large, and 4.0 was defined as extremely large (Hopkins, Marshall, Batterham, & Hanin, 2009), and partial eta (η) squared between the groups (0.01 = small effect, 0.06 = medium effect and 0.14 = large effect) (Lakens, 2013). All tests were performed with SPSS, version 22 (SPSS Inc., Chicago, IL, USA) and evaluated at the significance level of $p \leq 0.05$.

RESULTS

When examining the impact of the MRT program on isometric force parameters (Table 2), there was a significant group x time interaction in isometric force of right-hand flexors ($F = 11.608$, $p = 0.001$, Partial $\eta^2 = 0.18$) and isometric force of upper-body flexors ($F = 10.329$, $p = 0.002$, Partial $\eta^2 = 0.17$). Highest effects favoring the MRT group were observed in isometric force of the right-hand flexors effect for time ($p < 0.001$). Significant pre-to post-test changes were noted in the MRT group in isometric force of knee extensors ($p < 0.05$); however, there was no significant group x time interaction ($F = 0.295$, $p = 0.589$, Partial $\eta^2 = 0.006$). Moreover, the results indicate no interaction in isometric force of the left-hand flexors ($F = 1.431$, $p = 0.237$, Partial $\eta^2 = 0.02$) and isometric force of the upper-body extensors ($F = 12.543$, $p = 0.001$, Partial $\eta^2 = 0.20$).

Table 2 Differences between MRT (n=25) and CON (n=27) in isometric measures from the pre- to post- test

	Group	Pretest	Posttest	ES	% change	A Group-by-Time Interaction Effect
Isometric force of the right-hand flexors	MRT	30.48 ± 6.65	34.76 ± 6.05*	+0.66	+13.1%	F = 11.608; *p* = 0.001;
	CON	30.29 ± 5.29	30.25 ± 5.29	-0.01	-0.1%	η^2_p: 0.188
Isometric force of the left-hand flexors	MRT	29.40 ± 3.93	30.84 ± 5.22	+0.31	+4.7%	F = 1.431; *p = 0.*237;
	CON	27.70 ± 4.27	27.81 ± 4.27	+0.03	+0.3%	η^2_p: 0.028
Isometric force of the upper-body flexors	MRT	41.04 ± 8.71	44.20 ± 7.75*	+0.38	+7.4%	F = 10.329; *p = 0.*002;
	CON	39.77 ± 8.86	39.70 ± 8.88	-0.01	-0.1%	η^2_p: 0.171
Isometric force of the upper-body extensors	MRT	99.48 ± 25.65	101.28 ± 21.34	+0.08	+1.7%	F = 0.295; *p = 0.*589;
	CON	94.14 ± 26.15	94.11 ± 26.13	0.00	0.0%	η^2_p: 0.006
Isometric force of the knee extensors	MRT	141.72 ± 39.03	151.84 ± 33.08*	+0.28	+6.8%	F = 2.984; *p = 0.*090;
	CON	133.92 ± 34.54	136.25 ± 36.39	+0.06	+1.7%	η^2_p: 0.056

Note: Pretest and posttest results are presented as mean ± SD
Abbreviations: MRT - mixed neuromuscular resistance training group, CON - control group, ES - effect size for pre- to post- test changes, F - F-test statistics, p - probability value, η^2_p - partial eta squared,
* - significant pre- to post-test changes at $p < 0.05$ (the simple main effect of time)

The results of the anthropological characteristics parameters from the repeated measures ANOVA (Table 3) indicated a significant group (MRT vs. CON) × time (pre to post)

Table 3 Differences between MRT (n=25) and CON (n=27) in body composition parameters measures from the pre- to post- test

	Group	Pretest	Posttest	ES	% change	A Group-by-Time Interaction Effect
Body Weight (kg)	MRT	58.78 ± 7.78	59.08 ± 7.36	+0.03	+0.5%	F = 1.333; *p* = 0.254;
	CON	61.56 ± 9.25	60.75 ± 10.89	-0.08	-1.3%	η^2_p: 0.001
BMI	MRT	21.29 ± 2.58	21.4 ± 2.48	+0.04	+0.5%	F = 1.386; *p* = 0.245;
	CON	21.41 ± 3.03	21.1 ± 3.55	-0.09	-1.4%	η^2_p: 0.027
Body Fat (%)	MRT	20.85 ± 5.65	19.12 ± 5.67*	-0.31	-8.6%	F = 98.160; *p* < 0.001;
	CON	19.05 ± 4.00	19.49 ± 4.03*	+0.11	+2.2%	η^2_p: 0.663
Waist-Hip Ratio	MRT	0.72 ± 0.04	0.69 ± 0.02*	-0.95	-4.2%	F= 12.489; *p* = 0.001;
	CON	0.73 ± 0.05	0.74 ± 0.06	+0.12	+1.0%	η^2_p: 0.200
Triceps Skinfold (mm)	MRT	9.56 ± 2.10	7.096 ± 1.37*	-1.37	-29.6%	F = 40.158; *p* < 0.001;
	CON	10.34 ± 3.91	10.348 ± 3.88	0.00	0.0%	η^2_p: 0.445
Tight Skinfold (mm)	MRT	11.30 ± 2.95	10.90 ± 2.14	-0.15	-3.6%	F = 0.701; *p = 0.406;*
	CON	12.76 ± 4.79	12.75 ± 4.78	0.00	0.0%	η^2_p: 0.013
Abdominal Skinfold (mm)	MRT	12.112 ± 4.03	10.84 ± 3.97*	-0.31	-11.0%	F = 12.543; *p* = 0.001;
	CON	12.963 ± 6.40	12.95 ± 6.40	0.00	0.0%	η^2_p: 0.201

Note: Pretest and posttest results are presented as mean ± SD
Abbreviations: MRT - mixed neuromuscular resistance training group, CON - control group, ES - effect size for pre- to post- test changes, F - F-test statistics, p - probability value, η^2_p - partial eta squared,
* - significant pre- to post-test changes at $p < 0.05$ (the simple main effect of time)

interaction for body fat ($F = 98.160$, $p < 0.001$, Partial $\eta^2 = 0.66$, See Table 1), Waist-Hip Ratio ($F = 12.489$, $p < 0.001$, Partial $\eta^2 = 0.20$), and in abdominal skinfold ($F = 12.543$, $p = 0.001$, Partial $\eta^2 = 0.20$). Large effects favoring the MRT group were observed in triceps skinfold (ES = -1.37 % change = -29.6%), compared to no effect in the CON group. The analysis did not show any significant group x time interaction and effect on intervention in body weight ($F = 1.333$, $p = 0.254$, Partial $\eta^2 = 0.001$); body mass index ($F = 1.386$, $p = 0.245$, Partial $\eta^2 = 0.02$) and thigh skinfold ($F = 0.701$, $p = 0.406$, Partial $\eta^2 = 0.01$).

DISCUSSION

The effects of resistant training on strength and anthropological characteristics is well known and documented (Eather, Morgan, & Lubans, 2016; Lasevicius et al., 2018; Paoli, Gentil, Moro, Marcolin, & Bianco, 2017; Velez, Golem, & Arent, 2010). However, there is a lack of information on mixed protocols on performance in untrained healthy females. Our mixed resistance training showed significant effects on anthropological characteristics as well as on upper body strength in young adult females. Ten weeks of MRT reduced body fat, waist-to-hip ratio, abdominal skinfold, and triceps skinfolds compared to the control group that showed the same or higher values for anthropological characteristics from pre to post-testing. Moreover, the isometric force of the right-hand flexors and isometric force of the upper-body flexors improved in the MRT group.

It is well documented that aerobic exercise is a powerful way for weight loss, especially body fat loss (Donnelly et al., 2013; Oda, Miyatake, Sakano, & Saito, 2014). On the contrary, Miller et al. (2018) stated that there is a great amount of research in the past several years that examined the effects of resistance training on weight loss. Resistance training showed to be effective in the improvement of anthropological characteristics in overweight/obese women (Campa et al., 2020). Moreover, Cavalcante et al. (2018) demonstrated a decreased body fat level after a low-volume 12-week resistance training program in overweight/obese older women. However, some studies that included resistance training showed to be ineffective for weight loss (Olson, Dengel, Leon, & Schmitz, 2007; Willis et al., 2012). The discrepancy in the results comes from the fact that anthropological characteristics typically do not change much with resistance training because the reduction in fat mass is accompanied by increases in fat-free mass (Hunter, McCarthy, & Bamman, 2004). In the current study, we did not assess fat mass or fat-free mass. However, our mixed resistance training showed a significant reduction in body fat (8.6%) compared to the control group that showed only a 2.2% reduction. Therefore, it could be speculated that our mixed resistance training-induced changes in body fat % and skinfold measurements due to an increase in metabolism in sedentary young adult females, which was started in a similar study but in overweight/obese adults (Willis et al., 2012). Moreover, some other reports that included resistance training showed that the decreases in fat percentage indicate a decrease in fat mass (Banz et al., 2003; Marx et al., 2001; Pollock et al., 2000). We can also assume that significant differences between the MRT and CON group in skinfold thickness and the percentage of body fat were possibly due to changes in body fat distribution.

Our findings showed that the mixed resistance training program showed considerable improvements in isometric force parameters, especially in the right-hand flexors and upper-body flexors. There were improvements in the MRT group in knee extensors but without differences compared to the control group. This could be explained by the nonspecific nature of knee extension testing compared to the exercise programs. Most of the exercises in the MRT program were performed with isotonic contractions, while during the testing, the isometric contractions were used to quantify strength. This was confirmed by Weiss et al. (Weiss et al., 2007). Moreover, the increases in lower body strength for the MRT group were less than for the hands and torso, which may be explained by the fact that the training program involved more upper body than lower body exercises. Cannon, Kay, Tarpenning, & Marino (2007) demonstrated significant increases in peak isometric torque in knee and muscle hypertrophy after a 10-week resistance training program in young and elderly women. However, resistance training programs consisted only of knee extensors and knee flexors exercises 3 days per week. Moreover, progressive resistance training alone compared to training, and a healthy diet, showed similar improvements in maximal rate of force development during isometric knee contractions in elderly women (Edholm, Strandberg, & Kadi, 2017). In one large population-based study, handgrip strength and lower limb extension power showed a significant and large decline with age (Aadahl, Beyer, Linneberg, Thuesen, & Jørgensen, 2011). However, only handgrip strength was associated with leisure-time physical activity. Therefore, although lower limb explosive capacity has been associated with reduced ability to perform normal daily activities as well as an increased prevalence for fall injuries (Pijnappels, van der Burg, Reeves, & van Dieën, 2008; Skelton, Greig, Davies, & Young, 1994), it is important to perform different physical activities in order to prevent the decline in upper body strength also. The current study showed that mixed resistance training might be a good option to improve whole-body strength, especially the upper part. Our novel findings expand previous research by indicating that improvements in isometric strength can occur following mixed resistance whole-body training after 10 weeks (3 days per week), which is not specific to the modality of the exercise used for testing.

Although the current research showed significant improvements in isometric strength and anthropological characteristics, we did not assess fat-free mass and muscle mass, which could be considered as the biggest limitation. Moreover, leisure physical activity and nutritional control were not measured in both groups. However, the participants were asked to continue their usual diet and to avoid any other physical activity programs. The strength of this study is the fact that females in the current study improved their upper-body isometric strength and reduced their body fat without additional aerobic sessions while instructed not to change their dietary habits.

Conclusion

Mixed resistance training can be an effective training modality to improve isometric strength and to stimulate a decrease in anthropological characteristics in young female adults. Based on the results of the current study, it can, therefore, be advised to recommend a mixed resistance training program consisting of muscular endurance resistance training and traditional resistance training, for the improvement of anthropological characteristics markers and strength in an inactive female population.

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KOMBINOVANI TRENING SNAGE POBOLJŠAVA SNAGU I ANTROPOLOŠKE KARAKTERISTIKE MLAĐIH ODRASLIH ŽENA

Ova studija je imala za cilj da ispita efekte desetonedeljnog kombinovanog treninga snage na parametre izometrijske sile i antropoloških karakteristika kod mlađih odraslih žena. Ukupno je 52 ispitanice (22.61 ± 1.86 godina) nasumično podeljeno na kombinovan trening snage (MRT; n = 25) i kontrolnu grupu (CON; n = 27). Parametri antropoloških karakteristika bili su telesna masa, procenat telesnih masti, kožni nabori (triceps, butina, abdomen), dok su parametri snage bili izometrijska sila fleksora šake, fleksori i ekstenzori gornjeg dela tela, kao i ekstenzori oba kolena. MRT grupa je realizovala kombinovan trening snage koji se sastojao od 4 nedelja treninga mišićne izdržljivosti (ERT), uz dodatnih 6 nedelja tradicionalnog treninga sa otporom (TRT), tri puta nedeljno. Što se tiče CON grupe, ona nije učestvovala u organizovanom treningu sa opterećenjem. Dvofaktorska ANOVA ponovljenog merenja je primenjena za određivanje efekata programa na snagu i telesnu kompoziciju. Značajna interakcija grupa x vreme je identifikovana kod varijabli procenta masti (p < 0.001), obim struka i kuka (p = 0.001), kožni nabor triceps (p < 0.001), kožni nabor abdomena (p = 0.001), izometrijske sile fleksora desne šake (p = 0.001) i izometrijske sile fleksora gornjeg dela tela (p = 0.002). Nije pronađena interakcija kod varijabli telesne težine, kožnog nabora butine, izometrijske sile fleksora leve šake, izometrijske sile ekstenzora gornjeg dela tela i izometrijske sile ekstenzora kolena. Trening kombinovanog treninga snage je validna metoda treninga za poboljšanje antropoloških karakteristika, ali njena uloga u izometrijskoj sili nije u potpunosti potvrđena kod mlađih odraslih žena.

Ključne reči: *trening snage, telesna težina, sila, žene*