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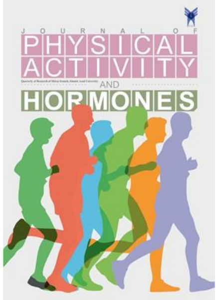

Comparison of two methods of high-intensity aerobic and strength training on insulin, growth hormone (GH), and glucose homeostasis in professional Taekwondo athletes

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Keywords
High-intensity aerobic training, high-intensity strength training, insulin hormone, growth hormone (GH), glucose homeostasis.

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Abstract

Introduction: The purpose of this study was to determine the difference between two methods of high-intensity aerobic and strength training on insulin, growth hormone (GH), and glucose homeostasis in professional taekwondo athletes.

Material & Methods: This quasi-experimental research was conducted on one group of professional Taekwondo players (n=12) with an average age of 22 ± 1.5 years. All athletes regularly trained three days a week. In the first-week training session, regular training sessions (RTS, 90 minutes) were performed, high-intensity strength training (80%, 1RM, 45min) in the second, and high-intensity aerobic training (80% VO2max, 45 min) in the third week respectively. 24 hours after each training session, insulin, growth hormone (GH), and glucose homeostasis (FBS, HOMA-IR, Insulin) were measured after 10 hours of fasting. Data related to the sample are presented with descriptive statistics, and repeat measurement of analysis of variance (ANOVA) was used to evaluate variables. All statistical tests were performed and considered significant at a $P \leqslant 0.05$.

Results: The findings showed that there is a significant difference between the three methods of regular exercise training, high-intensity aerobic and strength training on the levels of insulin hormones, growth hormone (GH), and glucose homeostasis of professional taekwondo athletes ($p<0.05$). Serum insulin, FBS, and HOMA-IR increased in high-intensity strength training more than in high-intensity aerobic training. HOMA-B and GH levels increased in high-intensity aerobic training more than in high-intensity strength training ($p<0.05$).

Conclusion: According to the findings, in professional taekwondo athletes, high-intensity strength training may increase serum insulin levels and insulin sensitivity, and high-intensity aerobic training increases growth hormone levels. The findings of this study show that high-intensity aerobic exercise is better for taekwondo practitioners to increase growth hormone levels and to increase insulin hormones and improve glucose homeostasis levels, it seems that it is better to implement and perform high-intensity strength training for professional taekwondo athletes.

1. Introduction

Taekwondo (TKD) is an Olympic martial art. It is currently held in more than 210 countries worldwide (1,2). TKD is the most popular sport among martial arts and is very popular among children and adolescents (3). Taekwondo competitions include three rounds, each for 2 minutes, separated by a 1-minute rest between rounds (4). The winner is the fighter who completes two out of three rounds in his/her favor (5). As such, taekwondo can be described as a high-intensity combat sport, known for its precise hand and foot strikes, its intermittent nature, and the high physical demands on the athletes (6,7). Taekwondo athletes present high general and specific physical fitness such as optimal dynamical strength performance, high cardiorespiratory fitness, and high ability to execute repeated high-intensity-specific and intermittent motor efforts and require relatively short durations of physical activity and explosive strength, thereby needing anaerobic power as well as aerobic capacity (7,8). Taekwondo athletes' strength, muscular endurance, postural stability, flexibility, agility, and speed are important factors for improving performance, including accuracy and skill development (9). The sport contains a wide range of high-intensity aggressive techniques. Athletes may have to fight 4–5 matches in one day to reach the final game; therefore, they encounter excessive physiological fatigue during the competition (6).

On the other hand, high values of maximum oxygen consumption (VO2 max), heart rate, and blood lactate concentration during competitions demonstrate the importance of aerobic metabolism to professional taekwondo athletes (10). Taekwondo training and competitions also include many high, fast, and jump kicks that require motor responses from the athletes. Therefore, taekwondo athletes must have excellent bio-motor capabilities, including aerobic and anaerobic fitness, muscle strength, speed, reaction time, agility, lactate production, clearance, and flexibility (6). One of the types of exercise that increases aerobic and anaerobic capacity in athletes is high-intensity interval training (HIIT). The popularity of this type of training is expanding due to the rapid improvement of sports capacity (11).

High-intensity training (HIT) was performed in repeated sessions with relatively short to long intermittent activities with a full intensity greater than 90% of the maximum oxygen consumption. Depending on the intensity of the exercises, HIT may take from a few seconds to a few minutes. In this case, different periods are separated by a few minutes of rest or low-intensity activity. This training protocol in different forms improves the physical performance of athletes (12). Furthermore, the effect on anthropometric parameters such as body fat and fat-free mass and enhancing the capacity of aerobic and anaerobic systems has been reported in athletes)8(.

Lia et al reported that 8 weeks of non-training in 16 taekwondo athletes caused a decrease in aerobic capacity an increase in body fat percentage and a decrease in muscle mass. There are various types of HIIT exercises, which can be referred to as intermittent resistance exercises or high-intensity endurance exercises, as well as simultaneous high-intensity resistance and endurance exercises)13,14(.

There is a lot of evidence showing significant hormonal changes in martial arts athletes. Growth hormone (GH) or somatotropin is a polypeptide hormone secreted by the anterior pituitary gland Therefore, it is important in human development. Metabolic and anabolic responses associated with growth hormone are mediated through the interaction of the hormone with its receptor, directly by tyrosine kinase activation and indirectly by induction of insulin-like growth factor 1 (IGF-1) (15,16). All types of exercise induce more growth hormone (GH), and plasma GH levels rise within 10 to 20 minutes after exercise. Physical activity can stimulate growth hormone and IGF-1 secretion, and therefore IGF-1 may be related to exercise intensity. Based on the results of studies, the duration and intensity of physical training and the type of training have a significant effect on IGF-1 concentration (17).

Insulin is a hormone that is secreted by the beta cells in the pancreas (18). Because insulin concentrations decrease during exercise, this makes insulin's position unique among other hormones (19). Investigations indicate that various types of exercise with an effect on the production of myokines may increase energy consumption by affecting the burning of white fats and affecting body composition and insulin resistance. So, changes in many biochemical parameters such as insulin, leptin, and glucose homeostasis hormones have been reported following intense resistance training (18, 20). Moderate-intensity continuous aerobic exercise causes a gradual decrease in blood glucose, while anaerobic physical activity or combined activities are often associated with a higher risk of hyperglycemia during exercise. In addition to the risk of hyperglycemia during combined and anaerobic activities, hypoglycemia can occur during recovery (21). Glucose homeostasis in athletes means the balance of glucose in the blood of athletes. Glucose homeostasis in athletes can change due to their physical activity and heavy training. Probably, the time of exercise intervention is an influential factor in changing fasting blood sugar and glucose homeostasis indicators (11). Taekwondo is one of the intermittent sports in which athletes must train and challenge with different intensities using all energy systems. This is because the actions involved in Taekwondo are characterized by periods of high levels of technical, tactical, psychological, physical, and physiological fitness. So, it is important to determine the effect of different training methods, alone or in composition, on blood muscle damage biomarkers (22). The ultimate goal of sports training is to improve performance, which is the result of adaptations created after training. Therefore, to improve sports performance and strengthen it, athletes need to increase the intensity of training. This increase in one exercise session can cause physiological changes followed by hormonal changes)23). The HOMA, a widely used clinical and epidemiological tool, is a method for assessing insulin sensitivity (ability to reduce blood glucose levels) and β-cell function (insulin secretion). It uses the communication between fasting glucose and insulin to reflect the balance between hepatic glucose output and insulin secretion, which is maintained by a feedback loop between the liver and β-cells (24).

The ultimate goal of sports training is to improve performance, which is the result of adaptations created after training)25(. Therefore, to improve sports performance and strengthen it, athletes need to increase the intensity of training. This increase in one exercise session can cause physiological changes followed by hormonal changes)26(. In recent years, the function of hormones, especially in sports activity, has received a lot of attention. It has been shown that there is a meaningful relationship between exercise and the hormonal system, so exercise, by affecting the functioning of the nervous and hormonal systems, can cause extensive changes in their levels compared to resting time (27) that needs further research. Kuching et al. (28) studied athletes and found that high-intensity strength training induces insulin-like growth. Hamzezadeh Borujeni et al. (29) studied the women of the Iranian national basketball team and observed that an intense interval training program with short rest periods can increase the levels of serum anabolic hormones and hormonal changes, and support the anabolic adaptations caused by training. Abbaspour Mojdehi et al. (11) showed that high-intensity endurance strength training on male taekwondo athletes can reduce leptin and insulin hormones and improve insulin sensitivity, which improves the performance of taekwondo athletes. Therefore, in the present study, the effect of two high-intensity aerobic and strength training methods on the levels of insulin hormones, growth hormone (GH), and glucose homeostasis in professional taekwondo athletes is investigated.

2. Methodology

2.1. Materials and methods

The method of the present study was semi-experimental and had a pre-test and post-test approach.

2.2. Participants

In this quasi-experimental study, from 12 professional taekwondo players (aged 22±1.5) of the selected club of Rasht City, 12 eligible volunteers participated in the research. The inclusion criteria included having at least 5 years of Taekwondo regular exercise training, having a black belt, there were no injuries, and participating in national competitions. Also, the excluded criteria included injury during training or three sessions of non-participation in training. The samples first participated in an orientation session before starting the research. In this session, while explaining the exercise program, and the time and duration of its completion, some of the athletes' questions were also answered. In addition, a written consent form was obtained from the athletes. The study was reviewed and approved by the Human Ethics Committee of the Rash Branch, Islamic Azad University (IR.IAU.RASHT.REC.1402.028).

2.3. Measurements

2.3.1. Anthropometric measurements

A Bürer digital scale (Germany) was used to measure the weight. Formula 2 was used to determine body mass index (BMI). The satiety equation (Formula 3) was used to calculate body fat percentage.

BMI = weight (Kg)/ height (m) 2

$Body\ fat\ percentage$=495/BMI – 450

2.3.2. Blood sampling and evaluation of hormone levels

Before and after the training period, 5 ml blood samples were collected from the brachial vein of taekwondo players to measure insulin, growth hormone (GH), and glucose homeostasis. Blood samples collected from the subjects were centrifuged for 12 min at 3,000 rpm and kept at −70°C. A blood glucose test was performed using the Biosystem kit (Biosystem S.A. Barcelona, Spain) by the enzymatic method of glucosidase peroxidase. The sensitivity of the test was 1.6 mg/dL, which was performed with a Hitachi autoanalyzer (902 Hitachi, Tokyo, Japan) and with the full automation method under the supervision of the internal-external quality control program at two levels. Insulin measurement was performed using an insulin kit (Diametra, Segrate, Italy) with a direct immunoenzymatic diagnostic method with two monoclonal antibodies, one of which was fixed on the microwell and the other was conjugated with horseradish peroxidase. The inter-test accuracy was 4.4% and the inter-test accuracy was 4.9%, which was done by Elisa method by Elisa device (stat Fax 303 pluse, Elisa Awarness, Technology CORP, Palm City, USA). Growth hormone (GH) values were analyzed by the ELISA method, an LDN kit made in Germany, with a coefficient of variation of 11%. Insulin resistance was measured using the glucose homeostasis model (HOMA-IR) and the following formula.

HOMA-IR=FBS×Insulin/22.5

2.3.3. High-intensity aerobic exercise protocol

The protocol of one session high-intensity aerobic exercise program included 60 minutes of exercise (10 minutes of stretching and aerobic running with an intensity of 55-60% of maximum heart rate for warm-up), then according to Table 1, exercise was implemented with an intensity of 80% of VO2max and finally ended with 10 minutes of cooling down by walking slowly on a treadmill (30).

Maximum heart rate = 220-Age

Table 1. *High-intensity aerobic exercise protocol (Ferguson et al. 2014)*

kilometers per hour	intervention	Time
3-4	Stretching and warming up	10 min
10-12	Speed	1min
7-9	Recovery	2min
10-12	Speed	1min
7-9	Recovery	2min
10-12	Speed	1min
7-9	Recovery	2min
10-12	Speed	1min
7-9	Recovery	2min
10-12	Speed	1min
7-9	Recovery	2min
10-12	Speed	1min
7-9	Recovery	2min
10-12	Speed	1min
7-9	Recovery	2min
10-12	Speed	1min
7-9	Recovery	2min
3-4	Cool down	10 min

2.3.4. High-intensity strength exercise protocol

One session of the High-intensity strength exercise program included 60 minutes of exercise (10 minutes of stretching and aerobic running with an intensity of 55-60% of maximum heart rate for warm-up), then according to Table 2, seven movements included (lower limb strength training, upper limb strength training, balance training) with 5 repetitions in 3 sets and 1 minute of rest between sets were performed. Before starting the exercise protocol, the appropriate weight was selected at 80% of 1RM and the weight selected that the athlete can perform 5 times was used for each movement (31). There was a 3-minute rest between each exercise and a 5-minute cool-down (22).

Table 2. *High-intensity strength exercise protocol*

Type of exercise	Intervention	duration	rest between sets
Walking and stretching	-	٥ min	-
-	3 sets of lower limb strength training with 5 repetitions	6 second	1min
Rest	-	3min	-
-	3 sets of upper limb strength training with 5 repetitions	6 second	1min
Rest	-	3min	-
-	3 sets of balance strength training with 5 repetitions	6 second	1min
Cool	-	5 min	-

2.4. Statistical Methods

Mean and standard deviation indicators were used to provide descriptive statistics. After checking the normal distribution of the data by the Shapiro-Wilk test, repeated measurements of the analysis of variance test (ANOVA) were used. The software used was SPSS version 26 and the significance level was considered as p<0.05.

3. Results

Demographic changes are presented in Table 3.

Table 3. *Demographic characteristic (n= 12)*

Measurement index	mean ± standard deviation
Age (year)	22±1.5
Height (cm)	173.6±3
Weight (kg)	54±7.2
BMI (Kg/m^2)	20.7±1.01
Body fat percentage (kg/cm)	9.2±1.1

Table (4) shows the serum insulin, growth hormone (GH), and glucose homeostasis (FBS, HOMA-IR) values of professional Taekwondo athletes in three stages: regular exercise training, high-intensity aerobic exercise, and high-intensity strength exercise.

Table 4. *Serum levels of study variable (n=12)*

Variable	Regular exercise training	high-intensity aerobic exercise	high-intensity strength exercise
insulin (ng/ml)	7.52±2.97	7.79±3.29	7.98±4.57
growth hormone (GH) (ng/ml)	0.16±0.09	0.38±0.32	0.25±0.10
FBS (ng/ml)	90±7.06	93.08±11.66	99.25±19.85
HOMA-IR	1.07±1.23	1.24±1.31	1.48±1.49
HOMA-%B	71.32±27.56	119.40±89.81	102.50±79.15

Values are presented as mean ±SD; HOMA-IR, Homeostatic Model Assessment for Insulin Resistance; FBS, fasting blood sugar

Table 5 shows the result of ANOVA repeated measurement result. According to this Table, serum insulin, FBS, GH, and HOMA-IR values increased more in high-intensity strength training than in regular and high-intensity aerobic training. However, HOMA-B and GH values increased more in high-intensity aerobic training than in regular, and high-intensity strength training.

The results of repeated measurements of ANOVA are shown in Table 5.

Table 5. *The results of repeated measurement ANOVA (n=12)*

Variable	Source		sum of squares	F	Sig
Insulin	Intergroup	Practice	1749.5	3.299	**0.097**
		Practice × group	3754.2	3.294	**0.093**
	between	group	19839.6	10.27	**0.008***
growth hormone (GH)	Intergroup	Practice	0.172	5.128	**0.045***
		Practice × group	0.070	3.975	**0.072**
	between	group	1.575	23.39	**0.001***
FBS	Intergroup	Practice	57.04	0.925	**0.357**
		Practice × group	475.3	1.870	**0.199**
	between	group	318848.4	1207.39	**0.001***
HOMA-IR	Intergroup	Practice	0.99	1.73	**0.214**
		Practice × group	1.11	0.49	**0.496**
	Between	group	70.6	26.70	**0.001***
HOMA-%B	Intergroup	Practice	5831.2	1.22	**0.293**
		Practice × group	8447.8	1.35	**0.268**
	Between	group	343943.1	83.99	**0.001***

*: P<0.05

4. Discussion

Based on the results, serum insulin, FBS, and HOMA-IR levels increased more in high-intensity strength training than in high-intensity aerobic training. In the explanation of the obtained findings, it can be stated that physical activities cause changes in body composition, and part of these changes are due to the decrease in fat percentage and increase in muscle mass. In this context, it has been shown that various types of exercise training by affecting the production of myokines can increase energy consumption by affecting the burning of white fats and affect body composition and insulin resistance. So, changes in many biochemical parameters such as insulin, leptin, and glucose homeostasis hormones have been reported following intense resistance training (11, 18). High-intensity exercise increases GLUT 4 translocation to the sarcolemma membrane, while chronic exercise training increases GLUT 4 mRNA expression. Resistance training or high-intensity strength training can lead to increased insulin levels and insulin resistance values. Also, this type of exercise can lead to a decrease in body fat percentage. Some have a positive effect on metabolic rate, some are metabolic and some are anabolic. High-intensity strength training followed by high-intensity aerobic exercise can help improve insulin resistance and better control blood glucose (18,20). It is necessary to know that changes in insulin and the index of insulin resistance are not the same in all people and depend on individual conditions. In line with the results of the present study, Mor et al. (34) stated that When comparing between groups, insulin in the experimental group with high-intensity training was significantly higher than in the control group during the supplementation phase. Hatfield et al. (35) found that High-intensity resistance training increased serum insulin levels in male and female athletes. However, inconsistent with the current research, Hayta et al.(37) eight weeks of strength training reduced serum insulin levels in adolescent athletes. This can be due to the pointed to the type of training conditions, gender, supplement consumption, along training protocols, which have provided inconsistent results with the current research.

The results showed that the serum levels of growth hormone (GH) increased after the high-intensity aerobic exercise. In explaining this goal, it can be said that high-intensity aerobic exercise increases the body's ability to transport and oxidize FFAs during exercise at different work rates. As mentioned earlier, growth hormone promotes lipolysis in adipose tissue and increases mitochondrial oxidative capacity (40). However, inconsistent with this research, Hayta et al. (37) stated that adolescent athletes did not change their serum level of growth hormone after performing strength training, this problem could be caused by the type of training protocol and the age of the sample of that study. Also, because this research had a session of high-intensity aerobic training, the response to growth hormone of different people has been shown from the results such as high-intensity strength protocols and short rest periods (1 minute), which have shown the greatest increase in serum GH concentrations. The exercise-induced growth hormone response (EIGR) is recognized. Evidence suggests that load and frequency are determining in the regulation of hGH secretion. The EIGR to endurance exercise is associated with the intensity, duration, frequency, and mode of endurance exercise. Some studies have suggested an intensity 'threshold' exists for EIGR. it seems to exercise intensity above the lactate threshold and for a minimum of 10 minutes appears to elicit the greatest stimulus to the secretion of hGH. A recent study suggests that endurance training results in decreased resting hGH and a blunted EIGR, which may be linked to an increased tissue sensitivity to hGH(41). It should be noted that in line with the results of this research, Heay et al. (38) stated that the growth hormone in endurance-trained athletes has increased favorably. In line with the results of the present study, Hayta et al. (34) and Kunching et al (28) stated that the growth hormone in high-intensity training in athletes has increased favorably. However, inconsistent with the current research, Hatfield et al. (35) found that the growth hormone increases in male and female athletes during high-intensity strength training. This can be due to the difference in the sample characteristics and the type of exercise.

Investigations showed that the levels of glucose homeostasis (FBS, HOMA-IR) increased after the high-intensity strength training, and there was no significant difference between HOMA-IR and HOMA-B before and after high-intensity aerobic and strength training. In explaining this goal, it can be stated that high-intensity strength training is an important strategy for improving blood sugar control and beta cell function. This effect can be due to the intrinsic effect of strength training or high-intensity strength training on pancreatic beta cells and also due to a mechanism dependent on some factors released in the blood circulation. High-intensity strength training has beneficial effects on blood glucose control and insulin secretion by reducing fasting glucose and insulin (42), metabolic effects of high-intensity strength training on key peripheral organs involved in regulating energy homeostasis are associated with this response. that the muscle immediately mobilizes stored glucose and then fatty acids and takes glucose and fatty acids from the plasma to meet the required energy (43) and also in high-intensity aerobic exercise, including mechanisms that can cause glucose homeostasis after aerobic exercises, increase the signaling of insulin receptors, increase the expression of glucose transporter protein (GLUT4), increase the activity of glycogen synthetase and hexokinase, decrease the release and increase the clearance of free fatty acids, increase the release of glucose from the blood to The muscle is due to the increase in the capillaries of the muscle and the change in the composition of the muscle to increase glucose uptake(11).In line with the results of the present study, Mosser et al. (33) stated that High-intensity exercise increases glucose homeostasis levels like FBS and HOMA-IR. Also, the inconsistency of the results of this research with the research of Abasspour Mojdehi et al. (11) can be pointed out that in the group studied in the above research, there were 8 training sessions and the duration of training was longer than the current research. Among the limitations of this research, we mention the lack of diet control, the level of anxiety of the samples, Supplement use, and Athletes' rest periods which affect the hormones controlled in this research.

5. Conclusion

According to the study, it can be concluded that there is a significant difference between the two methods of high-intensity aerobic and strength training on the levels of insulin hormones, growth hormone (GH), and glucose homeostasis(FBS, HOMA-IR) of professional taekwondo athletes. So serum insulin levels increased more after high-intensity strength training compared to high-intensity aerobic training. Serum levels of GH and HOMA-B increased after high-intensity aerobic training compared to high-intensity strength training. Finally, the levels of FBS and HOMA-IR in high-intensity strength training were reported to increase more than in high-intensity aerobic training.

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