Med. J. Cairo Univ., Vol. 90, No. 4, June: 997-1003, 2022
www.medicaljournalofcairouniversity.net

Effect of High Intensity Interval Training on Plasma Cortisol Level in Women with Abdominal Obesity

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Abstract

Background: Cortisol or 'stress hormone' is a product of hypothalamic-pituitary-adrenal axis. Its primary functions are to increase protein breakdown, inhibit glucose uptake and increase lipolysis.

Aim of Study: To investigate the effect of high intensity interval training on plasma cortisol level in women with abdominal obesity.

Subjects and Methods: Forty women with central obesity participated in this study. They were recruited from El Menshawy general hospital. Their ages ranged from 30 to 40 year. They were randomly assigned into two groups; Group (A) included 30 women who underwent high intensity interval training (HIIT) in the form of running on treadmill for 4 minutes within 85%-95% of maximum heart rate with 4 minutes interval of active recovery for one month (3 sessions /week). Group (B) were 10 women who didn't perform any physical activity. International Physical Activity Questionnaire (IPAQ)was used to ensure that they didn't perform more than 150 minutes of any physical activity per week for last six months. Anthropometric measurements (weight, height, waist circumference waist hip ratio) and cortisol level were assessed before and after study.

Results: Significant decrease in weight, body mass index (BMI), waist circumference (WC) and waist hip ratio (WHR) in and significant increase in cortisol level in group (A). In group (B) there was no significant difference in weight, BMI, WC and cortisol level while there was a significant increase in WHR.

Conclusion: HIIT significantly improved weight, BMI, WC and WHR with significant increase in cortisol.

Key Words: *High intensity interval training – Cortisol – Central obesity.*

Introduction

THE prevalence of obesity worldwide, over the last three decades demonstrates a major public health epidemic in both the developed and the developing countries. Therefore, Obesity and its negative consequences have been of considerable attention as a major health hazard [1].

Obesity, resulting in ectopic fat deposition mainly in the central trunk, as well as in tissues such as the liver and skeletal muscle, is highly prevalent and has been linked to adverse cardiometabolic profiles such as metabolic syndrome, diabetes, dyslipidemia andhypertension [2].

Central obesity, which is defined as a state of excessive visceral fat accumulation, is associated with a decreased production of adiponectin, an adipose-specific molecule with anti-diabetic, anti-atherosclerotic and anti-inflammatory functions [3].

Obesity is characterized as a chronic state of low-grade inflammation due to the high levels of adipose tissue and its constituents, which secrete adipokines, such as pro-inflammatory cytokines in the circulation [4]. This inflammatory state has negative systemic effects including: Changes in metabolism, muscle morphology, endocrine, immunity, and cardiac function [5].

Two integral endocrine gland hormones greatly affected by obesity are testosterone and cortisol. These hormones have significant effects on both protein metabolism and lipolysis, two metabolic pathways affected by obesity, but also essential in the management and treatment of obesity and cardiovascular comorbidities [6].

Cortisol is a glucocorticoid hormone released by the adrenal glands in response to both psychological and physiological stress. Basal, or baseline,

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levels of cortisol rise with age in both men and women; suggesting that as we age, the hypothalamic-pituitary-adrenal (HPA) axis can become disrupted. In healthy adults, after waking in the morning, cortisol levels quickly increase and then taper across the morning hours [2].

Its primary functions are to increase protein breakdown, inhibit glucose uptake and increase lipolysis. The level of serum cortisol is affected by many factors such as intensity, duration and timing of exercise, type of exercise, age, altitude, environmental temperature and psychology.

Visceral adipose tissue, due to its large number of glucocorticoid receptors (GRs), is also particularly responsive to the actions of glucocorticoids, which further accentuates adipocyte differentiation and lipid deposition. However, high levels of cortisol are followed by a decrease in the number of GRs in adipose tissue, which attenuates lipolysis, further promoting the obese state [3].

Interestingly, physical exercise, particularly physical training is an effective strategy to combat metabolic disorders due to its ability to influence body composition and some biomarkers, such as cholesterol, inflammatory cytokines, and insulin resistance. High-intensity exercise (>80% of peak oxygen uptake), has been shown to produce significant increases in circulating hormones [7].

High-intensity interval training is practical for many individuals due to the minimal time commitment required when compared to traditional continuous endurance training; indeed, HIIT is characterized by high intensity sessions, that can range anywhere from 5 or 10 seconds to 5 or 10 minutes, interspersed by periods of recovery, which modality (i.e. active or passive recovery) and duration can vary according to the target [8].

Some studies have shown that HIIT may confer superior benefits to moderate intensity continuous training (MICT) in reducing adiposity in patients afflicted with overweight or obesity [9].

Obesity is a major health problem. Due to excessive weight especially central trunk, it causes bad appearance and less self-confidence specifically in women resulting in anxiety and depression. Not only affect psychological state but also hormonal changes (cortisol hormone). Hence the significance of this study is to discuss effect of high intensity interval training on cortisol and anthropometric measures.

Subjects and Methods

The current study is a randomized controlled comparative study to identify efficacy of high interval training on plasma cortisol level in women with central obesity.

This study was conducted at El-Menshawy general hospital from July 2020 till April 2021. The study was approved by research ethical committee of Faculty of Physical Therapy, Cairo University in March 2020 (No: P.T.REC/012/001972).

Forty women with abdominal obesity aged from 30 to 40 year who fulfilled the inclusion criteria of the study were randomly assigned to either interval training group (A) or control group (B). group (A) included 30 women who underwent high intensity interval training (HIIT) in the form of running on treadmill for 4 minutes within 85%-95% of maximum heart rate with 4 minutes interval of active recovery within 75-85% of maximum heart rate for one month (3 sessions /week). Group (B) included 10 women who did not participate in any regular training program during study.

Inclusion criteria:

Physical inactivity (i.e., <150 min of moderate-intensity exercise per week for greater than 6 months) according to International Physical Activity Questionnaire (IPAQ). Body mass index (BMI) ≥ 30 and $\leq 34.9 kg/m^2$. Waist circumference and waist hip ratio >88cm, >0.85 respectively. No evidence of adrenal impairment.

Exclusion criteria:

Cushing's disease (hypercortisolism) or Addison's disease (hypocortisolism), History of hormonal and cardiovascular diseases, adrenal tumor, uncontrolled diabetes or hypertension, deep venous thrombosis, musculoskeletal disorders which may affect their physical ability to do the exercises (foot instability, osteoarthritis), any medications that influence neuromuscular metabolism and contraceptive pills.

All participants were given a full explanation of assessment and treatment procedures, and informed consent form had been signed before participating in the study.

All patients were subjected to the following measurements before and after study period:

1- Weight and height was measured by weight and height scale to calculate BMI.

$$BMI = Bodyweight (kg) / Height (m^2)$$

2- Tap measurement was used to measure WC at the midpoint between the last rib and iliac crest, hip circumference at the highest point of hip and then calculate WHR within waist circumference/hip circumference.

3- International Physical Activity Questionnaire (IPAQ):

The International Physical Activity Questionnaires (IPAQ) comprises a set of 4 questionnaires. Long (5 activity domains asked independently) and short (4 generic items) versions for use by either telephone or self-administered methods are available. The purpose of the questionnaires is to provide common instruments that can be used to obtain internationally comparable data on health-related physical activity [7].

Blood collection and analysis:

Blood samples were collected before and after training in the morning between 8.00 to 9:00 am to avoid possiple diurnal influence. The time of blood collection was chosen because of its use in many studies conducted with these procedures for the control of the circadian hormonal range [10]. The post-training visit was scheduled at least 48h after the end of the training period to exclude acute effects of the final training session. To control the experimental conditions and potentially confounding factors, the patients were asked to minimize the possible stressors during the day before the loading measurements. Furthermore, the patients were asked to have at least 8h of sleep. Standardized kits were used to detect the serum cortisol level, using a SnibeMaglumi 1000 fully automated chemiluminescence immunoassay serum analyzer.

Therapeutic procedure:

First, maximum heart rate was calculated (MHR) (MHR = 208-0.7 x age) [11].

Then, The HIIT protocol was completed with fast walking or running on a treadmill. HIIT consisted of 40 minutes as follows: 4x4 minutes at 90% of MHR alternated by 3x3 minutes active recovery at 70% of MHR and a 10-min warm-up and 5-minute cool-down at 70% of MHR [12].

HIIT was conducted 3 days per week for four weeks.

Statistical analysis:

Unpaired *t*-test were conducted for comparison of subject characteristics between groups. Normal distribution of data was checked using the Shapiro-Wilk test. Levene's test for homogeneity of variances was conducted to ensure the homogeneity between groups. Unpaired *t*-test was conducted to compare the mean values of weight, BMI, WC, WHR and cortisol level between group A and B. Paired *t*-test was conducted for comparison between pre and post treatment in each group. The level of significance for all statistical tests was set at $p<0.05$. All statistical analysis was conducted through the statistical package for social studies (SPSS) version 25 for windows (IBM SPSS, Chicago, IL, USA).

Results

Subject characteristics:

Table (1) showed the subject characteristics of the group A and B. There was no significant difference between both groups in the mean age, weight, height and BMI ($p>0.05$).

Table (1): Comparison of subject characteristics between group A and B.

	Group A Mean ± SD	Group B Mean ± SD	MD	*t*-value	*p*-value
Age (years)	34.3±2.91	32.8±1.68	1.5	1.53	0.13
Weight (kg)	83.11±5.86	82.85±4.82	0.26	0.12	0.9
Height (cm)	161±3.51	161.5±3.47	-0.5	–0.39	0.69
BMI (kg/m^2)	32.03±1.36	31.74±0.96	0.29	0.61	0.54

SD: Standard deviation.
MD: Mean difference.
p-value: Probability value.

Effect of treatment on weight, BMI, WC, WHR and cortisol level:

- Within group comparison:

There was a significant decrease in weight, BMI, WC and WHR and a significant increase in cortisol levelin the group A post treatment compared with that pre treatment ($p>0.0001$). The percent of change of weight, BMI, WC, WHR and cortisol level in group A was 2.51, 2.53, 2.07, 1.33 and 36.3% respectively. There was no significant difference in weight, BMI, WC and cortisol level in group B between pre and post treatment ($p>0.05$); while there was a significant increase in WHR post treatment ($p<0.05$).

- Between groups comparison:

There was no significant difference in all variables between groups pre-treatment ($p>0.05$). Comparison between groups post treatment revealed a significant decrease in WHR and a significant increase in cortisol level of the group A compared with that of the group B ($p>0.01$) while there was no significant difference between groups in weight, BMI and WC post treatment ($p>0.05$).

Table (2): Mean weight, BMI, WC, WHR and cortisol level pre and post treatment of the group A and B.

	Pre treatment	Post treatment	MD	% of change	*t*-value	*p*-value
	Mean ± SD	Mean ± SD				
Weight (kg):						
Group A	83.11±5.86	81.02±5.94	2.09	2.51	20.22	0.0001
Group B	82.85±4.82	83.2±4.46	–0.35	0.42	–1.48	0.17
MD	0.26	–2.18				
t-value	0.12	–1.06				
	p=0.9	*p*=0.29				
BMI (kg/m^2):						
Group A	32.03±1.36	31.22±1.44	0.81	2.53	20.23	0.0001
Group B	31.74±0.96	31.88±0.88	–0.14	0.44	–1.55	0.15
MD	0.29	–0.66				
t-value	0.61	–1.35				
	p=0.54	*p*=0.18				
WC (cm):						
Group A	99.08±5.61	97.03±5.49	2.05	2.07	16.65	0.0001
Group B	100±4.06	100.45±3.91	–0.45	0.45	–1.64	0.13
MD	–0.92	–3.42				
t-value	–0.47	–1.81				
	p=0.63	*p*=0.07				
WHR:						
Group A	0.900±0.018	0.888±0.109	0.012	1.33	7.66	0.0001
Group B	0.905±0.017	0.911±0.108	–0.006	0.66	–2.71	0.02
MD	–0.005	–0.023				
t-value	–0.74	–3.34				
	p=0.46	*p*=0.002				
Cortisol level (mcg/dl):						
Group A	15.84±3.34	21.59±3.53	–5.75	36.3	–10.04	0.0001
Group B	15.27±2.99	15.31±2.93	–0.04	0.26	–0.61	0.55
MD	0.57	6.28				
t-value	0.47	5.05				
	p=0.63	*p*=0.0001				

SD: Standard deviation. MD: Mean difference. *p*-value: Probability value.

Discussion

Previous studies have been reported that exercise has a significant impact on the levels of several hormones, and can increase resistance and performance, as well as muscle mass. Hormone levels can change according to several parameters, including the type and length of exercise, the duration of time following exercise, the age and gender of the athletes, among others [13].

The study findings have shown that there were significant increase of the cortisol level and significant decrease in weight, BMI, WC and WHR after 4 weeks of high intensity interval training in study group, while no significant difference in weight, BMI, WC and cortisol level in group B between pre and post treatment while there was a significant increase in WHR post treatment.

The result of this study is supported by Sayyah et al., [14] who executedquasi experimental research on 20 healthy sedentary volunteer male who assigned into experimental and control group. The Experimental group participated in 8 consecutive weeks of intermittent aerobic exercise running 4 distances of 200 meter with rest interval between each run. There was a significant increase in serum blood cortisol level of the subjects following the running program (pre-test=149 vs. post-test=226 ng/mL, *p*=0.001). There was also a significant difference between the control and exercise group (exercise=226.7 vs. control= 156.1ng/mL, *p*= 0.0001) in the post-test.

This present study was consistent with the results of study by Abderrahman et al., [15] which examined effect of recovery mode of HIIT on glucoregulatory hormone in young adults.Twenty-four participants divided into control group, active recovery group (arg) and passive recovery group (prg). Blood samples were obtained at rest, at the end of the maximal graded test (MGT), after 10 and 30min of recovery, both before and after training. The two HIIT groups performed HIIT 3 times weekly for 7 weeks in the form of 30 second running and 30 second recovery for 400 meter. The result of this study revealed that there was significant increase of cortisol level in active recovery mode at the end of exercise (+20.50 ± 87.06; p 0.046),after 10min (+55.00±86.51; p=0.034) and after 30min of recovery (+30.00 ± 65.79; p=0.042) after training.

These results came in accordance with Paahoo et al., [16] who reported an increase in serum cortisol levels in obese children after 12 weeks of high intensity periodic training.

On the other hand Bahreini et al., [17] opposed our results as they who conductedexercises three days a week for eight weeks. The exercises were performed at 70% of VO2max in the first four weeks and at 80% of VO2max in the following weeks. Fasting blood sample of cortisol was taken 72 hours before and after training. Results revealed that cortisol level decreased insignificantly (p=0.131) in the interval training group.

In recent years, growing evidence has supported the role of high intensity interval training (HIIT) as an important strategy for reducing body mass, adiposity and cardiometabolic risk factors [18].

The result of this study was agree with the results of study by Tofighi et al., [19] who investigated the effect of eight weeks of high intensity interval training on serum amounts of fibroblast growth factor 21 (FGF21) and Irisin in sedentary obese women. The results of dependent t-test showed that 8 weeks of HIIT reduced WHR (p=0.002) 4.93%.

Our findings also were in agreement with Racil et al., [20] who examined the effects of high versus moderate-intensity interval training on cardiovascular fitness in obese female adolescents. Forty-seven participants were randomly assigned to one of three groups receiving either moderate-intensity interval training (MIIT at 80% maximal aerobic speed: MAS) or high-intensity interval training (HIIT at 100% MAS), with matched 15s recovery at 50% MAS, three times weekly for 12 week, or a no-training control group. Results showed that significant decrease in body mass and BMI in HIIT and MIT group, while Waist circumference decreased significantly only in the HIIT group (p=0.017).

Similar to our results, Alves et al., [21] compared the effects of 6 weeks of long or short high-intensity interval training (long- or short-HIIT) on body composition. Twenty previously untrained women (25±5 years) were randomly assigned to do a long-HIIT (n=10) or a short-HIIT (n=10). The long-HIIT group performed fifteen 1-min bouts at 90% of MHR, interspersed by 30-sec active recovery (60% MHR). The short-HIIT group per-formed forty-five 20-sec bouts at 90% of MHR, interspersed by 10-sec active recovery (60% MHR). The training for both groups was con-ducted 3 times a week for 6 weeks. Results revealed that there were significant decrease in WC ($F[1, 18]=9.36$, p=0.006, partial $\eta 2$=0.262), and WHR $F[1, 18]=6.41$, P=0.021, partial $\eta 2$=0.262).

Conclusion:

In conclusion, high intensity interval training increase cortisol level and have effective improvement in anthropometric variables (weight, body mass index, waist circumference and waist hip ratio). In addition, HIIT has a time efficient and has a superior effect of moderate continuous training.

Conflicts of interests:

All authors disclose no financial or personal relation ships with other people or organization that could influence the research's results.

Acknowledgements:

Many thanks, to all women who participated in this study for their cooperation.

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التعرف على تأثير التمارين المتقطعة عالية الشدة على مستوى الكرزتيزول فى السمنة المركزية فى السيدات

هدف الدراسة : التعرف على تأثير التمارين المتقطعة عالية الشدة على مستوى الكورتيزول فى الدم فى النساء ممن يعانون من الدرجة الأولى من السمنة المركزية.

فرضية البحث : لا يوجد تأثير للتمارين المتقطعة عالية الشدة على مستوى الكورتيزول فى الدم فى السمنة المركزية.

عناصر وأساليب : البحث لقد أجريت هذه الدراسة فى الفترة من يوليو ٢٠٢٠ حتى ابريل ٢٠٢١ على ٤٠ سيدة يتراوح أعمارهم من ٣٠ إلى ٤٠ سنة والذين تم اختيارهم من مستشفى المنشاوى العام بمدينة طنطا وتقسيمهم لمجموعتين متساويتين.

تم تقيمهم على مقياس الوزن والطول وقياس محيط الخصر بحيث يكون أكثر من ٨٨ سنتيميترا ونسبة محيط الخصر إلى محيط الحوض بحيث تكون أكثر من ٨٥. سنتيميترا ومؤشر كتلة الجسم يتراوح من ٣٠ فأكثر حتى ٣٤.٩ كيلو جرام لكل متر مربع فاقل. واستخدام استبيان معدل النشاط الدولى للتأكد أن النشاط لا يزيد عن ١٥٠ دقيقة فى الاسبوع. يتم سحب عينة من الوريد فى الفترة من ٨ حتى ٩ صباحاً لقياس مستوى الكورتيزول فى الدم. قامت مجموعة (أ) باستخدام التمارين المتقطعة عالية الشدة على المشاية لمدة ٤٠ دقيقة: ٤x٤ دقائق عند ٩٠٪ من معدل ضربات القلب القصوى بالتبادل مع ٣x٣ دقائق عند ٧٠٪ من معدل ضربات القلب القصوى. يقام التدريب ٣ مرات فى الأسبوع لمدة شهر. أما مجموعة (ب) لم تقوم بأى نشاط بدنى خلال هذه المدة.

أظهرت النتائج : أن هناك تحسن كبير بالنقصان فى الوزن ومؤشر كتلة الجسم ومحيط الخصر ونسبة محيط الخصر إلى محيط الحوض وزيادة كبيرة فى مستوى الكورتيزول فى الدم فى مجموعة (أ). بينما فى مجموعة (ب) لا يوجد اختلاف فى الكورتيزول والوزن ومؤشر كتلة الجسم ومحيط الخصر ويوجد زيادة كبيرة فى نسبة محيط الخصر إلى محيط الحوض.