# PJSS

dergipark.gov.tr/psbd

Pamukkale Spor Bilimleri Dergisi • Pamukkale Journal Of Sport Sciences

ISSN: 1309-0356 | Year: 2018 | Volume: 9 | Number: 1
Pamukkale University
Faculty of Sport Sciences
Denizli / TURKEY

VOL 9, No:1 (2018)

## TABLE OF CONTENTS

EFFECTS OF MODERATE INTENSITY CIRCUIT RESISTANCE TRAINING ON RESTING METABOLIC RATE AND BODY COMPOSITION IN YOUNG ADULTS 01-08
*Yilmaz Ucan, Erbil Murat Aydin*

Pamukkale Journal of Sport Sciences
ISSN: 1309-0356
2018, Vol. 9, No. 1, 01-08
accepted: 17.01.2018

# Effects of moderate intensity circuit resistance training on resting metabolic rate and body composition in young adults

**Yilmaz Ucan[1], Erbil Murat Aydin[1]**

[1]Abant Izzet Baysal University, School of Physical Education and Sport, Bolu, Turkey.

mr_ucan@hotmail.com

**Abstract**

Resistance exercises are commonly used by sportsmen and trainers to increase strength, muscle mass, and fat-free mass. The aim of this study is to investigate the effects of moderate-intensity circuit resistance training on resting metabolic rate and body composition. Moderately active male subjects (n=16) were voluntarily participated in this study and the subjects were randomly assigned into either training (n=8, 25.1±1.3 years) or control (n=8, 24.8±1.4 years) group. The moderate-intensity circuit resistance training group followed a 12-week exercise program while the control group had no resistance training. The subjects' resting metabolic rates and body composition assessments were performed at the beginning of the study and at the end of the 12-week training period as pre- and post-tests. Statistical analyses conducted by using paired samples *t*-test showed that there were no significant differences ($p>.05$) in the resting metabolic rates, heart rates and respiratory exchange ratios between the training and control groups. At the end of the 12-week training period there was a significant increase ($p<.05$) in fat-free mass (2.5%) and a significant decrease ($p<.05$) in fat mass (-8.5%) and body fat percentage (-8.9%) of the training group. No significant differences were observed in the control group. Bone mineral density and body weight values were not statistically different in any group, either. The results showed that the 12-week moderate-intensity circuit strength training had no significant effect on resting metabolic rate but body composition values of the training group were improved.

**Keywords:** Indirect calorimeter, DXA, bone mineral density, heart rate

## INTRODUCTION

Resting metabolic rate (RMR) is the minimum amount of calorie needed for a human to continue his/her vital functions at rest, in leaning position and while awake (Heyward, 1991). It is generally measured in kcals burnt in a day (kcal.day$^{-1}$). RMR is directly proportional to the individual's body size and surface area; tall and heavy individuals have greater RMR values than those of short and light individuals (Cunningham, 1982). Along with body size and age factors, RMR is also affected by body composition. Individuals with more fat-free mass (FFM) have higher RMR values than those of who have less FFM (Ravussin and Bogardus, 1989; Segal et al., 1985), because fat mass (FM) is metabolically less active than the muscle tissue (Heyward, 1991).

RMR makes up 60-70% of our daily calories burnt but this depends on the individual's activity level (Byrne and Wilmore, 2001; Poehlman and Melby 1998; Wilmore and Costill 1994). An increase about 1-2% in RMR may contribute to one's body composition and weight control in long-term (Byrne and Wilmore, 2001). The effects of physical exercises on increasing RMR are not revealed completely (Wilmore and Costill, 1994). RMR is closely related to body fat-free mass and following a resistance training program to increase the fat-free mass can be an effective way to increase RMR (Wilmore and Costill, 1994). There are many studies in literature showing the effects of aerobic training on RMR. Some of them state that aerobic exercise does not have an effect on RMR (Antunes et al., 2005; Broeder et al., 1991; Broeder et al., 1992; Heijden et al., 2010; Jennings et al., 2009; Lee et al., 2009; Wilmore et al., 1998), some state a detrimental effect on RMR (Donnelly et al., 1991; Geliebter et al., 1997) while some others state that aerobic exercise increases RMR (Potteiger, 2008). In a limited number of studies done to reveal the effects of resistance exercise on RMR (Heden et al., 2011; Hunter et al., 2000; Kirk et al., 2009; Abboud et al., 2013; Scharhag-Rosenberger et al., 2014; Aristizabal et al., 2015; Greer et al., 2015), the effects of resistance training on RMR was not shown clearly.

No specific study on how the moderate-intensity circuit resistance training (MICRT) affects RMR was found. Circuit resistance training (CRT) increases aerobic endurance moderately while an increase occurs in strength, muscular endurance and flexibility. More, it may change one's body composition well by increasing the muscle mass and decreasing fat-mass (Wilmore and Costill, 1994). Especially, when the total workloads of the moderate-intensity circuit resistance trainings are considered, they also contribute to both aerobic and muscular endurance. These kind of exercises may increase fat-free mass and contribute to both RMR and body composition positively. In this context, the aim of this study is to investigate the effects of MICRT on RMR and body composition in young adults.

## METHOD

Research Group

Sixteen moderately active males volunteered to participate in this study and were randomly assigned to circuit resistance trained (n=8; 25.1±1.3 years) and control groups (n=8; 24.8±1.4 years). Physical characteristics of the participants are presented in table 2. The study was performed in accordance with the Helsinki Declaration of 1975. All subjects were informed of the purpose of the study, completed a medical history form and signed a written consent form approved by the Duzce University, School of Medicine, Ethics Committee of Non-invasive Clinical Researches.

Resting metabolic rate (RMR) assessment

RMR assessments of the subjects were done both before and after the 12-week training period. The assessments were done in the morning time following an all-night sleep (approx. 8 hours) and 12-hour fasting. The subjects did not have any strenuous physical activity in the last 48 hours before the RMR assessment. After the subjects were invited into the laboratory, they were asked to stay in semi recumbent position for 45 mins. The lab was a semi-dark, temperature controlled (21.8±.6 $^{\circ}$C), and isolated room. The subjects were not allowed to speak, move, or sleep during the assessment. Oxygen uptake ($VO_2$) and carbon dioxide output ($VCO_2$) were recorded automatically in every 10 secs by an automatic gas analyser (Cortex Metalyzer II, CORTEX Biophysik GmbH Germany) in the last 30 min of the assessment period. Gas analyser was calibrated before the assessment according to the protocol provided by the producing company. In the 10-min period between the minutes 15 and 25, the mean values of oxygen uptake ($VO_2$) and carbon dioxide output ($VCO_2$) were taken and used to compute RMR. RMR calculation was done by using Weir equation as follows:

$RMR = [(3.941)(VO_2) + (1.106)(VCO_2)]$ (Weir, 1949).

Where $VO_2$ is the volume of oxygen uptake ($mL.min^{-1}$) and $VCO_2$ is the volume of carbon dioxide output ($mL.min^{-1}$). The subjects' heart rates were recorded during the measurements of resting metabolic rate procedure with the recording device (Polar Sport Tester Heart Rate Monitor, Polar Vantage Nv, Polar Electro Oy, Finland).

Assessment of body composition

Body weight and height were measured by using a mechanical scale with height rod (Seca 700; Seca GmbH & Co. KG., Hamburg, Germany). Weight graduation was 50 g and measure rod graduation was 1 mm. Body composition was assessed by dual-energy X-ray absorptiometry (DXA) by using the GE Lunar DPX Pro Pencil Beam Scanner (GE-Lunar Corporation, Madison, WI). The calibration was done on a daily basis by the technician using the instrument and the certificated officials of the company on a monthly basis. Tests, checks and phantom measurements of the system were checked every three months at the company technical service.The total body scan provided values for bone mineral density ($gr/cm^2$), non-bone lean tissue (kg), and fat-mass (FM) in the whole body and in the arms, legs, trunk, android, gynoid separately. Fat-free mass (FFM) was defined as the sum of non-bone lean tissue and bone mineral content.

MICRT protocol

After completing all pre-tests a total of 8 subjects participated in a MICRT for 12 weeks, three days per week. The resistance training program consisted of the following 16 exercises for the lower and upper body: barbell curl, preacher's curl, pushdown, triceps extension, back press, lateral raise, chest press, pec deck fly, lat pull down, seated row, leg press, leg extension, lying leg curl, floor hip extension (kick back), floor hip abduction, and crunch. Training sessions began following a 10-min warm-up. During the resistance training sessions, subjects performed 10-14 repetitions per set, with a work load equivalent to 40-60% of their one repetition maximum (1RM) (Brzycki, 1993). Two or three sets per exercise per training session lasted approximately 1 hour. Training intensity (weight, and repetitions) was adjusted according to each participant's progress during the training period. The training protocol is presented in table 1.

**Table 1.** Training protocol for the MICRT group

| Weeks | Session/week | Sets | Repetitions | Rest between sets | Rest between exercises | Workload (1RM%) |
|---|---|---|---|---|---|---|
| 1-3 | 3 | 2 | 10-12 | 45 sec. | 90 sec. | 40 |
| 4-6 | 3 | 2 | 10-12 | 45 sec. | 90 sec. | 40 |
| 7-9 | 3 | 3 | 12-14 | 30-45 sec. | 60-90 sec. | 50 |
| 10-12 | 3 | 3 | 12-14 | 30-45 sec. | 60-90 sec. | 60 |

Analyses of data

The mean and standard deviations (mean ± SD) were calculated as descriptive statistics. Data were analysed by using SPSS version 16.0 (SPSS Inc., Chicago, IL, USA). Independent sample *t*-test was used to assess differences between (pre- and post-tests) group values. Differences between pre- and post-test (within group) were analysed using paired samples *t*-test. The homogeneity of variances was assessed by Levene tests. The level of significance was set at $p<.05$.

## RESULTS

Resting Metabolic Rate

Results of the RMR measurements are presented in table 2. There were no significant group differences before and after the intervention. RMR, heart rate (HR) and respiratory exchange ratio (RER) were not significantly ($p>.05$) changed either in the control or in the training group over the 12 weeks (Table 2).

**Table 2.** Pre- and post-test RMR, HR and RER results of the MICRT (n=8) and Control (n=8) groups (mean ± SD)

| Variables | Group | Pre-training | Post-training | Change | p |
|---|---|---|---|---|---|
| RMR (kcal.d$^{-1}$) | MICRT | 1466.6 ± 92.4 | 1496.9 ± 85.9 | 30.3 | .606 |
| | Control | 1558.5 ± 82.8 | 1561.5 ± 79.6 | 2.9 | .939 |
| HR (beats.min$^{-1}$) | MICRT | 62.8±5.2 | 60.9±5.6 | -2 | .143 |
| | Control | 61.1±4.7 | 61.2±5.6 | 0.1 | .936 |
| RER | MICRT | .8968±.168 | .8151±.034 | -.081 | .230 |
| | Control | .7949±.083 | .8269±.048 | .032 | .295 |

**Table 3.** Physical characteristics and body composition at baseline and at 12 weeks between the circuit resistance training (MICRT, n=8) and Control (C, n=8) groups. (mean ± SD)

| Variables | Groups | Pre-test | Post-test | Change | p |
|---|---|---|---|---|---|
| Age (years) | MICRT | 25.1±1.3 | | | |
| | Control | 24.8±1.4 | | | |
| Height (cm) | MICRT | 173.7±.6 | | | |
| | Control | 173.8±.5 | | | |
| Body weight (kg) | MICRT | 67.5±3.1 | 67.7±3.8 | .2 | .657 |
| | Control | 69.7±3.3 | 70.6±3.4 | .9 | .329 |
| BMI ($kg/m^2$) | MICRT | 22.3±1.9 | 22.4±1.8 | .1 | .756 |
| | Control | 23.1±3.8 | 23.3±4.2 | .2 | .427 |
| FM (kg) | MICRT | 12.9±3.9 | 11.7±3.3 | -1.2 | .040# |
| | Control | 14.8±3.1 | 15.9±3.2 | 1.1 | .072 |
| FFM (kg) | MICRT | 54.6±2.7 | 56.0±2.2 | 1.4 | .004* |
| | Control | 54.7±2.3 | 55.4±2.7 | .6 | .219 |
| PBF (%) | MICRT | 19.8±2.7 | 17.9±3.3 | -1.8 | .014# |
| | Control | 21.9±4.2 | 22.8±2.4 | .8 | .151 |
| Bone mineral density ($gr/cm^2$) | MICRT | 1.19±.08 | 1.20±.08 | .01 | .371 |
| | Control | 1.24±.12 | 1.24±.11 | .00 | .826 |

* Significantly different from pre-training for same group, $p < 0.05$.
# Significantly different from MICRT Pre, and Control Post, $p < 0.05$.
MICRT = Moderate Intensity Circuit Resistance Training
BMI = Body Mass Index; FM = Fat Mass; FFM = Fat Free Mass; PBF = Percent Body Fat.

Body mass and composition

Results of body mass and body composition analyses are presented in table 3. There were no significant group differences before the intervention. After the intervention, significant (p<.05) increases were seen in FFM (2.5%), decreases were seen in FM (-8.5%) and percent body fat (PBF) (-8.9%) in MICRT, whereas the control group showed no significant changes from baseline to week 12. Bone mineral density, body weight and body mass index (BMI) were not significantly (p>.05) changed either in the control or in the MICRT group over the 12 weeks (Table 3). Between-groups comparison showed significantly greater decrease for FM (-8.5%) and PBF (-8.9%) for the MICRT group than for the control group.

## DISCUSSION

In the present study, the effects of MICRT on RMR, body weight, and body composition in young adults were studied. No dietary restriction was applied to the subjects. The results showed that 12-week MICRT had no effect on RMR. MICRT had some positive effects on some body composition parameters. MICRT applied had an increasing effect on the subjects' RMR by 2% but this was not statistically significant. In some studies, it was reported that FFM was related to RMR and an increase in FFM was considered to cause an increase on RMR (Heyward, 1991; Segal et al., 1985; Wilmore and Costill, 1994). Although the increase in FFM by 2.5% was statistically significant, it caused no positive effect on RMR. There are some studies supporting the findings of the present study (Antunes et al., 2005; Broeder et al., 1992; Jennings et al., 2010). In one of these researches, Broeder et al. (1992) stated that 12-week high-intensity resistance training decreased PBF and increased FFM but had no significant effect on RMR. On the contrary, there are some studies with opposing results (Byrne and Wilmore, 2001; Hunter et al., 2000; Kirk et al., 2009). Kirk et al. (2009) found that 24-week minimal resistance training had a statistically significant effect on FFM and RMR (7.4%) in young adults. In the present study, the reasons for insignificant results on RMR may be a relatively short training period or the inappropriate statistical results due to insufficient number of subjects.

One of the aims of the present study was to examine the effects of MICRT on body composition. According to the results, at the end of the 12-week period there were statistically significant changes in FM, PBF and FFM, -8.5%, -8.9% and 2.5%, respectively. No statistically significant differences were observed in the control group. Additionally, there were no statistically significant differences on body weight, BMI, bone mineral density in either control or training groups. Resistance training is commonly used as a method to increase FFM and decrease PBF (Ferreira et al., 2010; Heyward, 1991; Ucan, 2013; Wilmore and Costill, 1994). In his study, Wilmore (1974) found that attending to resistance training 2 times a week for 10 weeks showed no significant effect on the subjects' body weight but PBF of the control and training groups were decreased by 10% and 7.6%, respectively. Similarly, Kwon et al., (2010), Marra et al., (2005) and Ucan (2013) stated in their studies that resistance trainings significantly increased the subjects' muscle mass and strength and decreased PBF, body weight and waist circumference values significantly. These studies support the findings of the present study. In some other studies, the effects of resistance training on body composition were not found statistically significant (Brown and Wilmore, 1974; Hanson et al., 2009). In a study conducted by Harber et al. (2004) 12 men (aged 18-35) were exposed to a CRT program which was consisted of 10 exercises, for 10 weeks and 3 times per week. As a result of the study, no significant differences were observed in the subjects' body weight, FFM, FM and PBF. As it can be clearly seen, the effects of resistance training on body composition parameters were widely investigated but no definite judgement about the effects of resistance training could be made. The findings of the present study showed that MICRT increased FFM and decreased PBF.

## CONCLUSION

No significant changes in RMR, bone mineral density and body weight were found either in the control or in the training group over 12 weeks. MICRT did not affect the RMR in moderately active young males. Furthermore CRT significantly increased FFM and decreased PBF and FM in the experimental group.

### References

Abboud, G. J., Greer, B. K., Campbell, S. C., Panton, L. B. (2013). Effects of load-volume on EPOC after acute bouts of resistance training in resistance-trained men. J Strength Cond Res, 27(7), 1936-1941.

Antunes, H. K. M., Santos, R. F., Boscolo, R. A., Bueno, O. F. A., Mello, M. T. (2005). Analysis of resting metabolic rate and body composition in elderly males before and after six months of endurance exercise. Rev Bras Med Esporte, 11(1), 76-80.

Aristizabal, J. C., Freidenreich, D. J., Volk, B. M., Kupchak, B. R., Saenz, C., Maresh, C. M., Kraemer, W. J., Volek, J. S. (2015). Effect of resistance training on resting metabolic rate and its estimation by a dual-energy X-ray absorptiometry metabolic map. Eur J Clin Nutr, 69, 831-836.

Broeder, C. E., Burrhus, K. A., Svanevik, L. S., Wilmore, J.H. (1992). The effects of either high-intensity resistance or endurance training on resting metabolic rate. Am J Clin Nutr, 55, 802-810.

Broeder, C. E., Burrhus, K. A., Svanevik, L. S., Wilmore, J.H. (1991). The effects of aerobic fitness on resting metabolic rate. Am J Clin Nutr, 55, 795-801.

Brown, C. H., Wilmore, J. H. (1974). The effect of maximal resistance training on the strength and body composition of women athletes. Med Sci Sports, 6, 174-177.

Brzycki, M. (1993). Strength testing—predicting a one-rep max from reps-to-fatigue. Journal of Physical Education, Recreation and Dance, 64(1), 88-90.

Byrne, H.K., Wilmore, J. H. (2001). The effects of a 20-week exercise training program on resting metabolic rate in previously sedentary, moderately obese women. Int J Sport Nutr Exerc Metab, 11(1), 15–31.

Cunningham, J. J. (1982). Body composition and resting metabolic rate: the myth of feminine metabolism. Am J Clin Nutr, 36, 721-726.

Donnelly, J. E., Pronk, N. P., Jacobsen, D. J., Pronk, S. J., Jakicic, J. M. (1991). Effects of a very-low-calorie diet and physical-training regimens on body composition and resting metabolic rate in obese females. Am J Clin Nutr, 54, 56-61.

Ferreira, F. C., Medeiros, A. I., Nicioli, C., Nunes, J. E. D., Shiguemoto, G. E., Prestes, J., Verzola, R. M., Baldissera, V., Perez, S. E. A. (2010). Circuit resistance training in sedentary women: body composition and serum cytokine levels. Appl Physiol Nutr Metab, 35, 163-171.

Geliebter, A., Maher, M. M., Gerace, L., Gutin, B., Heymsfield, S. B., Hashim, S. A. (1997). Effects of strength or aerobic training on body composition, resting metabolic rate, and peak oxygen consumption in obese dieting subjects. Am J Clin Nutr, 66, 557-563.

Greer, B. K., Sirithienthad, P., Moffatt, R. J., Marcello, R. T., Panton, L. B. (2015). EPOC comparison between isocaloric bouts of steady-state aerobic, intermittent aerobic, and resistance training. Research Quarterly for Exercise and Sport, 86(2), 190-195.

Hanson, E. D., Srivatsan, S. R., Agrawal, S., Menon, K. S., Delmonico, M. J., Wang, M. Q., Hurley, B. F. (2009). Effects of strength training on physical function: influence of power, strength, and body composition. J Strength Cond Res, 23(9), 2627-2637.

Harber, M. P., Fry, A. C., Rubin, M. R., Smith, J. C., Weiss, L. W. (2004). Skeletal muscle and hormonal adaptations to circuit weight training in untrained men. Scand J Med Sci Sports, 14, 176–185.

Heden, T., Lox, C., Rose, P., Steven, R., Kirk, E. P. (2011). One-set resistance training elevates energy expenditure for 72 h similar to three sets. Eur J Appl Physiol, 111, 477-484.

Heijden, G. J., Sauer, P. J. J., Sunehag, A. L. (2010). Twelve weeks of moderate aerobic exercise without dietary intervention or weight loss does not affect 24-h energy expenditure in lean and obese adolescents. Am J Clin Nutr, 91, 589-596.

Heyward, V. (1991). Advanced Fitness Assessment & Exercise Prescription. Human Kinetics Publications.

Hunter, G. R., Wetzstein, C. J., Fields, D. A., Brown, A., Bamman, M. M. (2000). Resistance training increases total energy expenditure and free-living physical activity in older adults. J Appl Physiol, 89, 977-984.

Jennings, A. E., Alberga, A., Sigal, R. J., Jay, O., Boule, N. G., Kenny, E. A. (2009). The effect of exercise training on resting metabolic rate in type 2 diabetes mellitus. Med Sci Sports Exerc, 41(8), 1558-1565.

Kirk, E. P., Donnelly, J. E., Smith, B. K., Honas, J., Lecheminant, J. D., Bailey, B. W., Jacopsen, D. J, Washburn, R. A. (2009). Minimal resistance training improves daily energy expenditure and fat oxidation. Med Sci Sports Exerc, 41(5), 1122-1129.

Kwon, H. R., Han, K. A., Ku, Y. H., Ahn, H. J., Koo, B. K., Kim, H. C., Min, K. W. (2010). The effects of resistance training on muscle and body fat mass and muscle strength in type 2 diabetic women. Korean Diabetes J, 34, 101-110.

Lee, M. G., Sedlock, D. A., Flynn, M. G., Kamimori, G. H. (2009). Resting metabolic rate after endurance exercise training. Med Sci Sports Exerc, 41(7), 1444-1451.

Marra, C., Bottaro, M., Oliveira, R. J., Novaes, J. S. (2005). Effects of moderate and high intensity aerobic exercise on the body composition of overweight men. JEPonline, 8(2), 39-45.

Poehlman, E. T., Melby, C. (1998). Resistance training and energy balance. Int J Sport Nutr, 8, 143-159.

Potteiger, J. A., Kirk, E. P., Jacobsen, D. J., Donnelly, J. E. (2008). Changes in resting metabolic rate and substrate oxidation after 16 months of exercise training in overweight adults. Int J Sport Nutr Exercise Metb, 18, 79-95.

Ravussin, E., Bogardus, C. (1989). Relationship of genetics, age, and physical fitness to daily energy expenditure and fuel utilization. Am J Clin Nutr, 49, 968-975.

Scharhag-Rosenberger, F., Meyer, T., Wegmann, M., Ruppenthal, S., Kaestner, L., Morsch, A., Hecksteden, A. (2014). Irisin does not mediate resistance training-induced alterations in resting metabolic rate. Med Sci Sports Exerc, 46(9), 1736-1743.

Segal, K. R., Gutin, B., Nyman, A. M., Pi-Sunyer, F. X. (1985). Thermic effect of food at rest, during exercise, and after exercise in lean and obese men of similar body weight. J Clin Invest, 76, 1107-1112.

Ucan, Y. (2013). Effects of different types of exercise on body composition in young men and women. Life Sci J, 10(3), 1799-1806.

Weir, J. B. (1949). New methods for calculating metabolic rate with special reference to protein metabolism. J Physiol, 109, 1-9.

Wilmore, J. H. (1974). Alterations in strength, body composition and anthropometric measurements consequent to a 10-week weight training program. Med Sci Sports, 6, 133-138.

Wilmore, J. H., Costill, D. (1994). Physiology of sport and exercise. Human Kinetics Publications.

Wilmore, J. H., Stanforth, P. R., Hudspeth, L. A., Gagnon, J., Daw, E. W., Leon, A. S., Rao, D. C., Skinner, J. S., Bouchard, C. (1998). Alterations in resting metabolic rate as a consequence of 20 wk of endurance training: the herıtage study. Am J Clin Nutr, 68, 66-71.