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# Effects of calisthenics and bodyweight high-intensity interval training on testosterone and cortisol levels in overweight men

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**ABSTRACT**

**Introduction:** Endocrine function and metabolic health can be impacted by obesity and overweight. The current study examined how bodyweight high-intensity interval training and calisthenics affected overweight men's cortisol and testosterone serum levels.

**Materials and Methods:** Thirty-two overweight men (age: 19.5 ± 5.4 year; height: 175.4 ± 4.2 cm; weight: 90.9 ± 7.6 kg) divided into three groups: Calisthenics training (n=12), bodyweight high-intensity interval training (HIIT) (n=12), and control (n=8). The HIIT and calisthenics groups trained three times a week for eight weeks. Ten mL blood samples were collected from the antecubital vein 24 h before and after the training. Testosterone and cortisol serum levels were measured by ELISA technique. ANOVA and Bonferroni were used for data analysis.

**Results:** The results showed that the serum levels of testosterone in HIIT and calisthenics groups increased significantly, and cortisol decreased compared to the control group ($P < 0.05$). However, there was no significant difference between the serum levels of testosterone and cortisol in HIIT and calisthenics groups.

**Conclusion:** Calisthenics and bodyweight HIIT can increase testosterone and decrease cortisol in overweight males.

**Keywords:** Calisthenics, HIIT, Testosterone, Cortisol, Overweight

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## Introduction

Obesity is a global health issue that has affected the majority of countries worldwide and affects children, teens, and adults. A well-controlled study revealed that obesity causes nearly 4 million deaths annually around the world, with 39% of these deaths happening in those with a BMI of 25 to 30 kg/m$^2$. This finding highlights the significance of dealing with obesity (1). The prevalence of obesity in societies has increased due to an array of behavioral, genetic, social, and economic factors. The prevalence of obesity is associated with technological progress and socio-economic development, which has created the so-called obesity-causing environment (2). Overweight and obesity are linked to several health problems, such as blood pressure, diabetes, dyslipidemia, arthritis, heart disease, stroke, and some types of cancer (1).

Overweight and obesity can also affect metabolic health and endocrine function. Among the endocrine system hormones greatly affected by overweight and obesity are testosterone and cortisol (3). These hormones significantly affect both protein metabolism and lipolysis, the metabolic pathways affected by obesity (4). Testosterone is an androgen produced by the activity of the hypothalamus-pituitary-gonadal axis. Some recent studies have shown a strong relationship between obesity and testosterone deficiency, so one of the leading causes of obesity is testosterone deficiency and on the other hand, testosterone deficiency can induce obesity (5).

Interestingly, overweight and obese children have been reported to have higher morning serum cortisol (6). This increment in serum cortisol levels is associated with hyperactivation of the hypothalamic-pituitary-adrenal axis (7). It is well established that prolonged elevated cortisol can result in higher fasting glucose levels, increased insulin resistance, higher blood pressure (activating the mineralocorticoid receptor), increased vascular responsiveness, and significant fat mass accumulation in the abdominal area (8). Scientists have shown that physical activity and exercise training effectively curb some metabolic disorders due to their effects on body composition and biological factors such as inflammatory cytokines, insulin resistance, and cholesterol (9). In this regard, high-intensity exercise is reported to significantly increase some hormones effective in metabolic regulation (10). Also, studies have suggested testosterone and cortisol as essential mediators of hormonal responses caused by exercise training and considered them effective biomarkers in anabolic and catabolic hormonal control, respectively (11). However, what kind of exercise training better affects body composition and hormones such as testosterone and cortisol is unclear.

An exercise training protocol that has recently attracted the attention of researchers and trainers is high-intensity interval training (HIIT) with body weight. HIIT consists of intervals of high-intensity exercise followed by periods of low-intensity active rest. These exercises are effective in weight loss (12). On the other hand, calisthenics are exercises that do not require special equipment but the weight of the person's body. These exercises are performed with different intensities and rhythms. These exercises develop strength, endurance, flexibility, and coordination (13). Since this type of exercise training does not require special tools and equipment, one can exercise more easily and quickly. In addition to using this type of training in athletes' success, scientists are also studying using calisthenics to contest obesity and help treat various diseases, such as cardiovascular diseases (13). Continuing this line of research, the present study aimed to investigate the effects of calisthenics and body weight high-intensity interval training on testosterone and cortisol serum levels in overweight males.

## Materials and Methods

### Participants

Thirty-two overweight men (age: 19.5 ± 5.4 yr; height: 175.4 ± 4.2 cm; weight: 90.9 ± 7.6 kg) were selected as subjects. The inclusion criteria were: ages 16 - 22 years, Body Mass Index >30 $kg{\cdot}m^{-2}$, sedentary less than about 1 hour of physical activity per week during the last six months), absence of diagnosed diseases (e.g., hypertension, diabetes, and cardiovascular disease), not under mental or hormonal therapy, and not using alcohol and cigarettes. Of the subjects in the pre and post-test phases and the absence of more than three sessions in exercises. Subjects were subsequently randomly divided into three groups: calisthenics training (n=12), body weight high-intensity interval training (HIIT) (n=12), and control (n=8). After examining the health condition of the subjects, A trainer measured the anthropometric indicators. All subjects read an informed consent form and consented to participate in this study. The study was approved by the Research and Ethics Committee of Arak University (Ethics code: IR-ARAKU.REC.1401.026).

Blood Sampling and Analysis

Blood samples (10 mL) were taken from the antecubital vein under the standard method after a 12-hour overnight fast. These blood samples were taken at baseline and 24 hours after the final exercise session. Cortisol and testosterone of blood samples were measured by the Chemiluminescence method using Liaison kits (England) with the sensitivities of 0.4 µg/dL and 0.17 nmol/L, respectively.

Training Protocols

Four subjects randomly participated in a pilot program to ensure that the subjects could perform the defined exercise protocol. The maximum heart rate ($HR_{max}$ = 220 - age) was used to determine the training intensity. In the HIIT stages, the exercise intensity was above 90% of $HR_{max}$, calculated for each subject individually. The HIIT with body weight and calisthenics training are shown in Tables 1 and 2 (12, 13). The HIIT and calisthenics groups trained three times a week for eight weeks. Participants performed a 10-minute warm-up and a five-minute cool-down for each exercise session. The control group did not have programmed training and followed their daily activities.

## Statistical Analyses

The Shapiro-Wilk test was used to determine the normality of the data distribution. Analysis of variance and Bonferroni post hoc test were used to determine mean differences between groups. The data were analyzed with the SPSS-26 statistical software. A significance level was set at $P < 0.05$ in all statistical tests.

**Table 1.** The eight exercises used in HIIT with the body weight training program are presented in this table.

| Exercise | Work/Rest interval | Sets | Rest between sets (min) |
|---|---|---|---|
| Lunge | 45sec/15sec | 3 | 2-3 |
| Jump squat | 45sec/15sec | 3 | 2-3 |
| Mountain climber | 45sec/15sec | 3 | 2-3 |
| Step-up | 45sec/15sec | 3 | 2-3 |
| Lateral jump squat | 45sec/15sec | 3 | 2-3 |
| Burpee | 45sec/15sec | 3 | 2-3 |
| Lateral step-up | 45sec/15sec | 3 | 2-3 |
| Jumping jacks | 45sec/15sec | 3 | 2-3 |

**Table 2.** The eight exercises used in the calisthenics training program are presented in this table.

| Exercise | Sets | Reiterations | Rest (min) |
|---|---|---|---|
| Lunge | 3 | 8-12 | 2 |
| Squat | 3 | 8-12 | 2 |
| Back extension | 3 | 18-22 | 2 |
| Crunch | 3 | 8-12 | 2 |
| Sissy squat | 3 | 8-12 | 2 |
| Burpee | 3 | 8-12 | 2 |
| Push-up | 3 | 8-12 | 2 |
| Incline sit up | 3 | 18-22 | 2 |

## Results

The baseline and post-exercise testosterone and cortisol levels of the three groups are presented in Table 3. The one-way ANOVA revealed no significant mean differences between groups in the baseline testosterone [$F(2,29) = 2.542$; $P = 0.09$]. The 2 × 3 mixed factorial ANOVA revealed a significant group × time interaction [$F(2,29) = 297.97$; $P < 0.001$] for testosterone. The Bonferroni analysis indicated that HIIT and calisthenics had significantly higher post-test testosterone than the control group ($P < 0.05$). There were, however, no significant differences between HIIT and calisthenics groups ($P > 0.05$) (Figure 1). The one-way ANOVA revealed no significant mean differences between groups in the baseline cortisol [$F(2,29) = 0.763$; $p = 0.47$]. The 2 × 3 mixed factorial ANOVA revealed a significant group × time interaction [$F(2,29) = 182.95$; $P < 0.001$] for cortisol. The Bonferroni analysis indicated that HIIT and calisthenics had significantly lower post-test cortisol than the control group ($P < 0.05$). There were, however, no significant differences between HIIT and calisthenics groups ($P > 0.05$) (Figure 2).

**Table 3.** The values of testosterone and cortisol before and after training of the groups are presented in this table.

| | **Control** | | **HIIT** | | **Calisthenics** | |
|---|---|---|---|---|---|---|
| | Pre | Post | Pre | Post | Pre | Post |
| **Testosterone** (nmol/L) | 11.03 ± 0.32 | 11.85 ± 0.35 | 10.56 ± 0.04 | 17.09 ± 0.37 | 10.72 ± 0.56 | 17.29 ± 0.47 |
| **Cortisol** (µg/dL) | 21.08 ± 1.06 | 22.55 ± 0.46 | 21.15 ± 0.78 | 14.57 ± 0.39 | 20.75 ± 0.75 | 15.20 ± 0.58 |

Data are shown as mean ± SD. HIIT: high-intensity interval training.

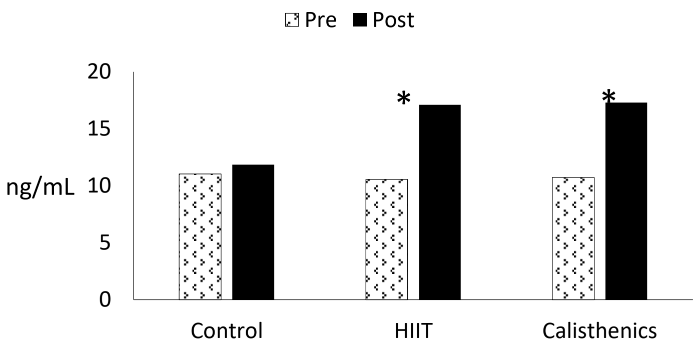


**Figure 1.** Pre and post-exercise training Testosterone levels (mean ± SD) in the control, high-intensity interval training (HIIT), and calisthenics groups. *Significant differences with the control group ($P < 0.05$).

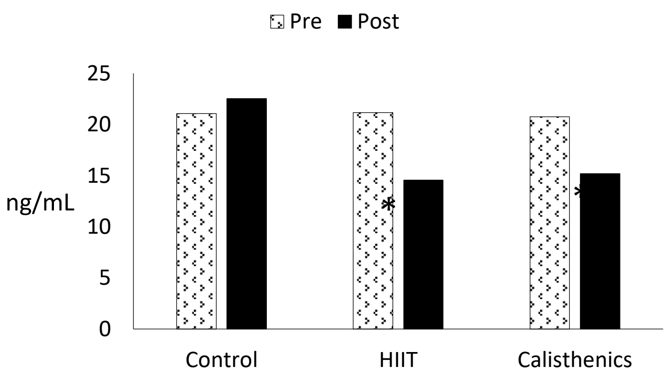


**Figure 2.** Pre and post-exercise training cortisol levels (mean ± SD) in the control, high-intensity interval training (HIIT), and calisthenics groups. *Significant differences with the control group ($P < 0.05$).

## Discussion

The present study showed that calisthenics and HIIT training increase testosterone and decrease cortisol levels compared to the control group. In confirming the positive effect of exercise training on increasing testosterone, in a systematic review and meta-analysis, Jansson et al. investigated the effects of resistance and endurance training alone or combined on hormonal adaptations in healthy children and adolescents. Subgroup analysis showed that resistance training significantly increased post-exercise testosterone levels (14). Velasco-Orjuela et al. studied the effect of HIIT on testosterone and cortisol in inactive, overweight people. They showed that this training increases testosterone concentration and decreases cortisol in overweight people (4). Kumagai et al. investigated the effect of 12 weeks of aerobic training on serum testosterone in overweight and obese men. At baseline, the testosterone levels of overweight and obese subjects were lower than normal weight subjects. After 12 weeks of training, serum testosterone levels increased significantly (15). In a comprehensive study, Riachy et al. showed that exercise training increases baseline serum testosterone concentration in overweight and obese individuals, associated with decreased body fat (16).

On the other hand, some studies have reported findings contrary to our findings. A study of professional cyclists showed that a training program decreased testosterone and increased cortisol concentrations, indicating an increased catabolic state (17). These inconsistencies can be caused by the differences in the training level of the subjects, the baseline values of cortisol and testosterone, and the type, intensity, and duration of the training used.

No study was found on the effect of calisthenics on testosterone or cortisol. In recent years, some studies have used the effect of calisthenics on body composition. Thomas and his colleagues investigated the effect of 8 weeks of calisthenics training on men's strength and body composition. Their study showed that this training affects body composition, especially in reducing fat mass (13). Kong et al. also reported that a calisthenics training program significantly reduces visceral fat in middle-aged and elderly obese people. They also reported that this exercise training can reduce blood sugar, insulin, and insulin resistance (18).

It is well-documented that the relationship between obesity and testosterone deficiency is bidirectional. Obesity is one of the most common and most potent risk factors for testosterone deficiency. The effect of obesity in reducing testosterone is more remarkable than aging (5). Decreased total testosterone levels are mainly the result of decreased sex hormone-binding globulin (SHBG) due to obesity-induced hyperinsulinemia and insulin resistance. Also, on the one hand, the increase in adipose tissue suppresses the hypothalamus-pituitary-testis axis by multiple mechanisms through increasing the secretion of factors such as pro-inflammatory cytokines and increasing insulin resistance (19). While on the other hand, low testosterone causes total and visceral fat mass accumulation. Obesity is associated with reduced free testosterone levels. Lutein hormone (LH) and follicle-stimulating hormone (FSH) levels are usually low or subnormal, suggesting that dominant suppression occurs at the hypothalamic-pituitary level. Therefore, adipose tissue expresses aromatase, which converts testosterone to estradiol (E2) (20). Exercise training could increase sex hormone-binding globulin (SHBG) by reducing fat mass and increasing insulin sensitivity. Interestingly, studies of lean subjects, in which even subjects using strict protocols to induce an acute increase in testosterone, did not observe a change in basal testosterone concentrations (16).

Some studies have shown that activation of the glycolytic pathway can stimulate testosterone production. Testosterone and lactate enhancement were observed during an exercise protocol in rats. In addition, these authors demonstrated that direct lactate injection into the testes increases testosterone production (21). Noppe et al. (2016) examined 3019 children and showed that even at age 6, high cortisol levels were associated with up to a 10-fold increased risk of obesity. In this study, cortisol levels were related to abdominal fat mass (22). Jackson et al. studied 2527 men and women and concluded a positive relationship between cortisol levels and body weight, body mass index, and waist circumference. They also found that long-term cortisol exposure was associated with persistent obesity over time. Jackson et al.'s findings seem to support the idea that high cortisol can be a factor in maintaining obesity (23).

The cause of increased cortisol levels in overweight and obese people is poorly determined and needs further investigation. People's inappropriate behavior toward obese people can increase cortisol in their bodies. Other factors that can increase cortisol in obese people include chronic stress, lack of sleep, pain, and inflammation caused by overweight and obesity. An interesting point to note is that high cortisol is one of the factors that induce insulin resistance (8). Exercise training seems to reduce cortisol by reducing body weight, insulin resistance, stress, and inflammation and increasing a person's mood and self-confidence (8).

Diet is essential in the body's response and adaptation to physical activity and exercise. One of the limitations of the current research is that the subjects' diet was not controlled. It is suggested to consider dietary control in future studies. Another limitation of this study is that the inflammatory status of the subjects was not measured. The production and secretion of cortisol and testosterone are affected by inflammatory conditions. Therefore, it is suggested to consider the inflammatory conditions of the subjects in future studies.

## Conclusion

Obesity is one of the leading health problems worldwide, which increases the risk of life-threatening diseases such as cardiovascular diseases, diabetes, and some cancers. One of the main problems caused by obesity is endocrine disorders, including increased cortisol and decreased testosterone levels. Experimental studies have shown that weight loss can decrease cortisol and increase testosterone. According to the present study, it seems that calisthenics and body weight HIIT can increase testosterone and decrease cortisol in overweight males.

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## Conflict of Interest

The authors declare no competing interests.

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