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EFFECTS OF AEROBIC AND COMBINED EXERCISE PROGRAMS ON BODY COMPOSITION AND RESTING METABOLIC RATE IN YOUNG ADULTS

UČINKI AEROBNIH IN KOMBINIRANIH PROGRAMOV VADBE NA SESTAVO TELESA IN ZMANJŠEVANJE PRESNOVNE STOPNJE PRI MLADIH ODRASLIH

ABSTRACT

The purpose of this study was to investigate the effects of 8-week aerobic and combined exercise (aerobic and resistance) modalities on body composition and resting metabolic rate (RMR) in sedentary young adults. Twenty-two physically inactive females (20.9 ± 1.6 years) were recruited to participate in the study. They were randomly assigned to three groups: aerobic exercise group (AEG), combined exercise group (CEG), and control group (CG). The training programs were performed three times a week. The body fat percentage was assessed by the bioelectrical impedance method. The RMR was determined via indirect calorimetry. Within-group analysis revealed no significant differences in body mass index and body fat percentage considering the three groups. However, both training groups increased their RMR significantly (AEG: 12.3%, p= 0.017; CEG: 9.7%, p= 0.043). No significant difference was observed in CG for the RMR. Between-group analysis revealed that participating in aerobic training induced slightly better (but insignificant) improvements in all measures compared to combine training. In conclusion, the results of the study highlighted the positive influences of both aerobic and combine training interventions on the RMR in sedentary female young adults compared to controls.

Keywords: Indirect calorimeter, aerobic exercise, combined exercise, resting metabolic rate, body composition

IZVLEČEK

Namen te študije je bil raziskati učinke 8-tedenske aerobne in kombinirane vadbe na telesno sestavo in stopnjo presnove v mirovanju (RMR) pri sedečih mladih odraslih. K sodelovanju smo povabili 22 telesno nedejavnih žensk (20,9 ± 1,6 let), ki smo jih naključno razdelili v tri skupine: skupino za aerobno vadbo (AEG), skupino za kombinirano vadbo (CEG) in kontrolno skupino (CG). Programi usposabljanja so se izvajali trikrat tedensko. Odstotek telesne maščobe je bil ocenjen z metodo bioelektrične impedance. RMR smo določili s posredno kalorimetrijo. Analiza znotraj skupine ni pokazala pomembnih razlik v indeksu telesne mase in odstotku telesne maščobe glede na tri skupine. Obe vadbeni skupini sta znatno povečali svoj RMR (AEG: 12,3 %, p= 0,017; CEG: 9,7 %, p= 0,043). V CG za RMR nismo zaznali značilnih razlik. Analiza med skupinami je pokazala, da je sodelovanje v aerobnem treningu povzročilo nekoliko boljše (vendar nepomembne) izboljšave pri vseh ukrepih v primerjavi s kombiniranim treningom. Rezultati študije so poudarili pozitivne vplive tako aerobnih kot kombiniranih vadbenih intervencij na RMR pri sedečih mladih odraslih ženskah v primerjavi s kontrolnimi skupinami.

Ključne besede: posredni kalorimeter, aerobna vadba, kombinirana vadba, hitrost presnove v mirovanju, telesna sestava

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INTRODUCTION

Human total energy expenditure is determined by biological (body size and energy expenditure during rest), behavioral (nutritional habit and physical activity), and environmental (ambient temperature) factors (Westerterp, 2017). The resting metabolic rate (RMR) is the largest component of daily energy expenditure and defined as the required energy for the body to maintain vital functions and homeostasis (Poehlman and Dvorak, 2000). Since it is mainly determined by the body size and composition, small changes in RMR could have a significant impact on the treatment of excessive adiposity (Byrne and Wilmore, 2001). Thus, the estimation of the RMR is crucial to establish effective weight management programs (Wright et al., 2015).

Energy expenditure during physical activity is one of the major factors that lead to inter-individual differences in total energy expenditure (den Hoed and Westerterp, 2008). Various forms of physical activity may influence the body composition and the level of RMR and consequently lead to changes in energy balance and weight status (Jakicic, 2002). Several earlier studies have examined the influences of different exercise interventions, such as aerobic exercise (Karstoft et al., 2017; Lee et al., 2009; Potteiger et al., 2008), resistance exercise (Kirk et al., 2009; Lemmer et al., 2001; Scharhag-Rosenberger et al., 2014), or combine exercise (Bonfante et al., 2017; Gomersall et al., 2016; Hunter et al., 2006; Jennings et al., 2009) on body composition and RMR. These investigations, however, have produced conflicting results which may be attributed to the characteristics of the research groups and/or the duration, intensity, and mode of the training protocols (Lee et al., 2009).

Emerging adulthood (age 18-25) is a critical period in lifespan development and characterized by greater weight gain (Lanoye, Brown, and LaRose, 2017). Thus, more attention is needed to establish weight gain prevention strategies for this age group (Laska et al., 2012). Nevertheless, current literature provides limited evidence regarding the influences of diverse exercise interventions on body composition and RMR in this particular sample. Researches may provide an insight into the potential consequences of different forms of exercise on weight status. Therefore, the purpose of this study was (i) to analyze the within-group changes (after 8-week period) promoted by aerobic and combined-exercise and control-group on body mass index, body fat percentage, and RMR in sedentary female young adults and (ii) to analyze the between-group changes occurred after the intervention period. It was hypothesized that both aerobic and combination of aerobic and resistance training programs would result in an increase in the RMR and a decrease in the body mass index and body fat percentage.

METHODS

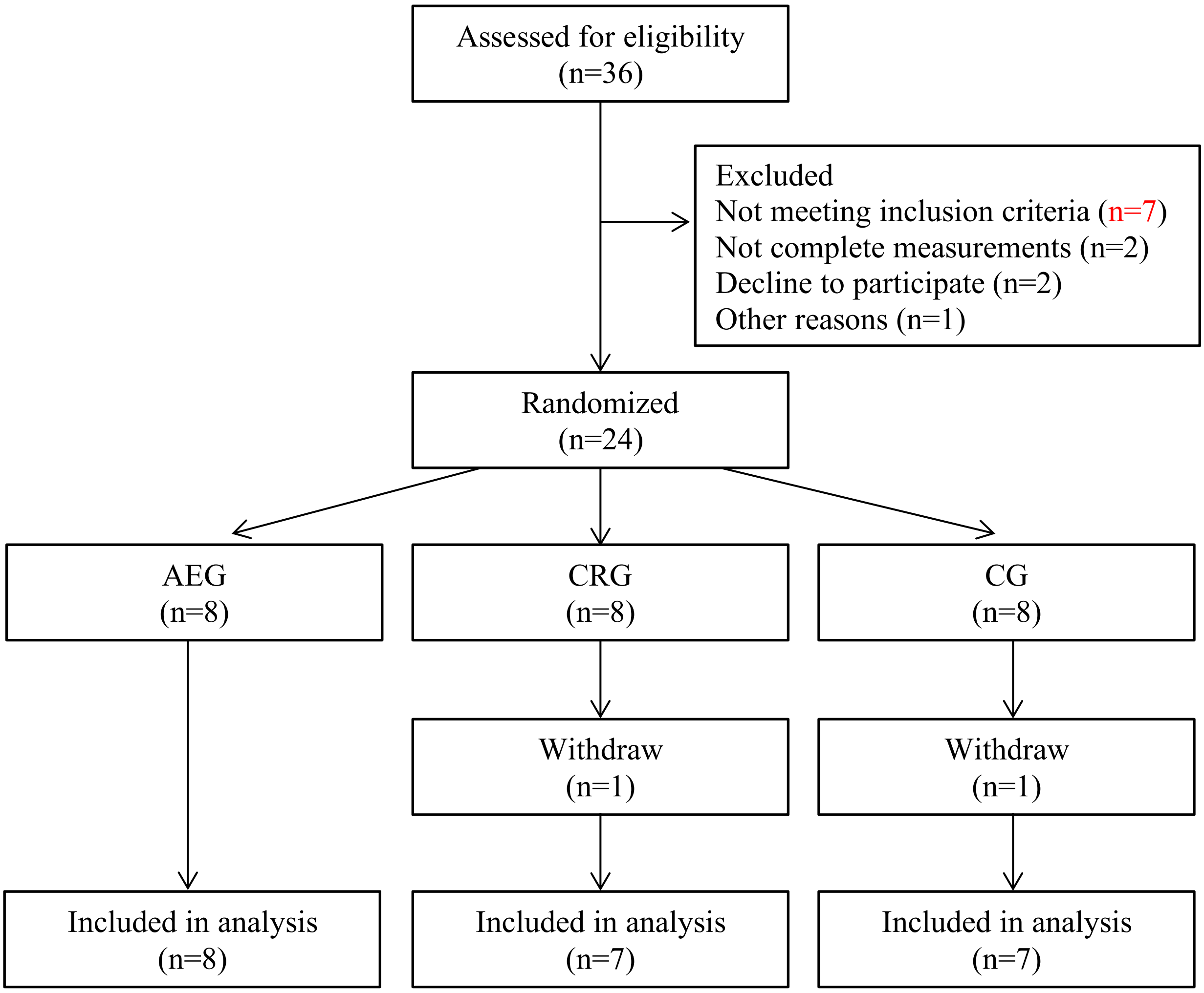
Study design

The present study followed a randomized controlled design.

Participants

The inclusion criteria for the study were: (i) physically inactive female young adults (aged 18-25 years); (ii) no chronic diseases or implanted electrical stimulators; (iii) no taking contraceptives. Exclusion criteria were age < 18 and > 25 years, and people with chronic diseases or implanted electrical stimulators. The participants were recruited using the notice boards of the university. A total of 36 students applied to take part in the study. They were informed of the procedures and the purpose of the study before signing the informed consent forms. Ethical approval was obtained from the Clinical Research Ethics Board of Abant İzzet Baysal University. Twenty-nine of them met the criteria. Two students did not complete all measurements. Three students declined to participate. Twenty-four students were assigned to three groups by simple randomization: aerobic exercise group (AEG), combined exercise group (CEG), and control group (CG). The randomization was unblinded and the allocation was not concealed. During the intervention period, two students were withdrawn from the study due to personal reasons. Then, the data of 22 students (20.9 ± 1.6) were used for the analysis. The recruitment flow chart for the study is presented in Figure 1.

Figure 1. Participant flow chart.



Intervention

Intervention groups performed eight-week training three times a week and for 60 min per session. Participants in the AEG completed running protocol on treadmills at moderate (75-80 % HRmax) intensity. The CEG followed a 30 min of resistance and 30 min of aerobic exercise program. The resistance exercises were lateral pulldown, leg extension, lying leg curl, leg press, bench press, calf raise, seated row, biceps curl, triceps extension, shoulder front raise, and crunch. They performed 3 sets of 10-12 repetitions at 50-60% of their 1 repetition of maximum. 30 and 90-second rest intervals were given between sets and exercises respectively. They then performed the similar aerobic exercise with the AEG. The intensities for aerobic and resistance training were adjusted every two weeks according to their heart rate and one repetition of maximum. Participants were asked to not to attend any other physical activity and maintain their usual dietary intake during the intervention period.

Outcomes

Participants completed two sets of measurements (before and after intervention). Each set consisted of one testing session. They were measured for anthropometrics, body fat percentage, and the RMR respectively. All measurements were conducted in physiology laboratory between 8-11 am.

Anthropometrics and body composition

A portable stadiometer (Seca 213, Hamburg, Germany) was unutilized to measure body height to the nearest 0.1 cm. Body mass (0.1 kg) and body fat percentage were assessed with bioelectrical impedance analysis (BIA, Tanita, BC-418, Japan). Body mass index was calculated by dividing the body mass (kg) by the squared height (m). The measurements were made by the same investigator.

Resting metabolic rate

Indirect calorimetry (Cortex Metalyzer II, Leipzig, Germany) was used to measure the RMR. The test was administered according to the procedure described by Matarese (1997). Following overnight fasting, participants were asked to rest in a supine position for 30 min in a quiet and thermoneutral (23 ± 1 °C) environment and requested to breathe normally until they reach their steady-state. They were measured during the days of follicular phase of the menstrual cycle. They were also instructed to keep their physical activity to a minimum level on the test morning. Measurements lasted 20 minute. However, the first 5 min were determined as an acclimatization period to the testing environment and the last 5 min were excluded from the analyses because of the fact that while closing to the end of testing possible increase in sympathetic activity. Post exercise measurements were conducted between 24 and 48 hour after the last exercise session. Using the measured CO_2 production and the oxygen consumption rate the Weir equation (1949) was used to calculate the RMR.

Statistical Analysis

Descriptive statistics (mean ± SD) were calculated for the study variables. The Wilcoxon test was conducted to examine the differences between pre-and post-test scores within each group. The Kruskal Wallis Test was used to determine the differences between baseline scores and also to compare the changes. In order to ascertain the magnitude of differences effects sizes (based on Cohen's d values) were calculated. Effect sizes were considered as trivial (0.0–0.19), small (0.20–0.49), medium (0.50–0.79), and large (0.80 and greater). The SPSS (v.24) for

Windows was used to conduct data analysis. The statistical significance level was set at $p < 0.05$.

RESULTS

Table 1 represents the baseline characteristics of the participants in different groups. The results indicated that there were no significant differences among groups in terms of age, height, and body mass.

Table 1. Characteristics of the participants by group.

Group	AEG	CEG	CG	χ^2	*p*
Age (years)	21.3 ±1.9	20.6 ± 1.1	20.9 ± 1.8	0.219	0.897
Height (cm)	160.6 ± 2.2	158.7 ± 5.5	160.6 ± 3.6	0.325	0.850
Weight (kg)	62.1 ± 4.4	58.6 ± 5.4	58.9 ± 4.4	2.302	0.316

The descriptive statistics (mean and standard deviation) for the pre- and post-test scores and the results of the Wilcoxon test are presented in Table 2. Within group changes revealed that, regardless of group, there were no significant differences in body mass indexes and body fat percentages. On the other hand, participants in both training groups increased their RMR significantly (p= 0.017 and p= 0.043 for AEG and CEG respectively). No significant difference was observed in the CG for the RMR. The Kruskal Wallis analysis regarding the improvement scores revealed no significant differences between groups.

Table 2. Comparison of pre- and post-test results.

Variables	Group	Pre	Post	Difference	Change (%)	*Z*	*p*	*d*
BMI (kg/m^2)	AEG	24.1 ± 1.7	23.5 ± 1.5	0.6 ± 0.7	-2.3	-1.823	0.068	-0.46
	CEG	23.3 ± 1.8	23.0 ± 1.8	0.3 ± 0.4	-1.3	-1.866	0.062	-0.50
	CG	22.9 ± 2.2	22.9 ± 2.1	-0.1 ± 0.5	0.2	-0.318	0.750	-0.08
BF (%)	AEG	29.6 ± 2.1	29.3 ± 2.3	0.3 ± 0.9	-1.1	-1.338	0.181	-0.33
	CEG	29.7 ± 2.9	29.5 ± 2.2	0.2 ± 1.1	-0.2	-0.338	0.735	-0.09
	CG	27.3 ± 3.1	27.3 ± 3.2	-0.01 ± 0.7	-0.02	-0.135	0.892	-0.04
RMR (kcal/day)	AEG	1187.1 ± 94.2	1364.7 ± 127.6	-177.6 ± 173.9	12.3	-2.380	0.017*	-0.60
	CEG	1175.1 ± 83.4	1314.6 ± 181.5	-139.5 ± 133.9	9.7	-2.028	0.043*	-0.54
	CG	1262.9 ± 125.3	1277.2 ± 114.7	-14.3 ± 10.5	0.9	-0.507	0.612	-0.14

*p<0.05

DISCUSSION

The aim of this randomized controlled study was to examine the effects of aerobic and combined exercise interventions on body composition and RMR in sedentary female young adults. Participating whether aerobic or combine training were expected to yield decreases in the body mass index and the body fat percentage and increases in the RMR. However, the result of the study failed to support this hypothesis regarding the adiposity parameters that there were no significant differences between pre- and post-test values. This observation contrasts with the findings of previous examinations conducted on overweight or obese adults (Lee et al., 2015; Rossi et al., 2016; Willis et al., 2012). It must be taken into account that participants of the current study were in the healthy body fat range 21-33% (Gallagher et al., 2000). Aerobic or aerobic plus resistance training may be more effective in overweight/obese young adults.

In a recent study (Stavres et al. 2018) the effects of six-week functional resistance training intervention on basal metabolic rate and body composition was investigated in a group of sedentary adult women. Similarly, their results indicated no changes in body fat percentage, fat free mass, fat mass, and body mass index. However, a significant increase was reported for basal metabolic rate.

The results on the RMR support the hypothesis that participants in training groups exhibited a significant increase. Accumulated data on the potential effects of exercise training to modulate the RMR have shown no consensus (Alberga et al., 2017; MacKenzie-Shalders et al., 2020). Nonetheless, the result is in line with the finding of Potteiger et al., (2008). They investigated the influences of long term (16 months) exercise training on body composition and RMR in female young adults. Similarly, they observed stable results in body composition but an increase in RMR. Although changes in RMR are usually attributed to the changes in body composition, nutritional intake, hormonal activities, or the level of adiposity might be confounding factors (MacKenzie-Shalders et al., 2020; Potteiger et al., 2008).

There are several limitations to the study. First, the relatively small sample size enrolled in this study may preclude finding statistical significance. Second, the dietary intake of the participants was not controlled during the intervention period. Third, rather than BIA, using criterion methods such as dual-energy x-ray absorptiometry may provide more precise data on the body fat percentages. Lastly, a relatively short term training period may have possible consequences on the results. On the other hand, these limitations may provide opportunities for future researches. For example, long-term effects of different exercise interventions with larger samples may yield a better understanding. Besides, additional studies are warranted on the other physiological factors that may be related to the changes in body composition and RMR in subjects with different weight status.

CONCLUSION

In conclusion, the findings of the study highlight the positive influences of short term aerobic and aerobic plus resistance exercise modalities on the RMR in sedentary female young adults. Furthermore, none of the interventions resulted in considerable decrease in body mass index and body fat percentage. Although the comparison of mean changes revealed no significant differences among groups the greatest changes were achieved by young adults participating in aerobic training. Overall, these evidences suggest that certain forms of exercise modalities may result changes in RMR without changes in body composition in female young adults.

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Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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