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Effects of a Combined 8-Week Group Exercise Program on the Anthropometric Characteristics of Female University Students

Nebojša Čokorilo[1], Goran Prebeg[2], Dragan Milić[3], Dragan Tomašević[3]

[1]Faculty of Sport and Physical Education Novi Sad, University of Novi Sad, Serbia, [2]Faculty of Sport and Physical Education Belgrade, University of Belgrade, Serbia, [3]Faculty of Physical Education and Sports, University of East Sarajevo, B&H

Abstract

The aim of this study was to analyse effects of a combined 8-week group exercise program on the anthropometric characteristics of female university students. Fifty two first year female students from the Faculty of Sports and Physical Education in Novi Sad were divided into two groups: experimental (N=27, 20.43±1.12years, 21.75±3.32 kg/m2) and control group (N= 25, 20.91±1.76years, 20.91±2.93 kg/m2). Experimental group attended 8 weeks of supervised additional exepriemntal program while the control group did not do any aditional physical activity. Over a 8-week period, changes in anthropometric characteristics were carefully monitored through thirteen measures with the Martin antropometer; bioelectrical impedance OMFRON BF 511, Gulick Anthropometric Tape and John Bull calliper. MANOVA and ANOVA were used to determine differences among groups before and after the experimental program. Primary findings of this study indicate that the combined group exercise intervention produced significant improvements in the female students' anthropometric characteristics. Specifically, increases were observed in calf circumference (p = 0.05), biceps skinfold thickness (p = 0.001), triceps skinfold thickness (p= 0.001), forearm skinfold thickness (p = 0.001), subscapular skinfold thickness (p = 0.03), and abdominal skinfold thickness (p = 0.001) These results highlight the positive contribution and significance of the group fitness program in transforming anthropometric characteristics among female students.

Keywords: *anthropometry, group, exercise program, female students*

Introduction

Anthropometric characteristics (AC) play a significant role in numerous medical disciplines, particularly in identifying risk factors that influence the onset and development of various diseases, as well as in the context of studying the processes of growth and development of the human body (Bjorntorp, 1990). Although body dimensions and composition are largely influenced by genetic factors, there is a potential for modification through adequate nutrition and physical activity (PA) (Lightfoot, De Geus, Booth, Bray, Den Hoed et al., 2018). The results of numerous studies indicate that physically active individuals show statistically significant differences in somatic characteristics compared to those leading a sedentary lifestyle (Sivapathy, Chang, Chai, Ang, & Yim, 2013; Zombra, 2018). The quantification of anthropometric measurements and body composition represents an essential element within the physiological profile, and in the athlete population, it plays a particularly important role as it allows for the monitoring of sports performance and training regimes (Chengliang & Li, 2011). This is especially relevant in strength sports (judo, wrestling, weightlifting), gravitational sports (ski jumping, cycling), and aesthetic sports (rhythmic gymnastics, artistic gymnastics), where body composition significantly impacts athletic performance and rankings (Ortansa & Ileana, 2006; Ackland, Lohman, Sundgot-Borgen,

Correspondence:

G. Prebeg
University of Belgrade, Faculty of Sport and Physical Education Belgrade, Blagoja Parovića 156, 11000 Belgrade, Republic of Serbia
E-Mail: prof.goranprebeg@gmail.com

Maughan, Meyer, Stewart, & Müller, 2012). Equally specific and important is the population of students at faculties of sport and physical education, who are selected in a specific way for studies, precisely because they are required to have above-average somatic characteristics and motor abilities.

PA plays a decisive role in energy expenditure, leading to an energy deficit that aids in weight reduction (DeLany, Kelley, Hames, Jakičić, & Goodpaster, 2014). One of the important factors is determining the appropriate load, as it is closely linked to the outcomes of exercise, such as weight loss and changes in AC (Jakičić, Marcus, & Gallegher, 2003; Slentz et al., 2004). Group fitness programs are a type of structured physical exercise designed with the aim of enhancing health and aesthetic appearance (Bjelica, 2020). These programs serve as an effective tool for controlling and reducing body weight (BW), leading to positive changes in body composition (Stasiulis, Mockiene, Vizbaraite, & Mockus, 2010). The implementation of specific group fitness programs leads to notable changes in body composition, as certain movement patterns act as a significant anabolic stimulus for the body (Eliakim & Beyth, 2003). Group exercise programs can also be combinations, so they can consist of different types of PA, such as aerobics and resistance training. Furthermore, there are studies that have demonstrated that both aerobic (Špirtović et al., 2024) and resistance training (Ndemba et al., 2020) contribute to a significant improvement of AC in women. Aerobics is a form of physical exercise that involves sustained, rhythmic activity to improve cardiovascular fitness and endurance and improve body image, i.e. enhance AC (McArdle, Katch, & Katch, 2014), while the resistance training involves exercises designed to improve muscular strength and endurance by working against a force (Baechle, & Earle, 2008).

Previous research has shown that exercise that combines both aerobic and resistance exercise can lead to desirable changes in both anthropometric and physiologic parameters of adults (Pollock, Franklin, Balady, Chaitman, & Fleg, 2000; Pescatello, Franklin, Fagard, Farquhar, Kelley et al., 2004). Also, when referring specifically to the female population, numerous studies have demonstrated the significant effects of the mentioned combined exercise program in younger women (Špirtović et al., 2024; Bjelica, 2020; Lim, Hwang, Eum, Kim, Cheung et al., 2024), in middle-aged women (Adebero, 2019), and in women with diabetes (Gilyana, Batrakoulis, Goulis, Symeonidou, Al-Mhanna et al., 2024). Similar effects have also been observed in individuals from the academic community (Pugliese, Tuccella, Maisto, D'Angelo, Delle Monache et al., 2025), who were in fact young women, just like the participants in this study. Investigating the effects of combined group exercise programs on AC of female university students is important because this population often experiences lifestyle changes that can negatively impact body composition, such as increased sedentary behavior and irregular eating habits. Understanding how structured PA interventions can mitigate these risks can contribute to the development of effective health promotion strategies tailored for young women in academic settings. Therefore, the aim of this study was to examine the effects of a combined group exercise program on AC of female university students.

Methods

Participants

For the purpose of this research, a sample of participants was drown from the population of female students of the Faculty of Sport and Physical Education in Novi Sad who had been physically inactive up to that point, and who are actively engaged in the exercise program. The study included 52 physical education female students (N=52), aged 20.71±1.51 years. Fuhteremore, the participants were divided into experimental (EG) group (N=27, 20.43±1.12years, 21.75±3.32 kg/m2) and control (CG) group (N= 25, 20.91±1.76years, 20.91±2.93 kg/m2). All participants voluntarily took part in the study, and informed consent for participation in the study and data processing was obtained from each of them. Eligible participants were required to attend regular classes in the faculty and have no chronic illnesses or medical restrictions that might impact their fitness or daily activity levels. Respondents were excluded if they had conditions limiting PA, had been advised by a physician to restrict such activity, or were engaged in external structured exercise programs that could influence outcomes. The procedure was conducted within the ethical standards of the Helsinki Declaration of 1964 and according to Resolution 466/12 of the Ministry of Health. The assessment of anthropometric parameters was carried out in the laboratories of the Faculty of Sport and Physical Education in Novi Sad.

Measured variables

AC were assessed using following equipment: Martin antropometer; bioelectrical impedance OMFRON BF 511, Gulick Anthropometric Tape and John Bull calliper.

Body height (BH) was measured using an anthropometer according to Martin (Martin metal anthropometer - GPM Swiss Made). During the measurement, the examinee stands barefoot on a flat and firm surface. Her head is in a position that meets the requirement of the Frankfurt horizontal (the Frankfurt horizontal is a line connecting the lower edge of the left orbit and the upper edge of the left external auditory opening). The examiner stands on the left side of the subject and controls whether the anthropometer is placed vertically and directly on the longitudinal side of the body. The measurement result is read with an accuracy of 0.1 cm (Đurašković 2001).

BW was measured using the bioelectrical impedance OMFRON BF 511 (Kyoto, Japan). During the measurement, the examinee stands barefoot on a flat and firm surface. The examiner stands on the left side of the subject and reads automatically generated result (Beleigoli et al., 2019).

Anthropometric circumferences were measured using a non-elastic medical tape (to the nearest 0.1 cm): Upper arm circumference (UAC) was measured at the midpoint between the acromion process and the olecranon tip of the right arm, with the subject's arm relaxed at the side. Forearm circumference (FRC) was taken at the point of greatest girth of the right forearm, with the palm facing upward and the muscles relaxed. Thigh circumference (TC) was measured midway between the inguinal crease and the proximal border of the patella on the right leg, with the subject standing and weight evenly distributed. Calf circumference (CC) was recorded at the maximal medial calf girth of the right leg, with the subject standing and the foot flat on the floor (Lohman, Roche, & Martorell, 1988).

Skinfold thicknesses were specified using a John Bull calliper with a constant pressure of 10 g/cm^2 and expressed in mm (Rebato, Salcez, Martin & Rosique, 1998). The biceps skinfold thickness (BSF) was measured over the belly of the biceps brachii muscle on the anterior surface of the right upper arm, midway between the acromion and the antecubital fossa. The triceps skinfold thickness (TSF) was taken on the posterior midline of the upper arm, directly opposite the biceps site, also midway between the acromion and the olecranon process. The forearm skinfold thickness (FSF) was measured on the posterior aspect of the right forearm, at the level of the largest circumference of the forearm. The thigh skinfold thickness (ThSF) was taken on the anterior aspect of the right thigh, midway between the inguinal crease and the proximal border of the patella. The calf skinfold thickness (CaSF) was measured on the medial side of the right calf at the level of the point of maximal circumference. The subscapular skinfold thickness (SSF) was measured just below the inferior angle of the right scapula, at a 45-degree angle following the natural fold of the skin. The abdominal skinfold thickness (AbSF) was taken vertically approximately 2 cm to the right of the umbilicus.

All measurements were carried out in the morning by the same examiner in a quiet, properly illuminated, and thermally neutral environment. The participantswere wearing light indoor clothing. All meantioned variables were measured according to a standardized International Biological Programme protocol (Weiner & Lourie 1996).

Procedures

Before conducting the study tests, all participants were notified of the study's purpose through an informational letter. All of the aforementioned variables were measured on two occasions: the first (initial measurement) to establish the participants' baseline status, and the second (final measurement) upon completion of the experimental program. Testing was done in the morning hours.

Experimental program

The experimental program lasted 8 weeks and included three supervised exercise sessions per week, consisting of two resistance-training sessions and one aerobic session, as previously implemented by Garber, Blissmer, Deschenes, Franklin, Lamonte, et al. (2011). Each session lasted 60 minutes with incorporated structured warm-up and cool-down. The resistance-training sessions targeted all major muscle groups using a combination of free weights, machines, and bodyweight exercises. Participants performed 2–4 sets of 8–12 repetitions at moderate to vigorous intensity (~60–80% of one-repetition maximum), with progressive overload applied as strength improved. Aerobic sessions consisted of ~50 minutes of continuous steady-state exercise (treadmill, cycling, or elliptical) performed at 40–59% heart rate reserve, corresponding to moderate intensity. The CG did not participate in any additional organized PA program. All sessions were conducted under supervision to ensure adherence and correct technique. The program was designed in accordance with established guidelines indicating that combined resistance and aerobic exercise interventions improve both muscular strength and cardiometabolic health in young adults (Garber et al., 2011).

Statistical analysis

All collected data were analyzed using the Statistical Package for the Social Sciences, version 21.0 (IBM SPSS 21.0, SPSS Inc., Chicago, USA). Descriptive statistics, including the mean and standard deviation, were calculated for each variable (Table 1, 2). The normality of the data distribution was examined with the Kolmogorov-Smirnov test. To determine differences between the initial and final testing, multivariate analysis of variance (MANOVA) and analysis of variance (ANOVA) were used. The level of statistical significance for all analyses was set at 0.05.

Results

Tables 1 and 2 present the arithmetic means (Mean) and standard deviations (SD) for each study group, together with the results of the MANOVA and ANOVA analyses.

Table 1. Univariate and multivariate analysis of variance of the experimentaln (EG) and control (CG) groups at the initial measurement.

	Initial testing		Differences between groups	
	EG (N=27) Mean ± SD	CG (N=25) Mean ± SD	F value	P value
BW (kg)	57.7 ± 7.9	62.5 ± 9.3	1.4	0.25
BH (cm)	166.1 ± 5.1	169.5 ± 5.6	0.2	0.51
UAC (cm)	25.1 ± 2.2	24.7 ± 2.6	0.9	0.24
FRC (cm)	21.7 ± 1.3	21.9 ± 1.7	0.2	0.62
TC (cm)	50.0 ± 4.3	51.1 ± 5.3	0.6	0.43
CC (cm)	36.2 ± 1.8	36.2 ± 2.6	0.6	0.51
BFS (mm)	7.0 ± 2.3	7.9 ± 3.0	0.9	0.34
TFS (mm)	9.5 ± 2.1	10.3 ± 3.9	0.7	0.37
FSF (mm)	5.7 ± 1.31	6.2 ± 1.8	0.9	0.34
ThSF (mm)	11.3 ± 2.9	12.7 ± 4.7	1.7	0.19
CaSF (mm)	5.7 ± 2.0	6.5 ± 2.6	1.2	0.21
SSF (mm)	13.6 ± 4.7	12.0 ± 6.4	0.1	0.73
AbSF (mm)	12.1 ± 4.03	12.9 ± 6.4	0.3	0.55

Legend: EG – experimental group; CG – control group; N – number of participants; F value – F test of multivariate analysis of variance (Manova); P value – value of analysis of variance (Anova); * - level of statistical significance <0.05; ** - level of statistical significance <0.01; Mean – mean values; SD – standard deviation; BW – body weight; BH – body height; UAC - Upper arm circumference; FRC – forearm circumference; TC – thigh circumference; CC – calf circumference; BFS - The biceps skinfold thickness; TFS - The triceps skinfold thickness; FSF - The forearm skinfold thickness; ThSF - The thigh skinfold thickness; CaSF - The calf skinfold thickness; SSF - The subscapular skinfold thickness; AbSF - The abdominal skinfold thickness.

From Table 1, it is evident that there are no statistically significant differences in the overall set of variables at baseline in the female students, as indicated by the MANOVA results (F = 1.16, p = 0.43) and by the univariate ANOVA outcomes shown in the final column. These findings confirm that the EG and CG did not differ significantly on the observed variables at the initial measurement.

After completing the 8-week experimental program, the primary findings of this study indicate that the combined group exercise intervention produced significant improvements in the female students' AC. Specifically, increases were observed in calf circumference (p = 0.05), BSF (p = 0.001), TSF (p= 0.001), FSF (p = 0.001), SSF (p = 0.03), and AbSF (p = 0.001) (Table 2).

Table 2. Univariate and multivariate analysis of variance of the experimentaln (EG) and control (CG) groups at the final measurement.

	Initial testing		Differences between groups	
	EG (N=27) Mean ± SD	CG (N=25) Mean ± SD	F value	P value
BW (kg)	61.0 ± 7.3	61.7 ± 10.8	2.1	0.12
BH (cm)	166.1 ± 5.2	159.5 ± 5.6	0.1	0.62
UAC (cm)	25.4 ± 2.1	25.8 ± 2.7	2.8	0.10
FRC (cm)	21.8 ± 1.3	21.9 ± 1.7	0.5	0.44
TC (cm)	50.3 ± 3.4	51.1 ± 5.3	0.1	0.71
CC (cm)	41.8 ± 1.6	35.3 ± 2.6	3.9	0.05*
BFS (mm)	6.4 ± 2.1	7.8 ± 3.0	12.7	0.001**
TFS (mm)	7.0 ± 1.5	10.3 ± 3.9	27.1	0.000**
FSF (mm)	5.0 ± 1.0	6.2 ± 1.8	15.8	0.001**
ThSF (mm)	10.9 ± 2.1	11.7 ± 4.7	1.5	0.21
CaSF (mm)	5.4 ± 1.6	6.4 ± 2.2	0.6	0.43
SSF (mm)	12.5 ± 3.9	14.4 ± 6.0	5.5	0.03*
AbSF (mm)	10.8 ± 3.8	12.9 ± 6.4	10.1	0.001**

Legend: EG – experimental group; CG – control group; N – number of participants; F value - test of multivariate analysis of variance (Manova); P value – value of analysis of variance (Anova); * - level of statistical significance <0.05; ** - level of statistical significance <0.01; Mean – mean values; SD – standard deviation; BW – body weight; BH – body height; UAC - Upper arm circumference; FRC – forearm circumference; TC – thigh circumference; CC – calf circumference; BFS - The biceps skinfold thickness; TFS - The triceps skinfold thickness; FSF - The forearm skinfold thickness; ThSF - The thigh skinfold thickness; CaSF - The calf skinfold thickness; SSF - The subscapular skinfold thickness; AbSF - The abdominal skinfold thickness.

Discussion

The purpose of this study was to assess how a combined group exercise program influences the AC of female university students. Upon completion of the 8-week intervention, the main findings showed that the combined group exercise program resulted in significant improvements in participants' anthropometric measures, including increased calf circumference and decreased skinfold thickness at the biceps, triceps, forearm, subscapular, and abdominal sites.

Anthropometric characteristic, such as body circumferences, are noninvasive indices of body size and composition (Casadei & Kiel, 2022). In female university students, these measures are especially relevant because they reflect physical fitness and fat distribution, which in turn predict metabolic and cardiovascular risk (Casadei & Kiel, 2022). For example, larger limb circumferences often indicate greater muscle mass (fitness), while central measures like waist circumference track adiposity and metabolic syndrome risk (Shen, Punyanitya, Chen, Gallagher, Albu et al., 2006). In the present study, participants that have went through the combined group exercise program showed a statistically significant increase in mean calf circumference post-intervention, suggesting enhanced lower-leg muscle development. This finding is consistent with other research in young adults: for instance, an 8-week combined HIIT and resistance training program significantly increased lean muscle mass in overweight young women, and so the cirfumferences in lower limbs (Wang, Yang, Deng, Wang, Yang et al., 2024), and structured strength training has been shown to raise calf circumference in college students (Wang, Zheng, Wang, & XuanxiI, 2023; and Gentil, Rodrigo, & Soares, 2013) who reported ~5% increases in arm circumference after an 8-week resistance program in young men. Likewise, Beak et al. (2022) found that low-intensity aerobic exercise with blood-flow restriction significantly increased calf circumference over 8 weeks (Beak, Park, Yang, & Kim, 2022). Relevant for the participants of our study, Liu et al. reported that a 6-week aerobics plus resistance program in female undergraduates substantially increased calf circumference and strength of female university students (Zhou & Hazel, 2024). Physiologically, this response is expected: repeated resistance loading of the calf muscles stimulates muscle protein synthesis and fiber hypertrophy (Smeuninx & McKendry, 2016), which leads to an increase in muscle cross-sectional area and thus larger calf circumference.

Skinfold thickness measurements quantify the thickness of subcutaneous fat at specific body sites (e.g. triceps, subscapular) using calipers, providing an estimate of total body fat (Reilly, Wilson, & Durnin, 1995). These measurements are important in young women because they reflect fat distribution; higher skinfold values, especially in central locations, are associated with increased adiposity and cardiometabolic risk (Duggleby, Jackson, Godfrey, & Robinson, Inskip, 2009). In our study, the 8-week combined aerobic plus resistance program produced significant reductions in most of the measured skinfolds (biceps, triceps, forearm, subscapular, and abdominal). This aligns with many interventional studies showing that exercise lowers subcutaneous fat: for example, O'Connor and Lamb (2003) reported that a 12-week high-repetition resistance program in active women reduced the sum of five skinfolds by about 17 mm (O'Connor & Lamb, 2003). Likewise, a 12-week mixed aerobics protocol in healthy women yielded large relative declines (≈14–21%) in abdominal, thigh, and arm skinfold thickness (Špirtović et al., 2024) These results mirror our findings of broad skinfold thinning, indicating effective fat loss from combined training. In female college populations, Ha and So (2012) similarly observed that 12 weeks of combined exercise significantly reduced waist circumference in obese students (Ha & So, 2012), consistent with decreased central adiposity. Collectively, these studies suggest that young women engaging in combined aerobic-resistance programs tend to lose subcutaneous fat across multiple sites. The physiological mechanism is that such training markedly increases total energy expenditure and fat oxidation: the aerobic component burns calories and mobilizes fat, while added muscle mass from resistance training raises resting metabolism (Melanson, MacLean, & Hill, 2009).

The main limitations of this study relate to the relatively small sample size (N = 52) and the brief duration of the intervention (only eight weeks), which may restrict the generalizability of the findings and the evaluation of the long-term effects of combined aerobic–resistance training. Additionally, the study did not control participants' dietary habits or monitor PA outside the prescribed program, potentially introducing extra variability into the results. To enhance the robustness and breadth of future conclusions, it is recommended that subsequent investigations employ larger samples, longer intervention periods, and rigorous control of nutrition and daily activity levels. Future research should investigate the dose–response relationship between combined aerobic–resistance training volume and anthropometric outcomes by employing varied training intensities and frequencies. Moreover, longitudinal studies incorporating nutritional interventions and objective PA monitoring are warranted to elucidate the mechanistic pathways underlying body composition changes in female university populations.

Conclusion

Based on the findings of this study, an 8-week combined aerobic resistance exercise program induced a significant improvements in female university students' body composition, as demonstrated by increased calf circumference and reduced skinfold thickness at the biceps, triceps, forearm, subscapular, and abdominal sites.

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