



Evaluation of Changes in Insulin Resistance and Serum Cortisol Levels after Eight Weeks of Continuous and Interval Aerobic Training in Healthy

Ameneh Bahreini

(PhD) Department of physical Education, Islamic Azad University, Chalous Branch, Iran

Maryam Akbarpour

(PhD) Department of Cultivation and Plant Breeding, Faculty of Agriculture and Natural Resources, Islamic Azad University, Chalous Branch, Iran

Rozita Fathi

(PhD) Department of sport physiology, Mazandaran University, Babolsar, Iran

Hossein Goldashti

(PhD) Department of Physical Education, Islamic Azad University, Chalous Branch, Iran

Corresponding author: Ameneh Bahreini

Tel: +989113251062

Email: a_bahreine2@yahoo.com

Address: Department of physical Education, Islamic Azad University, Chalous Branch, Iran

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ABSTRACT

Background and objectives: Given the growing prevalence of obesity in children, the present study aimed to investigate effects of continuous and interval aerobic training on insulin resistance index and serum cortisol levels of obese girls.

Methods: The study was performed on 36 healthy girls aged 9-11 years with a body mass index (BMI) of higher than 85th percentile. The subjects were randomly divided into three groups of interval training, continuous training and control. The training groups performed exercises three days a week for eight weeks. The exercises were performed at 70% of $\dot{V}O_{2max}$ in the first four weeks and at 80% of $\dot{V}O_{2max}$ in the following weeks. Fasting blood samples were taken 72 hours before the first session and 72 hours after the last training session in order to measure levels of cortisol, glucose, insulin and Homeostatic Model Assessment for Insulin Resistance (HOMA-IR). Weight, BMI and body fat percentage were also measured by conventional methods. Data analysis was performed in SPSS 21 using paired t-test and one-way analysis of variance.

Results: The mean level of BMI and body fat percentage decreased significantly after the interval and continuous training, respectively ($P < 0.05$). The HOMA-IR index did not change significantly in the study groups ($P > 0.05$). The cortisol level increased slightly in the continuous training and control groups ($P = 0.075$) and decreased insignificantly ($P = 0.131$) in the interval training group. There was no difference between the training groups and the control group in terms of HOMA-IR and cortisol levels.

Conclusion: Insulin levels, HOMA-IR showed a decrease trend while a reasonable increase in cortisol level we showed in the continuous training group. BMI level and fat percentage decreased in two both training groups.

Keywords: Continuous training; Interval training; Insulin Resistance; Cortisol; Obese children.

INTRODUCTION

Obesity is increasing among children worldwide (1, 2). Childhood obesity is considered as a predictor of obesity in adulthood (3), so that an increase in body mass index (BMI) in childhood indicates an increase in BMI in adulthood (4). According to predictions, about 35 million children will be overweight or obese worldwide (5). About 27% of children and 21% of adolescents were obese in Iran in 2016 (1).

Proper physical activity is the easiest way to maintain good health and weight because about one-third of the daily energy is spent on physical activity (6). Childhood obesity can lead to chronic diseases such as diabetes, apnea, cardiovascular disease and high blood pressure in childhood and adulthood (7-10). Behavioral problems and reduced puberty age, especially in girls, are other complications of childhood obesity (11). In addition to obesity, secretion of growth hormone and IGF-I increases during puberty, leading to increased oxidation of free fatty acids and the resistance of peripheral tissues to glucose uptake, thereby increasing insulin resistance (12, 13). With regard to increase in insulin concentration, serum level of sex hormone-binding globulin increases the fat tissue and cortisol level and also impairs the hypothalamic-pituitary axis in obese individuals (14). Regular physical activity is a non-pharmacological treatment of obesity and insulin resistance (2). Ciolac et al. found that a 16-week intense aerobic training program in healthy young women can improve insulin sensitivity (15). Ramezani et al. reported that endurance training could significantly reduce insulin resistance in obese children aged 8-12 years (16). According to Papovic et al., the minimum intensity of endurance exercise necessary to produce cortisol response is about 60% of VO_2 max (17). Tartibian et al. also observed a significant increase in creatine kinase and cortisol levels in children immediately after training (18). Paahoo et al. indicated an increase in serum cortisol levels after 12 weeks of intense periodic training (14).

Given the importance of training in weight control and reducing risk factors of diabetes and insulin resistance (14, 18), the present study aimed to investigate effects of eight weeks of continuous and interval aerobic training on some metabolic factors, insulin resistance and serum cortisol levels in obese

girls aged 9-11 years.

MATERIALS AND METHODS

This applied and semi-experimental study was carried out in Mazandaran University in Babolsar, Iran. Thirty-six female students aged 9 to 11 years with a BMI of more than the 85th percentile were selected via convenience sampling. The participants were randomly assigned to three groups of interval training, continuous training and control. Luteinizing hormone (LH) and follicle-stimulating hormone (FSH) and estradiol levels were also evaluated to assess the students' puberty. The study was registered in Iran Clinical Trial center (IRCT20180928041160N1) and received ethics approval (ethical code: IR.UMZ.REC.1397.015).

The experimental groups trained three days a week for eight weeks according to the training protocol introduced by Mahgoub and Aly with some modifications (19). Maximum heart rate was calculated using the equation of Tanaka, Monahan and Seals (20). Heart rate was controlled using a heartbeat monitor (Polar AXN500, Finland). The subjects were weighed using a scale (Seca, Germany) and BMI was calculated by dividing weight (kg) by square height (meters).

Fasting blood samples were taken 72 hours before the first training session and 72 hours after the last training session. The samples were centrifuged at 10,000 rpm for 10 min (Universal, BH-1200, Netherland) to separate serum. Serum glucose level was measured by enzymatic pigmentation method (peroxidase (POD)/glucose oxidase (GOD) using an autoanalyzer (Hitachi, 917, Germany). Serum levels of insulin and cortisol were measured by an electrochemiluminescence technique using an autoanalyzer (Cobas E-411, Japan). Body fat percentage was measured by Harpenden caliper (Baty, UK) and the Jackson/Pollock method using the following formula (21):

Percent body fat = $(0.41563 \times \text{sum of skinfolds}) - (0.00112 \times \text{square of the sum of skinfolds}) + (0.03661 \times \text{age}) + 4.03653$, where the skinfold sites (measured in mm) are abdominal, triceps and suprailiac.

The insulin resistance index (HOMA-IR) was calculated using the following equation:

$\text{HOMA-IR} = [\text{fasting insulin } (\mu\text{U/mL}) \times \text{Fasting glucose (mmol/L)}] \div 22.5$ (22). HOMA-IR cut-off point was considered 4.0 for II-III stages of tanner puberty table.

Normal range of cortisol, insulin and glucose in children was considered as 135-635 nmol/L, 2.6-25.9 μ IU/mL and 60-110 mg/dL, respectively.

Data were presented as mean \pm standard deviation. Statistical analysis was performed using the SPSS software (version 21). Normal distribution of data and equality of variances were examined by Shapiro-Wilk test and Levene's test, respectively. The paired t-test was used to examine intragroup changes, while one-way analysis of variance was used to evaluate intergroup differences. A p-value of less than 0.05 was considered as statistically significant.

RESULTS

[Table 1](#) shows the demographic information of subjects in the study groups.

The mean weight of subjects in the training groups did not change significantly after the training period, but a significant weight gain ($P < 0.05$) was observed in the control group compared to the pretest state. In addition, BMI

and body fat percentage of subjects in the training groups decreased significantly after the training. However, no change in BMI was observed in the control group, and the body fat percentage showed an increasing trend. Serum glucose level increased in all groups compared to pretest ($P > 0.05$). Serum insulin level increased slightly in the interval training group but reduce insignificantly in the continuous training group ($P > 0.05$). Moreover, serum insulin level increased significantly in the control group ($P < 0.05$). Insulin resistance increased significantly in the control and interval training groups ($P < 0.05$) but reduced slightly in the continuous training group ($P > 0.05$). Serum cortisol levels did not change significantly in the study groups ([Table 2](#)).

One-way analysis of variance indicated significant differences in weight, BMI, body fat percentage and blood glucose levels between the study groups. The insulin resistance index and serum cortisol levels did not differ significantly between the study groups ([Table 3](#)).

Table 1- Demographic information of participants in the study groups

Variables	Control group (n=9)	Continuous training group (n= 11)	Interval training group (n= 12)
Age (year)	9.66 \pm 0.56	9.33 \pm 0.57	9.86 \pm 0.95
Height (cm)	139.55 \pm 4.91	137.63 \pm 7.52	142.75 \pm 8.66
Weight (kg)	46.95 \pm 4.98	47.76 \pm 9.88	53.57 \pm 10.42
BMI (kg/m ²)	24.03 \pm 1.29	26.04 \pm 4.18	25.83 \pm 2.18

Table 2- Mean level of study variables in the pretest and posttest stages

Groups	Variables	Pre-test	Post-test
Interval training group	Weight (kg)	53.5 \pm 10.4	53.0 \pm 10.1
	BMI (kg/m ²)	25.8 \pm 2.1	25.1 \pm 12.1*
	Body fat percentage	31.6 \pm 1.9	29.7 \pm 1.8*
	Glucose (mg/dL)	81.8 \pm 4.1	87.5 \pm 5.5
	Insulin (μ IU/mL)	17.4 \pm 8.5	18.4 \pm 4.2
	HOMA-IR	3.5 \pm 1.8	3.9 \pm 0.9
	Cortisol (nmol/L)	526.811 \pm 174.905	449.301 \pm 198.512
Continuous training group	Weight (kg)	52.3 \pm 19.1	52.5 \pm 19.4
	BMI (kg/m ²)	26.9 \pm 6.3	26.4 \pm 6.4*
	Body fat percentage	31.3 \pm 4.2	30.3 \pm 4.4*
	Glucose (mg/dL)	80.7 \pm 7.5	82 \pm 7.4
	Insulin (μ IU/mL)	17.1 \pm 12.3	15.2 \pm 5.7
	HOMA-IR	3.4 \pm 2.7	3.1 \pm 1.3
	Cortisol (nmol/L)	548.777 \pm 89.254	632.504 \pm 221.203
Control group	Weight (kg)	46.9 \pm 4.9	47.8 \pm 5.1*
	BMI (kg/m ²)	24.1 \pm 1.29	24.1 \pm 1.28
	Body fat percentage	31.5 \pm 1.8	32.1 \pm 1.8
	Glucose (mg/dL)	91 \pm 4.2	92 \pm 5
	Insulin (μ IU/mL)	15.2 \pm 5.9	16.3 \pm 6.3
	HOMA-IR	3.4 \pm 1.4	3.8 \pm 1.6
	Cortisol (nmol/L)	402.716 \pm 108.220	477.627 \pm 203.175

Table 3- One-way analysis of variance between pretest and posttest level of target variables in the study groups

Variables	F-Value	Significance level	Degrees of freedom
Weight	6.03	0.005	2
BMI	4.6	0.01	2
Body Fat percentage	14.7	0.0	2
Glucose	5.54	0.009	2
Insulin	0.46	0.63	2
Insulin resistance index (HOMA)	0.58	0.56	2
Cortisol	1.891	1.170	2

DISCUSSION

Given the growing prevalence of obesity in children and its complications (16), the present study aimed to investigate the effects of aerobic training on demographic factors such as weight, BMI and body fat percentage as well as some metabolic factors such as serum glucose and insulin levels in obese girls. In the present study, the mean weight of participants in the sedentary group increased significantly after eight weeks, but no increase was seen in the continuous and interval training groups. In addition, BMI and body fat percentage decreased significantly in the training groups but remained almost unchanged in the sedentary group. Unlike the result of this research, Habibian et al. did not see any significant difference in weight and body fat percentage after eight weeks of training aerobic training groups (23). Similar to our findings, Fazelifar and Ebrahim also reported a significant reduction in body fat mass, weight and BMI after endurance-strength training, but the type and duration of the trainings were different (1). Russell et al. reported a significant reduction in BMI after moderate and high intensity interval training in adolescents (24, 25).

In all study groups, a significant increase was noted in serum glucose levels. Although the levels were still in the normal range, the changes in glucose level were more significant in the interval training group compared to the control group. Serum insulin level decreased in the continuous training group and increased in the interval training and control groups, but none of these changes were significant. Inconsistent with our findings, Habibian et al. reported a significant reduction in these two

variables 48 hours after aerobic training in obese girls aged 8-12 years (23). Tang et al. also reported a reduction in serum glucose and insulin levels after a period of resistance training (26). In line with our findings, Garcia Hermoso et al. observed no significant change in serum glucose, insulin and insulin resistance index after 12 weeks of high-intensity interval training in obese/overweight individuals aged 6 to 17 years (27).

There was no significant difference in the HOMA-IR index between the training groups. Similarly, Hamedinia et al. stated that the insulin resistance index did not change significantly in obese children and adolescents after eight weeks of endurance training in Cortisol is a catabolic hormone that can be affected by obesity (14). Organs involved in physical activity secrete corticotropin releasing hormone and activate the hypothalamic-pituitary-adrenal axis, which eventually increases cortisol secretion (10, 14). Due to the higher energy demand during physical activity, increasing cortisol concentrations can increase blood sugar levels and help break down of fats and proteins and stimulate gluconeogenesis while reducing glucose uptake in peripheral tissues. However, the extent of increase in cortisol concentration depends on the intensity, duration and type of physical activity. The highest cortisol response is achieved when the overall stress (volume and/or intensity) of the training is high (36). In exercise adaptation, cortisol prepares the body for the next bout of exercise. Following acute exercise, there is an increased tissue sensitivity to glucocorticoids that serves to counteract muscle inflammation, cytokine synthesis and muscle damage.

Inactivation of cortisol to cortisone appears to be another adaptation strategy to exercise but overtraining may impair inactivation of cortisol in athletes (36, 37). Despite the fact that an increase in baseline or acute increase in cortisol in stressful conditions is detrimental to health, an increase in acute and basal levels of this hormone may be helpful in response to chronic training.

water (28). Lee et al. reported that six weeks of skipping rope training improved the HOMA-IR index in obese adolescents (29). Furthermore, Nasis et al. indicated that a 12-month aerobic training program could improve insulin sensitivity in obese/overweight adolescent girls (16). Nasimento et al. found that after eight months of training without weight change, the HOMA-IR index decreased in obese/overweight children and adolescents (15). It seems that improvement of HOMA-IR requires longer training interventions. Despite the inactivity of the control group, there was an increase in the level of HOMA-IR. Owing to the fact that the subjects of this research were in the puberty period, they are not resistant to insulin because the cut-off point of HOMA-IR in these two stages was defined as 4.0 (30). In general, puberty contributes to insulin resistance due to the increased secretion of growth hormone and IGF-I, which increases the probability of temporary insulin resistance in non-diabetic children with normal weight; however, this change is irreversible in obese children (12). Abbasi et al. observed a significant increase in insulin levels in obese children with insulin resistance compared to insulin sensitive obese children, but there was no difference between two groups in terms of glucose levels (31).

In our study, serum cortisol level did not change significantly in the training groups. Paahoo et al. reported an increase in serum cortisol levels in obese children after 12 weeks of high intensity periodic training. Papovic et al. reported a significant increase in serum cortisol level after endurance training with 60% VO_2 max (17). Hamedinia et al. also reported an increase in peripheral cortisol production in the phenomenon of abdominal and visceral obesity (32). Foley et al. found no significant change in fasting cortisol levels in non-athletes after six and 12 weeks of aerobic training (33).

CONCLUSION

In summary, the reduction in weight, BMI and fat percentage were obtained in both training groups after eight weeks of training intervention. It appears that the continuous training is more promising because of a decreasing trend in insulin level, HOMA-IR and a reasonable increase in cortisol level.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest regarding publication of this article.

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