Research Article

The effect of primary swimming on the hormonal anabolic-catabolic balance and serum leptin in obese children and adolescents

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Abstract

The main purpose of this study was to investigate the effect of primary swimming on the hormonal anabolic-catabolic balance and serum leptin in obese children and adolescents. Sixty obese subjects (children and adolescents) were randomly assigned to one of four groups: 1) Primary swimming training (children); 2) control (children); 3) Primary swimming training (adolescents); and 4) control (adolescents) groups. Our experimental subjects performed a primary swimming training for 8 weeks, 3 sessions per week and 60 minutes per session. Before and after training period, blood samples, anthropometric and body composition measurements were taken in fasting state from all subjects. The findings showed that the primary swimming training prevents significant increase of serum leptin and insulin hormone in adolescents. Furthermore, primary swimming training caused a significant decrease in body fat percent, body fat mass and body mass index, a significant increase of VO_{2max} in children and adolescents, a significant decrease in cortisol hormone as well as a significant increase in fat free mass in adolescents ($p<0.05$). There was a positive and significant correlation between levels of leptin changes and body fat percent and fat mass after primary swimming training ($p<0.05$). In addition, there was a negative and significant correlation between levels of leptin hormone changes and fat free mass after primary swimming training ($p<0.05$). Therefore, it can be concluded that eight weeks of primary swimming training improves serum leptin and some of the anthropometric, hormonal and metabolic parameters.

Key Words: **Obesity, Swimming, Leptin, Cortisol, Insulin, Testosterone**

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Introduction

Despite the continuous advances in technology and industry, as well as the increasing expansion of urbanization and the reduction of physical activities, obesity and its complications are increasingly a more important place in the field of macro-health planning in the country. In our country, statistics and surveys show a significant prevalence of this disease in the younger generation, especially children (Allison et al., 2017). Obesity is a complex reaction between genetic-physiology, socioeconomic and cultural factors. Several environmental and genetic factors affect the incidence and severity of obesity.

Moreover, leptin is a hormonal agent that has gained special attention in recent years considering its role in obesity, especially in childhood and puberty. Leptin is an amino acid protein 167 that is involved in regulating metabolic processes, and represents the amount of body fat stored. This hormone with special receptors in the hypothalamus, inhibits the secretion of Y neuropeptide, reduces appetite. On the other hand, by increasing the metabolic rate of the body, it controls the amount of energy needed and thus the amount of body fat (Pasman, Westerterp, & Saris, 2013). Its plasma values are directly related to the body's fat reserves and respond to changes in the body's energy balance. There is a direct relationship between body fat mass and serum leptin levels in all age groups of infants, children and adults. The onset of severe primary obesity in humans may be due to congenital leptin deficiency and mutations in the leptin receptor gene. On the other hand, obesity may be associated with higher amounts of leptin, so that leptin levels in obese children and adolescents are 4 to 5 times higher than those in children of normal weight. This refers to some types of resistance to leptin, which may be similar to the insulin resistance phenomenon seen in obese people (Houmard et al., 2019).

Various physiological factors such as fasting, exercise and exposure to cold affect serum leptin levels; each of which can reduce the incidence of obesity gene and consequently decreases circulatory leptin. Other factors may be involved in r-

-egulating leptin levels. Among these factors, insulin, corticosteroids, free fatty acids and food intake have been noted. The effect of physical activity (exercise) on leptin concentration is usually controversial. Exercise is known as an effective reducer of obesity (fat mass) (Kelishadi et al., 2017). Exercises have the concentration of certain hormones such as insulin, cortisol, cataclamins, estrogen, testosterone, dihydropy and growth hormone, which may alter leptin concentrations. It has been shown that leptin can be a potentially reliable factor in assessing sensitivity of obese adolescents to exercise programs. Many previous findings about exercise and leptin reactions in adults, information about children, especially sedentary obese children are sparse. To our knowledge, the effect of swimming exercises in children and adolescents on leptin has not been investigated and children and adolescents have not been compared with each other due to puberty phenomenon (Pilcova et al., 2016; Rasa'i & Gini, 2014). Therefore, more research should be conducted in this area and their results should be provided to researchers, parents and planners and managers in order to better manage the phenomenon of obesity in these ages. To this end, the present study aimed to investigate the effect of preliminary swimming exercises on serum leptin and testosterone, cortisol, growth and insulin hormones in obese children and adolescents.

Materials and Methods

Subjects

After explaining the methodology and purpose of the study, a written consent was obtained from the subjects and their parents to participate in the study. According to the demographic and well being questionnaire, people who had no history of disease, drug use, smoking and exercise were selected. Then, the subjects were divided into 4 groups with considering the percentage of fat for each subjects (Pilcova et al., 2016).

1- Swimming exercise group (children: 15)

2- Control group (children: 15)

3- Swimming exercise group (adolescents: 15)

4- Control group (adolescents: 15)

Preliminary swimming exercises

Preliminary swimming exercises were determined for 8 weeks and 3 sessions per week. The duration of each session was 60 minutes. In the initial sessions, 35 minutes of each training session were devoted to warm-up along with stretching, softness, running in water and relief games, ball games (water polo, hand-discipline, etc.), and in the remaining 15 minutes, the subjects swam with initial intensity of 60 to 70 percent of maximum heart rate. With the continuation of training sessions, swimming time increased so that in the last sessions, swimming time increased to 45 minutes and maximum heart rate increased to 75-85% of heart rate.

Anthropometric and body composition

Percentage of body fat, weight, body mass index, fat mass, lean mass, in the pre-test and post-test stages were measured using body composition analysis, model 418 B-C- made by TANITA Japan.

Table 1. Physical, physiological and biochemical indicators of experimental and control groups of children and adolescents before swimming exercises.

	Children's swimming (1)	Children's control (2)	P value between groups	Adolescents swimming (3)	Adolescents control (4)	P value between groups (6)
Height (cm)	154±7.98	155.33±0.5	0.005	168.31±7.7	171.08±5.5	0.002
Age (year)	11.5±0.51	12.8±0.7	0.003	16.02±0.8	16.33±0.71	0.004
Weight (kg)	63.95±0.44	59.42±7.92	0.001	82.48±11.12	89.26±10.34	0.001
Body fat (percent) %	32.61±4.47	30.42±2.94	0.001	29.28±3.95	27.0±2.83	0.001
Body fat weight (kg)	21.07±5.35	18.23±3.64	0.006	23.81±4.9	24.38±4.34	0.007
Lean weight (kg)	42.87±6.37	41.05±3.94	0.003	58.28±7.8	66.33±6.71	0.002
BMI (kg/m^2)	26.43±2.45	25.7±2.05	0.001	29.01±2.15	30.53±3.26	0.001
Maximum aerobic power (ml/kg/min)	32.61±3.3	81.33±2.27	0.002	27.47±2.39	26.39±2.29	0.001
Leptin (ng/ml)	12.71±3.73	10.04±4.06	0.001	5.52±3.95	5.44±2.02	0.009
Testosterone (ng/ml)	0.26±0.14	0.27±0.09	0.008	1.51±0.71	1.59±0.56	0.007
Growth (ng/ml)	0.34±0.15	0.32±0.01	0.007	0.47±0.32	0.4±0.2	0.007
Insulin (mul)	8.33±2.5	6.82±2.76	0.001	37.10±2.9	9.97±4.01	0.007

Blood sampling and hormone measurement

Blood samples were taken after 12 to 14 hours of fasting condition in the morning. Blood samples were sent to the University Endocrinology Research Center to measure serum levels of leptin, growth, cortisol, testosterone and insulin hormones. Elisa method was used using diagnostics biochem kits of Canada and concentrations of leptin, growth, cortisol and testosterone were assessed and mecrodia kit was used to measure insulin hormone. The coefficient of determination between the experiments (CV Intraassay) of all measurements was less than 8.3%.

Maximum oxygen

It was used to determine the maximum oxygen consumption of the subjects under a maximum of one mile of Rockport walking. The maximum oxygen consumption was calculated through the following formula: -25.7 (body weight in kg) 20.02+2.6965)= Vo_{2Max} (test time per minute) 224-(0.1)+595.5 (age per year) (body weight in kg) / (heart rate per minute) -11.5.

Statistical analysis

The Kolmograph-Smirnov test was used to determine the normality of the distribution of variables in the research; one-way variance analysis (ANOVA) to assess the homogeneity of the groups and to compare each of the changes in the existing variables (added scores) in the four groups (if significant); Bonfrroni and Dantes c follow-up test; and Pearson correlation test was used to investigate the relationship between the variables. All statistical operations were performed by SPSS software (version 13) and the significance of the tests was considered at p<0.05.

Results

The findings showed that preliminary swimming exercises prevented a significant increase in serum leptin levels in adolescents (45.47%) (less than the control group). The results of hormones also showed that preliminary swimming exercises had no significant effect on testosterone in children and adolescents and on the other hand, caused a significant decrease in serum cortisol levels (15.97%) only in adolescents (table 1,2 & 3). As shown in table 4, there was a positive and non-significant correlation between leptin and cortisol changes (P=0.06, R=0.37), and between changes in leptin hormone and mass index (P=0.5, R=0.10). Also, there was a significant positive correlation between changes in leptin and body fat percentage (P=0.43, R=0.01), as well as between changes in leptin and body fat weight (P=0.01, R=0.44), and there was a negative and significant correlation between leptin and lean weight.

Discussion

The results of the present study showed that preliminary swimming exercises in children caused a non-significant reduction in serum leptin (8.41%). However, this change was significant in adolescents Which is in line with the findings of Thong et al. (2014). Also, it can be stated that preliminary swimming exercises prevented a significant increase in serum leptin levels in adolescents (45.47%). Leptin increased for unknown reasons in adolescents (both the preliminary swimming training and the control groups) (Larijani & Ghodsi, 2019). In the preliminary swimming training group, this may be somewhat related to the increase in insulin (0.28%) and in the control group, it may be due to an increase in body fat mass (2.84%) and an increase in body fat percentage (0.9%). In a study on obese child-

Table 2. Physical, physiological and biochemical indices of experimental and control groups of children and adolescents after swimming exercises

	Children's swimming (1)	Children's control (2)	Adolescents swimming (3)	Adolescents control (4)
Weight (kg)	63.97±10.99	60.87±8.68	83.04±11.49	90.09±11.75
Body fat (percent)	31.13±4.39	30.15±4.04	28.32±3.97	27.3±3.79
Body fat weight(kg)	20.01±5.28	18.17±4.95	23.34±5.05	24.97±6.22
Lean weight (kg)	43.9±6.87	41.49±5.2	59.12±7.94	64.2±7.01
BMI (Kg/m2)	25.9±2.6	24.57±2.84	28.71±2.23	30.39±3.63
Maximum aerobic power (ml/kg/mi)	36.38±4.38	36.03±1.77	31.56±3.67	26.54±2.13
Leptin (ng/ml)	11.64±3.59	8.06±4.26	8.03±4.79	12.04±5.38
Testosterone(ng/m)	0.26±0.18	0.26±0.15	1.92±0.79	2.13±0.72
Growth (ng/ml)	0.26±0.04	0.27±0.07	0.56±0.5	0.04±0.156
Insulin (mu/l)	10.33±3.63	9.87±3.12	10.4±2.78	12.28±3.89
Cortisol (mg/di)	6.5±2.96	7.53±3.05	6.05±1.01	6.04±1.87

Table 3. Changes in physical, physiological and biochemical indicators of experiment and control groups of children and adolescents after exercises

	Children's swimming (1)	Children's control (2)	Adolescents swimming (3)	Adolescents control (4)	P value between groups
Weight (kg)	0.76±0.3	0.85±0.28	0.95±0.21	0.65±1.16	0.006
Body fat (percent)	- 1.52±1.07	- 0.11±0.71	- 0.63±1.23	0.57±1.13	0.001
Body fat weight (kg)	-0.98±0.77	-0.05±0.5	- 0.38±0.84	0.69±0.94	0.001
Lean weight (kg)	1.04±0.96	0.3±0.61	1.06±1.04	- 0.23±1.46	0.002
BMI (Kg/m2)	- 0.5±0.34	- 0.07±0.03	- 0.44±0.42	- 0.02±0.53	0.003
Maximum aerobic power(ml/kg/mi)	4.35±3.02	1.25±0.77	2.63±1.96	0.92±0.92	0.001
Leptin (ng/ml)	1.03±3.18	- 10.97±3.06	2.19±3.18	6.78±2.97	0.001
Testosterone (ng/ml)	-0/09±0/04	- 0.01±0.03	0.44±0,60	0.35±0.52	0.005
Growth (ng/ml)	0.07±0.18	0.05±0,13	0.12±0.48	0.01±0.22	0.002
Insulin (mu/l)	2.46±4.46	2.53±2.39	0.02±2.86	2.81±2.18	0.001
Cortisol (mg/id)	- 2.70±3.07	- 3.28±4.4	- 1.36±0.96	1.65±1.45	0.006

-ren and adolescents, it was reported that leptin levels in obese children and adolescents are associated with body mass index and after a 5-week weight loss program, the mean age of leptin in obese children and adolescents has been significantly reduced (Maddah et al., 2019). Researchers claimed that leptin is a sensitive parameter to body composition and weight loss in children. On the other hand, Houmard et al. (2019) investigated the effects of short-term aerobic training (7 consecutive days) 1 hour a day with 75% maximal oxygen consumption on leptin concentration and insulin action in healthy young men and old people and showed that although training programs improved insulin sensitivity but had no effect on leptin concentration and that exercise can reduce body fat mass (Kohrt, Landt, & Birge, 2015). It has been reported that the decrease in leptin levels due to long-term exercises is also due to a decrease in fat mass (Mohasi, Afkhami, & Sedghi, 2017). There are many factors that may reduce serum leptin concentration due to exercise including the reduction of body fat mass, weight loss and some unknown factors, changes in energy balance due to training programs and changes in free leptin compared to protein-bound leptin. Maziekas et al. (2015) found that in long-term exercise performed with less intensity, the body uses beta-oxidation as a primary energy system and increase in beta-oxidation leads to a decrease in fat mass. Therefore, the reduction of leptin due to endurance training is due to a significant decrease in subcutaneous adipose tissue (French & Castiglione, 2018).

In addition, exercise can increase lipolysis response to beta-adrenergic stimulant in subcutaneous adipose tissue and thus reduce the incidence of obesity gene and consequently decrease the concentration of head leptin (Pocai et al., 2016). Pasman, Westerterp, and Saris (2013) reported that endurance training, independent of changes in insulin content and body fat percentage, reduced plasma leptin content. The results of the present study showed that in children, body fat percentage (4.53%) and fat mass weight (4.6%) decreased and lean weight did not change significantly after preliminary swimming exercises. In adolescents, body fat percentage (3.27%) and fat mass weight (1.97%) decreased, while their lean weight increased after preliminary swimming exercises (1.74%). This may be due to low serum testosterone in obese boys, which cannot effectively reduce leptin production (Afkhami & Sedghi, 2017).

Although some effects of testosterone are supported by the association of leptin to testosterone ratio and age remain (Okazaki et al., 2014). No significant changes in testosterone in the present study may be due to the number of subjects or the type and magnitude of training protocol pressure noted in some researches (Fakhrzadeh et al., 2018). In the present study, there was no significant correlation between changes in leptin and cortisol changes after preliminary swimming exercises, but preliminary swimming exercises caused a significant decrease in serum cortisol in adolescents (15.97%). In their research, Fisher

Table 4. Correlation between leptin and other dependent variables

Variable	Cortisol	Body fat	Free fat mass	BMI	Testosterone	Growth	Insulin	Weight
Leptin	0.43	0.42*	-0.4*	0.9	0.29	0.20	0.13	0.26

* Sign of significant

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and colleagues showed that cortisol stimulates the incidence of leptin genes. A large increase in cortisol concentration stimulated an increase in leptin levels, but only a weak correlation was observed between leptin and cortisol (Fisher et al., 2017). Moreover, in this study, there was no significant correlation between leptin changes and insulin changes after preliminary swimming exercises, but the results of a study showed that the concentration of leptin is positively correlated with insulin and high glucose concentrations in normal and obese individuals (Moshtaz, Ahmad Gholam, & Sanjari 2018). Research has showed that in adolescents, the relationship between leptin and insulin is mediated by body fat. It seems that insulin is involved in regulating leptin gene expression, although it is influenced by changes related to circulatory glucose status. Lack of significant increase in leptin in adolescent swimming training group may be partly related to no significant increase in insulin in this group (Guiglino & Carnerio, 2017).

The present study did not show a significant correlation between changes in leptin and growth hormone changes in both children and adolescents' training groups which is consistent with the results of Marilisa et al. (2019). The intensity and duration of training in the present study may not be enough to provide the necessary stimulants for increasing growth hormone in children and adolescents (Marilisa & et al, 2019). The role of growth hormone in lipid enhancement has been emphasized by parallel increase in plasma growth hormone after exercise, muscle lipoprotein lipase activity and lipid oxidation. Although obese children and adolescents were unable to perform continuous activities and swimming exercises during one hour of training, preliminary swimming exercises during the training period caused more activity and mobility (Marilisa & et al, 2019), so that they were able to practice swimming within one hour at the end of the training period. In general, in this study, preliminary swimming exercises prevented a significant increase in leptin in adolescents (Kraemer et al., 2018). This effect can be due to a significant decrease in body fat and serum cortisol percentage and significant increase in lean weight in adolescents due to preliminary swimming exercises. Also, no significant increase in insulin was due to these exercises, so doing such exercises and training programs is a necessity for obese adolescents (Kunning, 2015).

Conclusion

The findings of the present study revealed that the primary swimming training prevents significant increase of serum leptin and insulin hormone in adolescents. Moreover, primary swimming training caused a significant decrease in body fat percent, body fat mass and body mass index, a significant increase of vo2max in children and adolescents, a significant decrease in cortisol hormone as well as a significant increase in fat free mass in adolescents. There was a positive and significant correlation between levels of leptin changes and body fat percent and fat mass after primary swimming training. In addition, there was a negative and significant correlation between levels of leptin hormone changes and fat free mass after primary swimming training. Therefore, it can be claimed that primary swimming training improves serum leptin and some of the anthropometric, hormonal and metabolic parameters.

What is already known on this subject?

Pervious study considers negative effects of obesity on levels of leptin in different age.

What this study adds?

Primary swimming training improves serum leptin and some of the anthropometric, hormonal and metabolic parameters.

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Compliance with ethical standards

Conflict of interest The author declare that he doesn't have any conflict of interest.

Ethical approval All procedures performed in the current study involving human participants were in accordance with ethical standards of the institutional research committee and with the 1975 Helsinki Declaration and its later amendments or comparable ethical standards. The study was approved by the ethical committee of Shahid Chamran University of Ahvaz.

Informed consent All participants signed a written informed consent form that was approved by the ethical committee.

Author contributions

Conceptualization: B.K.; Methodology: B.K.; Software: B.K.; Validation: B.K.; Formal analysis: B.K.; Investigation: B.K.; Resources: B.K.; Data curation: B.K.; Writing- original draft B.K.; Writing - review & editing: B.K.; Visualization: B.K.; Supervision: B.K.; Project administration: B.K.; Funding acquisition: B.K.

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