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## **Effect of Acute Exercise on Hunger in Healthy Woman<sup>1</sup>**

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### **Abstract**

This study investigated the effects of different acute exercise mode on subjective hunger rating. Ten healthy woman subjects participated voluntarily in the study and written informed consent was obtained from all subjects before participation. Subjects undertook four, 1,5 h trials (3exercises and 1 control) in a randomized crossover design. In the exercise trials subjects were performed three different exercise protocol (resistance, resistance+endurance, endurance). In the control trial, subjects rested for 1,5 h. Ratings of subjective feelings of hunger was reported on 100 mm visual analogue scales (VAS) at baseline (-20) and at 0, 20, 40, 60 and 90 mins after baseline. Repeated-measures, two factor ANOVA was used to examine differences between the four trials over time for hunger change. Between-trial differences at each time point were examined using repeated measures ANOVA and Bonferroni post hoc tests when significant interactions were found. Two-way ANOVAs revealed significant trial (p=0.047) trial x time effects (p=0.041) and time (p=0.000) effects for hunger. Endurance+resistance exercise trial increases the feeling of hunger more than resistance exercises trial (p=0.021) and control trial (p=0.046). In conclusion, acute resistance+endurance exercise increases appetite in healthy woman.

**Keywords:** Exercise modes, hunger, weight control

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## Introduction

Diet and exercise are two lifestyle behaviors that can influence appetite and energy intake; thus, ultimately altering energy balance. The relationship between exercise and appetite regulation has important implications regarding the role of exercise in weight management (King et al., 2015). Exercise can suppress subjective appetite ratings, subsequent energy intake, and alter appetite-regulating hormones for a period of time post-exercise (Howe et al., 2014).

The effect of exercise on appetite markers has been studied by many researchers up to now. Most of these researches on acute exercises studied the effects of endurance and sprint-interval exercises (Thivel et al., 2012; Deighton et al., 2013; Hagobianet al., 2013; Williams et al., 2013; Alkahtani et al., 2014; Desgorces et al., 2014; Martins et al., 2014). Today, endurance, resistance and combined exercises is frequently used in weight-control exercise programs (Haskell et al., 2007; Nelson et al., 2007; Donnelly et al., 2009, Garber et al., 2011). Therefore, it is of great importance that the effects of resistance and combined exercises are known besides the effects of aerobic exercise on appetite markers.

There are few researches that examine the effect of resistance exercises on appetite, and most of these are chronic studies (Guelfi et al., 2013) in men. To the best of our knowledge, there are only two researches on the effect of acute resistance exercise on appetite and the findings of which are contradictory (Broom et al., 2009; Laan et al., 2010; Ozen et al., 2014) and there is no any study investigate effect of acute combined exercise on appetite.

However, various factors such as gender, exercise mode, intensity and individual characteristics including training status or hedonic responses to exercise may moderate the relationship between exercise and appetite (Horner et al., 2014). Thus, more research is needed to understand the impact of various modes and intensities of exercise and fitness level on appetite in different populations and gender. Accordingly, the purpose of the study is to examine the effect of 60-minute acute resistance, treadmill and combined exercise on appetite markers in healthy woman.

## Materials and Methods

**Study design:** Ratings of subjective feelings of hunger, in response to rest and exercises trials (endurance, resistance, combine exercise) were investigated using a randomized crossover design. Subjects acted as their own controls and were assigned to the two experimental conditions (resting and exercises), 1 week apart, in a counter balanced order.

**Subjects:** Ten healthy female subjects participated voluntarily in the study and written informed consent was obtained from all subjects before participation. Subjects were excluded from participation in the study if they had a history of a chronic disease (e.g. cancer, heart disease, diabetes), uncontrolled hypertension or taking blood pressure medication, any condition that would alter one's metabolism (e.g. thyroid disease) or ability to exercise (e.g. orthopedic limitations), diagnosed psychological disorders (e.g. depression), recent weight loss of greater than 5 kg. or low levels of sleep (<6 h/night). Participants had regularly occurring menstrual cycles, and were considered "low exercise risk" as per the American College of Sports Medicine (ACSM) guidelines. The study was approved by the ethical board of the Abant İzzet Baysal University School of Medicine Clinical Laboratory Research, Bolu,

TURKEY and it was performed in accordance with the principles of the Declaration of Helsinki. The characteristics of the subjects at baseline are shown in Table 1.

### **Preliminary Test**

***Anthropometric measurements:*** Height was measured to the nearest 0.1 cm using a Holtain fixed wall stadiometer. Body mass was measured to the nearest 0.01 kg using a beam balance. BMI was calculated as weight in kilograms divided by the square of height in meters. Percentage body fat was measured with the Tanita Body Composition Analyzer. All body weight measurements were obtained with subjects wearing shorts and a tee-shirt, without shoes.

***10-repetition maximum strength test:*** A 10-repetition maximum test was completed for each of the 7 resistance exercises employed in the study. The order in which each exercise was performed was leg press, leg curl, chest press, lat pull down, shoulder press, biceps curl, sit-up. On a separate visit, subjects undertook a 60-min familiarization session in which they completed a full weight-lifting session: three sets of 10 repetitions of 7 different weight-lifting exercises at 80% of 10 repetitions maximum.

***Maximal aerobic capacity measurement:*** Maximal oxygen uptake test was performed one week before the main trials. The subject's VO<sub>2</sub>max was assessed during a graded exercise treadmill (HP Cosmos Mercury Med 4.0) test using standard Bruce protocol (Bruce et al., 1973) in the morning hours. The test was terminated when subjects stated they could no longer continue with the maximum workload. At the terminal workload, all subjects had to meet at least two of the following criteria for a valid test: (1) a final respiratory exchange ratio (RER) > 1.0, (2) O<sub>2</sub> consumption increased by < 2 ml·kg<sup>-1</sup> with an increase in exercise intensity, (3) attainment of >85% of age-predicted maximal heart rate. Respiratory gases were collected and analyzed throughout the entire exercise session with the use of a computer controlled breath-by-breath analyzer Cortex II Metalyser (Cortex Biophysik, Leipzig, Germany). The highest achieved value for oxygen consumption was considered the subject's VO<sub>2</sub>max. Heart rate (HR) was measured continuously throughout the test using a commercially available HR monitor (Polar S725X, Polar Electro, Finland).

### **Main trials**

Participants were given at least one week to recover from the preliminary exercise tests before performing four main trials (3 exercise and control) in a random, crossover design with an interval of at least one week between trials.

***Exercises and Control Trials:*** Subjects undertook four, 1.5 h trials (3 exercises and 1 control) in a randomized crossover design. In the exercise trials subjects were performed three different exercise protocol (resistance, resistance+endurance, endurance). In the control trial, subjects rested for 1.5 h. (60 minutes exercise and 30 minutes recovery).

#### ***Exercise Trials***

##### ***Resistance exercise***

In the resistance exercise trial subjects were performed three sets of 10 repetitions for each exercise (leg press, leg curl, chest press, lat pull down, shoulder press, biceps curl, sit-up ) at

80% of 10RM and a 60-second rest interval between exercises and a 2-minute rest interval between sets were provided.

**Endurance exercise**

In the treadmill trial subjects ran for 60 min at 70% of maximal oxygen uptake followed by a 30 min rest period.

**Resistance+endurance exercise**

In the combined exercise trial subjects ran for 40 min. at 70% of maximal oxygen uptake and 20 min. resistance exercise followed by a 30 min rest period.

**Appetite**

Ratings of subjective feelings of appetite markers in response to rest and exercise forms were investigated using a randomized crossover design. Ratings of subjective feelings of appetite markers were reported on 100 mm visual analogue scales (VAS) at baseline (-20) and at 0, 20, 40, 60 and 90 mins after baseline. Visual analogue scales (VAS) were used to measure the following appetite markers: (i) *Hunger*, (ii) *Fullness*, (iii) *Desire to Eat* and (iv) *Prospective Food Consumption*. Specifically, participants were asked to provide subjective ratings of their current state for the following appetite markers: (i) *Hunger* – ‘How hungry do you feel at this moment?’ (ii) *Fullness* – ‘How full does your stomach feel at this moment?’ (iii) *Desire to Eat* – ‘How strong is your desire to eat at this moment?’ and (iv) *Prospective Food Consumption* – ‘How much food do you think you could eat at this moment?’

**Statistical Analysis**

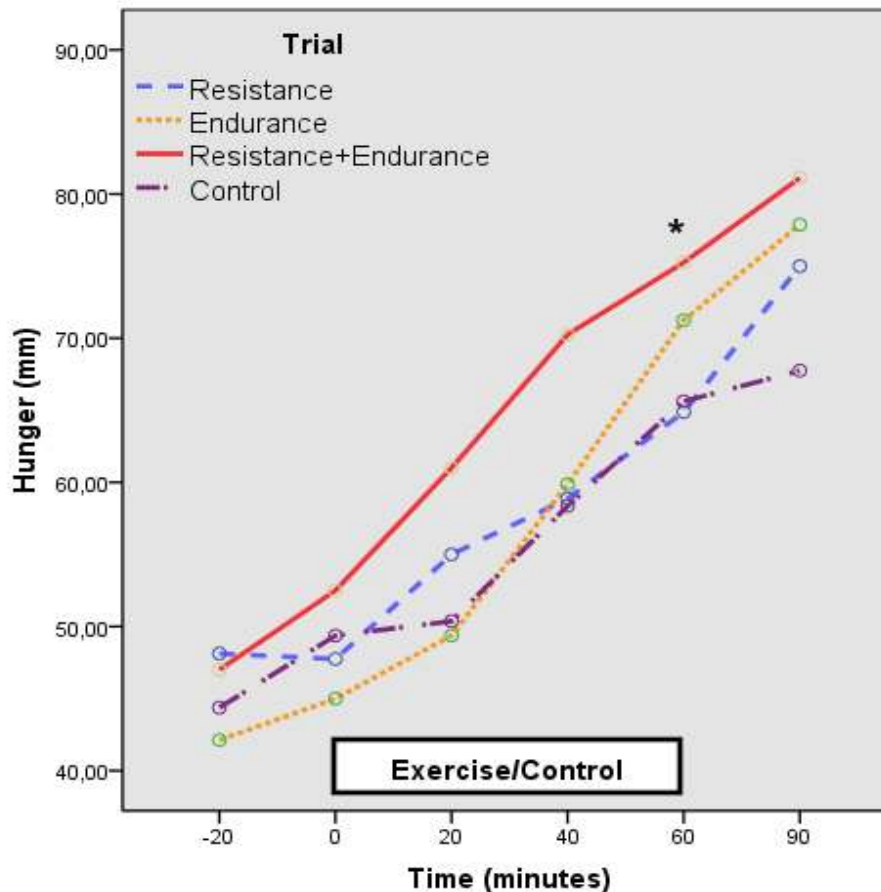
Repeated-measures ANOVA were used to assess differences between baseline values for each of these variables on the control and exercises trials. Repeated-measures, two factor ANOVA was used to examine differences between the four trials over time for hunger change. Between-trial differences at each time point were examined using Repeated-measures ANOVA and Bonferroni post hoc tests when significant interactions were found. Mauchley’s test was conducted to examine sphericity for the repeated measures analyses. If the assumption of sphericity was violated, the Greenhouse-Geisser adjustment was used to protect against type I error. Statistical analysis was carried out using SPSS version 20.0 (SPSS, Inc., Chicago, IL, USA). Statistical significance was accepted at the 5% level.

**Results**

**Table 1.** Descriptive characteristics of subjects at baseline (mean±sd)

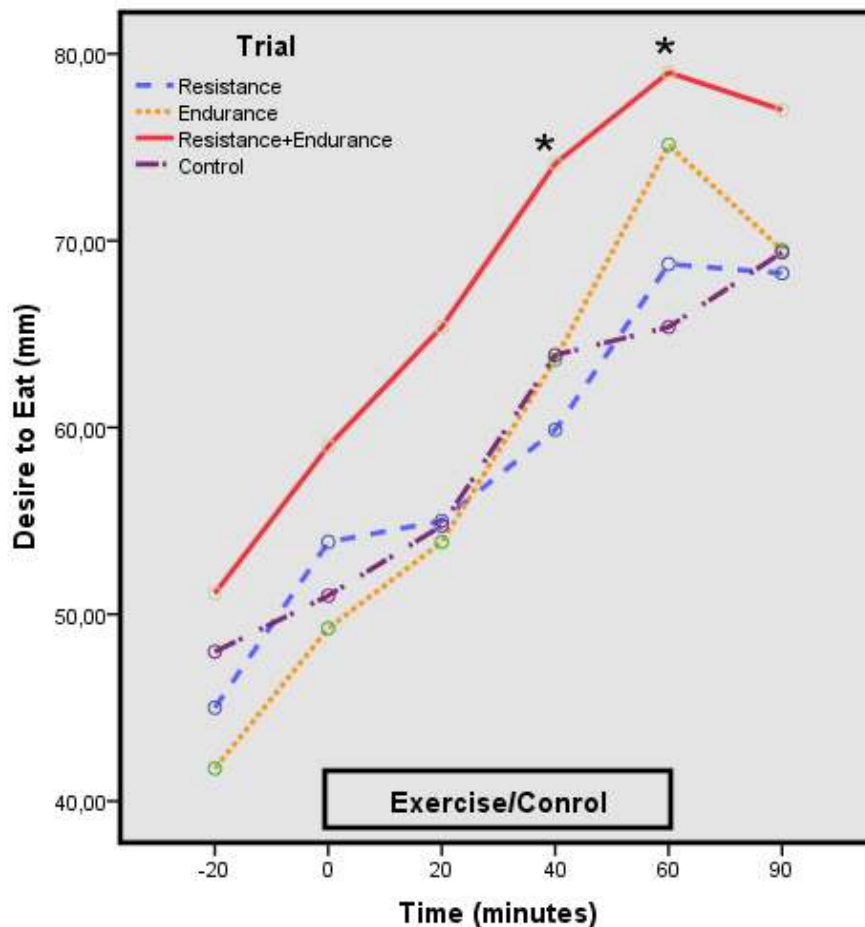
Age (yrs)	20.77±2.99
Height (cm)	157.88±2.99
Weight (kg)	53.50±7.03
BMI (kg/m <sup>2</sup> )	22.02±2.46
Body fat (%)	22.13±5.25

**Hunger:** Baseline fasting hunger did not differ significantly (Repeated Measures ANOVA,  $P=0.550$ ) between trials. Two-way ANOVAs revealed significant trial ( $p=0.047$ ) trial x time effects ( $p=0.041$ ) and time ( $p=0.000$ ) effects for hunger. Post hoc analysis indicated that endurance+resistance exercise trial increases the feeling of hunger more than resistance exercises trial ( $p=0.021$ ) and control trial ( $p=0.046$ ) at 60 min (Fig.1).



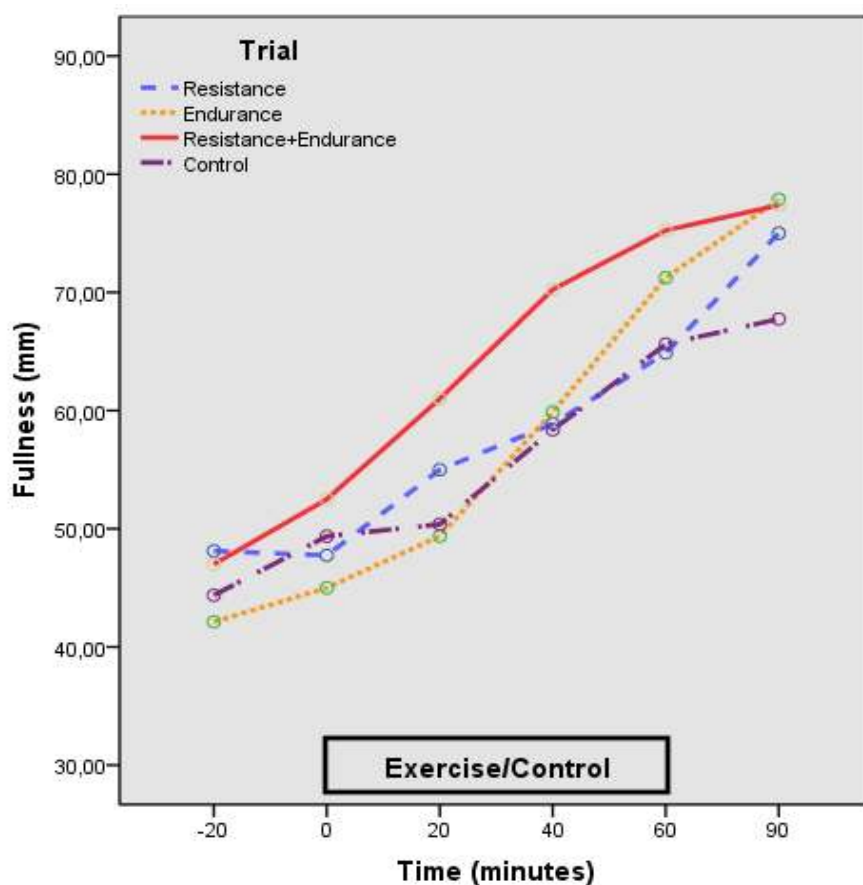
**Figure 1.** Hunger values over 90 min during the exercises and control trials. There was an effect of time ( $P= 0.000$ ), and a trial x time interaction ( $P = 0.041$ ) for hunger. \*Significantly different from the resistance exercise trial and control trial ( $P<0.05$ ) after Bonferroni adjustment.

**Desire to Eat:** Baseline desire to eat did not differ significantly (Repeated Measures ANOVA,  $P=0.650$ ) between trials. Two-factor ANOVA revealed a main effect of time ( $P= 0.000$ ), and a trial and time interaction ( $P=0.049$ ) for desire to eat, indicating that responses differed over time between trials. Post hoc analysis indicated significant differences between combined exercise trial and control trial at 40 ( $P=0.024$ ) and 60 ( $P=0.002$ ) min (Fig.2).



**Figure 2.** Desire to eat values over 120 min during the exercise and control trials. There was an effect of time ( $P= 0.000$ ), and a trial x time interaction ( $P = 0.046$ ) for desire to eat. \*Significantly different from the resistance exercise trial ( $P= 0,041$ ) after Bonferroni adjustment.

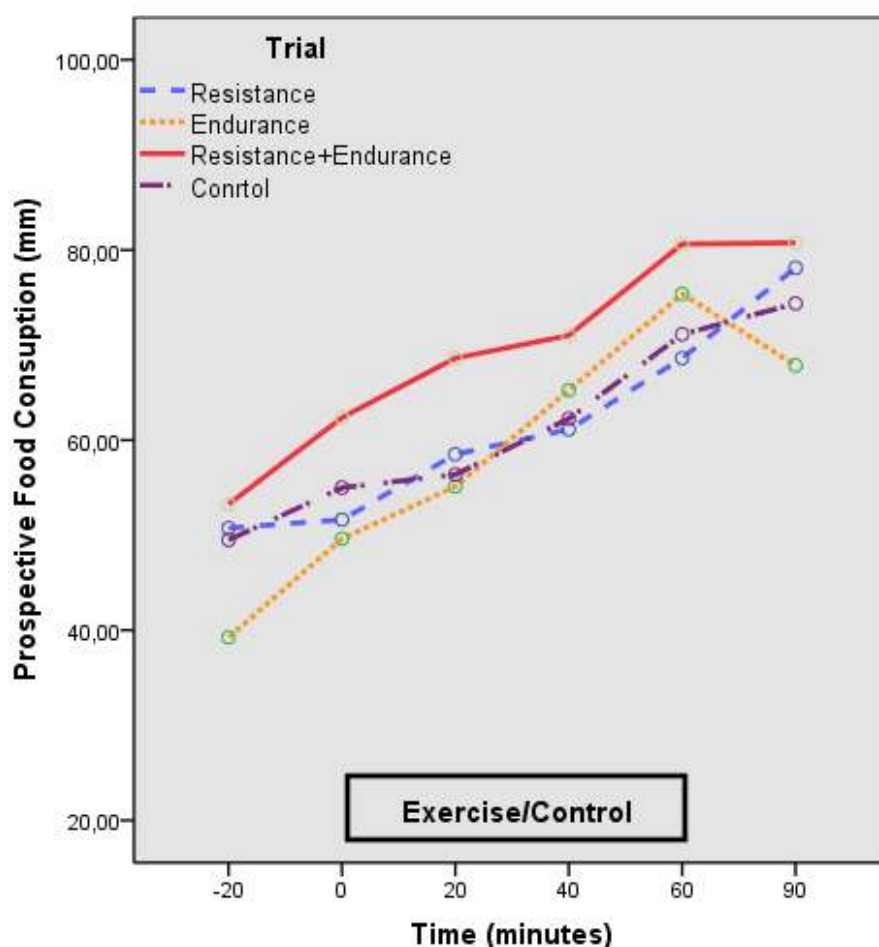
**Fullness:** Baseline fullness did not differ significantly (Repeated Measures ANOVA,  $P=0.760$ ) between trials. Two-factor ANOVA revealed a main effect of time ( $P =0.003$ ) for fullness, but there was no main effect of trial ( $P= 0.187$ ) and no interaction ( $P= 0.904$ ) effect (Fig. 3). These results indicate that fullness changed significantly during the trials but were not influenced by modes of exercise.



**Figure 3.** Fullness values over 90 min during the exercise and control trials. Two-factor ANOVA revealed a main effect of time ( $P = 0.003$ ) for hunger, but there was no main effect of trial and no interaction effect.

**Prospective Food Consumption:** Baseline prospective food consumption did not differ significantly (Repeated Measures ANOVA,  $P = 0.330$ ) between trials. Two-factor ANOVA revealed a main effect of time ( $P = 0.000$ ) for prospective food consumption, but there was no main effect of trial ( $P = 0.330$ ) and no interaction ( $P = 0.177$ ) effect (Fig. 4). These results indicate that prospective food consumption changed significantly during the trials but were not influenced by modes of exercise.





**Figure 4.** Prospective food consumption values over 90 min during the exercises and control trials. Two-factor ANOVA revealed a main effect of time ( $P = 0.000$ ) for prospective food consumption, but there was no main effect of trial and no interaction effect.

## Discussion

The aim of this study is to test the effects of acute resistance, endurance and resistance+endurance exercises on appetite markers ratings of healthy female individuals. According to the findings of the present research, resistance+endurance exercises trial increases the hunger and desire to eat more than control trial.

Recently many short and long term acute exercise studies have been conducted to determine the effects of acute exercise on appetite (Lofrano-Prado et al., 2012; Kawano et al., 2013; Bilski et al., 2013; Deighton et al., 2013; Alkahtani et al., 2014; Hagobian et al., 2013; Martins et al., 2014; Thivel et al., 2014). King et al. (1994) reported a suppression of hunger and a delay in the onset of eating following high-intensity exercise (70 %  $VO_{2max}$ ). Other studies have shown similar findings (King et al., 1994, 1995; Broom et al., 2007, 2009; Bilski et al., 2013; Deighton et al., 2013), and a recent meta-analysis demonstrated that energy intake during subsequent meals is not increased to match the energy expended during exercise (Schubert et al., 2012).



To the best of our knowledge, there have been only three researches on the effect of acute resistance exercise on appetite (Broom et al., 2009; Laan et al., 2010; Ozen et al., 2014). In the study conducted by Broom et al. (2009), 11 healthy male individuals participated in 3 different 8-hour trials with one-week intervals. These are resistance (at 12 RM 80%, 10 different exercises 12 reps 3 sets and 3-minute rests between sets; a 90-minute of exercise in total), aerobic (60-minute treadmill exercise at 70% of Max. VO<sub>2</sub>), and control trial. The findings showed that, hunger decreased in both exercise trials during exercise, but increased after exercise. Aerobic exercise resulted in a greater suppression of hunger than resistance exercise. Lean et al. (2010) conducted a similar research on nineteen young active adults involving separately conducted 35-minute aerobic and resistance exercises. Broom et al. (2009), Lean et al. (2010) found that hunger decreased only after aerobic exercise, and no significant changes were observed after resistance exercise. In a research conducted by Ozen et al. (2014) 10 healthy young men participated in two trials of 90-minute resistance (at 10RM 80% 7 different exercises 10 reps 3 sets and 2-minute rests between sets; a 60-minute of exercise in total) and control with one-week interval. They reported that appetite increased at a significant level during and after resistance exercise.

As can be seen above, the effects of acute exercise on appetite, either aerobic or resistance, are very contradictory. The possible reasons for these contradictions can be methodological differences such as exercise intensity, exercise duration, exercise type, gender, participant selection etc. Even there are some contradictory findings (Alkahtani et al., 2014; Martins et al., 2014), appetite is observed to be affected especially by exercise intensity (Bilski et al., 2013; Deighton et al., 2013; Williams et al., 2013). When the studies focusing on this subject are examined, despite some contradictory studies, generally, it can be seen that low or moderate intensity exercises do not affect hunger and food intake or increases them (Blundell et al., 2003; Stensel, 2010; King, 2010; Rumbold et al., 2011; Ozen, 2012; Bilski et al., 2013). Researches on the effect of high intensity exercises (>max.VO<sub>2</sub> %70) found that acute exercise suppresses hunger and energy intake (Blundell et al., 2003; King et al., 2011; Vatansever et al., 2011; Bilski et al., 2013). The possible cause for the suppression of hunger only after high intensity exercises is that, during high intensity exercise, sympathetic nervous system activation increases, blood flow in splanchnic area decreases and most of the blood in the circulation is directed to active muscles (Ikeda et al., 2010).

One of the important findings of the present research is that, resistance+endurance exercise affected appetite markers negatively more than resistance exercise. Combined exercise increased hunger more than resistance exercise. Concordantly, we can claim that resistance exercise is the most appropriate exercise type for weight control. The reason for the negative effects of combined exercise is not exactly known, though the amount of consumed energy may be one of the possible reasons. One of the limitations of the present research is that exercises were not isocaloric. Further researches with isocaloric exercises may provide more accurate information on the relationship between exercise mode and appetite. Thus, more research is needed to understand the impact of various modes and intensities of exercise and fitness level on appetite in different populations.

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