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Effect of a High Intensity Interval Training (HIIT) on Serotonin and Cortisol Levels in Obese Women With Sleep Disorders

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Abstract

Background: Physical and physiological changes in obese middle-aged women cause hormonal changes, which are threatening factor for quality of life and health of elderly.

Objectives: The purpose of this study was to investigate the effect of a one-week HIIT on serotonin and cortisol levels in obese women with sleep disorders.

Methods: The research method was semi-experimental with pre-test post-test design, in which 34 middle-aged obese women with mean age of 47.11 $\pm$ 2.3, body mass index of 33.4 $\pm$ 2.7, and body fat percentage of 35.8 $\pm$ 2.3 were selected based on convenience sampling. Subjects were randomly divided to experimental groups (HIIT exercises) and control group. The experimental group performed a training program for one week, including three sets of RAST protocol (six bouts of 35 meters with 10 seconds of rest between each) with a four-minute rest between each set. Pittsburgh sleep test was used to diagnose sleep disorders (score 11 and above). Actiwatch 8 was used to evaluate quality of sleep in the post-test. In order to to measure the serotonin and cortisol levels, a serotonin kit from the German company LBL and SSGN kit was used, respectively. Independent and dependent *t*-test were used for data analysis at $P \leq 0.05$.

Results: The results suggested that cortisol level of HIIT training group was decreased significantly after the exercise intervention ($P = 0.01$; $t = 0.93$). On the other hand, the serotonin levels of the HIIT training group was significantly lower ($P = 0.001$; $t = 11.02$), while in the control group, the change was not significant ($P = 0.15$; $t = 1.53$) and the quality of sleep in the training group was improved significantly ($P = 0.001$; $t = 6.52$).

Conclusions: In conclusion, HIIT exercises can improve the quality of sleep through hormonal changes and as a result, improve the physiological functions of middle-aged women.

Keywords: High Intensity Interval Training, Serotonin, Cortisol, Sleep Disorders

1. Background

A common problem throughout the world is overweightness and obesity, which has caused metabolic syndrome diseases, such as diabetes, hypertension and fatty liver, and has incurred economic and social costs (1). Based on research evidence, obesity, regardless of physical and physiological effects, has led to behavioral disorders, such as insomnia and sleep disorders (2). A study by Spiegel et al. concluded that sleep disorders for several consecutive days increased the resistance of peripheral tissues to insulin, impaired glucose tolerance, increased hunger, and food intake, all of which led to hormonal imbalance in the body (3). It was shown in another study that lower quality of life is associated with more stressful hormones produced in the body (4). In this regard, specific protocols for the prevention and treatment of these disorders have been developed and proper exercise has always been an effective method (5). Sleep is a kind of restorative treatment that affects the homeostatic adjustment of body physiology, autoimmune nervous system, endocrinology, and immune system, and plays an important role in regulating physiological and psychological behaviors (6). Prevention of sleep disorders is important due to its vital role in various functions of the body (7). Regarding the circadian rhythm, hormonal homeostasis is among subjects pursued by researchers. In this regard, the use of excersize protocols with the goal of regulating this cycle can bring about better effectiveness for these interventions (8, 9). High intensity interval training (HIIT) is one of the exercise types that has been taken into consideration by researchers in the recent decades. This exercise involves repetitive sessions with short periods of intense intensity, approaching

the maximum VO2 max (10). Unlike aerobic exercises, the HIIT protocol has less been studied in middle aged people. With regards to age-related physiological changes, exercise training can probably have different effects on middle-aged people compared to young individuals. On the other hand, no research has been done on the effect of HIIT exercises on serum serotonin levels, cortisol, and the quality of sleep in middle-aged women. In general, any strategy that can reduce stress hormones and release more hormones of vitality and improve sleep quality, can be effective in preventing obesity consequences.

2. Objectives

Attempts were made to investigate the effect of a one-week HIIT on serotonin and cortisol levels in obese women with sleep disturbances.

3. Methods

The research method was semi-experimental with pre-test and post-test design. The sample size was calculated based on Equation 1:

$$n = \frac{\left(\sigma_1^2 + {\sigma_1}^2\right)\left(Z_{1-\frac{\alpha}{2}} + Z_{1-\beta}\right)^2}{d^2} \quad (1)$$

In this regard, 34 middle-aged obese women (with mean age of 47.11 ± 2.3 years and body mass index of 33.4 ± 2.7 kg/m^2), who referred to the Sports Counseling Center of Sport and Youth Administration of Qazvin in 2017, were selected based on convenience sampling. Inclusion criteria were age of 40 to 50 years old, lack of regular resistance exercise in the past six months, having sleep disorders (score 11 and above in Pitsburg scale), and having physical activity readiness. Individuals were excluded from the study due to the absence from the training session and measurement phases. In order to eliminate the possible effects of nutritional status and physical fitness level of the subjects on the results of the study, their status was measured using the N4 Software and Physical Activity Readiness questionnaire (PAR-Q). Furthermore, PAR-Q was used with the subjects responding before participation in the training. If they answered the questionnaire questions positively, they were excluded. The PAR-Q is a tool for screening and evaluating the readiness of participation in physical activity (11), the reliability and validity of which has been reported in previous studies (12). All measurements were performed at the exercise physiology laboratory of Imam Khomeini International University. Written consents were obtained prior to the study. Subjects were selected first through convenience and purposive sampling and then divided to exercise and control groups based on random allocation, using a table of random numbers. Five subjects discontinued the study due to absence from either training session or measurement sessions. Pittsburgh sleep test was used to diagnose sleep disorders (score of 11 and above). The measurement of blood pressure was carried out by the physician. The experimental group performed a training program for one week, including three sets of the RAST protocol (six bouts of 35 meters with 10 seconds of rest between each) with a four-minute rest between each set. All training sessions were conducted between 8 am and 11 am (13). To control the intensity of the training, Polar's pulsator (manufactured by Polar, Finland) was used. During this period, the control group did not participate in any regular training program and were only examined in the pre-test and post-test. The second stage of blood sampling was performed with the same initial test conditions, 48 hours after the last exercise session. A blood sample was taken from an antecubital vein in the sitting position and was taken by a lab technician at Imam Khomeini International Sport Sciences Laboratory. Blood samples were then rinsed at 3000 rpm and centrifuged for 10 minutes (with Hettich-Germany), and the extracted plasma was then stored at -17°C until measurement. Serotonin serum levels were measured from the serum Kit (LBL Company; Germany). Cortisol was measured using the Canadian SSGN kit and ELISA method. To measure the quality of sleep, an actigraphic technique was used using the Actiwatch edition 8 (made in England). The study protocols and procedures were approved by the Ethics Committee of Imam Khomeini International University. Independent and dependent *t*-test was used for data analysis at $P \leq 0.05$.

4. Results

At baseline, there was no significant difference between the experimental and control groups in the level of physical activity of readiness, systolic and diastolic pressure, and quality of sleep (respectively, P = 0.61; P = 0.44; P = 0.31; P = 0.39). As shown in Table 1 (paired *t*-test), there were no significant differences in the indices related to obesity (fat percentage and BMI) in the two groups in the post-test (respectively, P = 0.42; P = 0.51), while the systolic and diastolic pressure in the experimental group after the intervention was significantly improved (respectively, P = 0.0.04; P = 0.0.03).

As shown in Table 2, there was no significant difference between the micronutrients and macronutrients of the two groups before the beginning of the study ($P \leq 0.05$).

Table 1. General Characteristics of Subjects

Variable	Experimental Group		Control Group		P Value (Independent *t*-test)
	Pre-test	Post-test	Pre-test	Post-test	
Fat percentage (%)	33.4 ± 2.2	33.3 ± 2.6	33.1 ± 2.4	33.2 ± 2.5	0.66
BMI (kg/m^2)	23.5 ± 1.5	23.1 ± 1.8	23.2 ± 2.2	23.1 ± 2.3	0.41
Systolic pressure (mmHg)	134.1 ± 2.1	131.1 ± 2.6*	134.3 ± 2.4	134.5 ± 2.3	0.04
Diastolic pressure (mmHg)	88.2 ± 3.1	83.4 ± 2.7*	85.2 ± 2.8	86.4 ± 2.4	0.03

Table 2. Comparison of Micronutrients and Macronutrients at Baseline

Food Analysis	HIIT Group	Control Group	P Value
Carbohydrate (g)	234 ± 35.1	238 ± 44.2	0.13
Protein (g)	1.51 ± 6.9	48 ± 2.5	0.47
Protein (g)	62.4 ± 7.6	68.2 ± 6.3	0.13
Selenium (mg)	84.3 ± 7.5	94.1 ± 5.3	0.51
Vitamin E (mg)	4.1 ± 0.9	4.4 ± 1.1	0.73
Calcium (mg)	8.572 ± 70.1	8.478 ± 58.2	0.17
Vitamin C (mg)	51.2 ± 4.3	45.1 ± 3.2	0.09
Fiber (g)	41.2 ± 3.2	13 ± 5.4	0.19
Cholesterol (mg)	76.3 ± 4.1	66 ± 3.7	0.29

As shown in Table 3, paired *t*-test results suggested that the cortisol level of the HIIT training group decreased significantly after the exercise intervention (P = 0.01; t = 0.93), while there was no significant difference for the control group (P = 0.71; t = 0.26). On the other hand, the results showed that the level of serotonin in the HIIT training group decreased significantly after the intervention (P = 0.001; t = 11.02), while it was not significant for the control group (P = 0.15; t = 1.53). Quality of sleep was improved significantly in the training group (P = 0.001; t = 6.52), while it was not significant in post-test for the control group (P = 0.08; t = 1.11).

As shown in Figure 1, mean difference of post and pre-test was significantly different in both groups; the difference between the pre-test and post-test of training group was significantly different (P = 0.035; t = 2.227).

As shown in Figure 2, mean difference of post and pre-test was significantly different in both groups (P = 0.001; t = 10.734).

As shown in Figure 3, independent *t*-test suggested that mean difference of post and pre-test was significantly different in both groups (P = 0.001; t = 5.35).

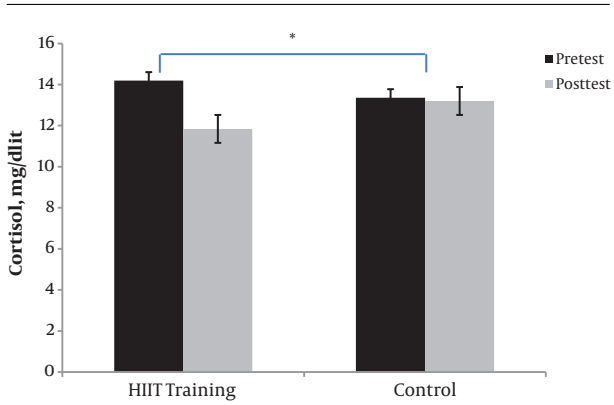

Figure 1. Comparison of cortisol levels in experimental and control groups

5. Discussion

Physical and physiological changes in obese middle aged women cause hormonal changes, which is a threatening factor for quality of life and health of elderly. Therefore, the aim of this research was to investigate the effect of a one-week HIIT on serotonin and cortisol levels in obese women with sleep disorders. It was found that decrease in cortisol hormone levels was accompanied by an increase in serotonin hormone following HIIT training. Another finding was the improvement of sleep quality in the training group. Concerning improvements in sleep in the training group, the results are consistent with the study by Taheri and Irandoust (2). They pointed out that an aerobic exercise would improve the sleep quality of obese individ-

Table 3. Cortisol and Serotonin Levels and Quality of Sleep Before and After the Intervention

Variables	HIIT Group (n=15)		Control Group (n=14)	
	Pre-test	Post-test	Pre-test	Post-test
Cortisol (mg/dL)	14.19 ± 2.34	11.84 ± 1.73*	13.36 ± 1.31	13.20 ± 1.47
Serotonin (ng/ml)	236.93 ± 68.82	351.10 ± 78.56*	249.20 ± 87.78	242.40 ± 77.49
Quality of sleep (%)	51.08 ± 12.36	67.90 ± 11.92*	52.48 ± 12.43	55.12 ± 12.50

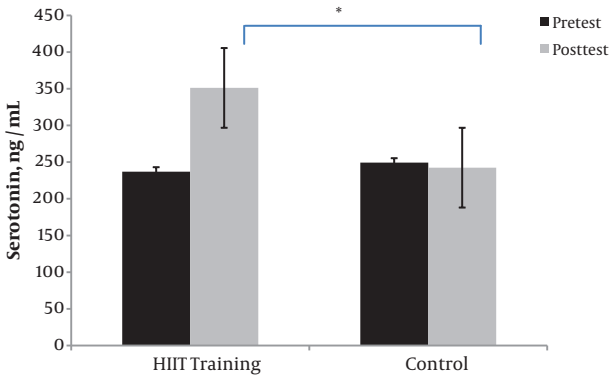

Figure 2. Comparison of serotonin levels in experimental and control groups

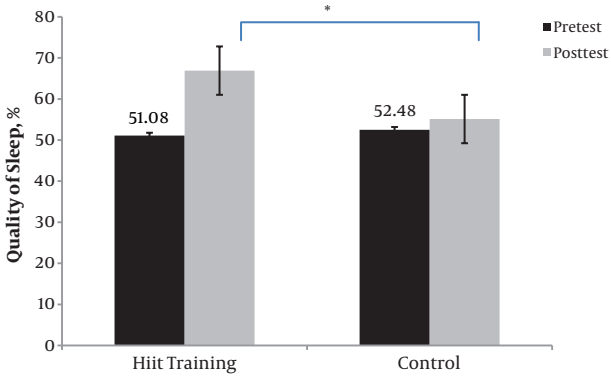

Figure 3. Comparison of quality of sleep in experimental and control groups discussion

uals. Along with the results of this study, Song MR and Song LR showed that implementation of regular aerobic exercise results in improved sleep quality in older women (14). Regarding the improvement in sleep quality following aerobic exercise, a possible reason may be a decrease in the percentage of body fat, in particular visceral fat, which can lead to better breathing during sleep and create a better quality of sleep. Regarding the effectiveness of HIIT exercises, it is important to note that the high accumulation of acidic lactate in the body following these exercises increases muscular fatigue and leads the body further towards relaxation (15, 16). In contrast to the results of this study, Arazi et al. found no significant difference in cortisol levels after combined strength-endurance exercise (17), while Rosa et al. observed a decrease in cortisol levels after combined exercise (18). Another finding was that HIIT exercises increase serum levels of serotonin. One possible reason can be attributed to the positive effect of physical activity on cerebral mechanisms affecting serotonin and dopamine secretion (19). On the other hand, it has been shown that increased serotonin can be a factor in improving quality of sleep (13). Based on research evidence, HIIT exercise increases tryptophan, which enters brain cells and stimulates serotonin synthesis and circulation in the bloodstream (20, 21). In summary, It was indicated that HIIT exercises can lead the body to release and improve physiologic relaxation, which itself facilitates the process of sleep as an effective behavior in the body. Besides the positive consequences of exercise therapy in general health of common people and athletes (22, 23), it can be used to cure problems, such as sleep disorders and hormonal imbalance. One of the study limitations was the relatively low number of subjects. Its recommended to recruit more subjects in future research to increase the generalizability of the results. Having more control over psychological characteristics of subjects through different psychological tests in terms of inclusion criteria is another point that should be considered by researchers.

5.1. Conclusion

High intensity interval training (HIIT) can help improve sleep quality through hormonal changes and as a result, improve the physiological functions of middle-aged women.

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Footnotes

Conflic of Interests: None declared.

Ethical Considerations: The study protocols and procedures were approved by the Ethics Committee of Imam Khomeini International University.

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