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Research Article

Comparison of Acute Hormonal Responses to High and Low-Intensity Resistance Exercise with Blood Flow Restriction in Young Wrestlers

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Abstract

Background: The traditional resistance training is the most effective way known to increase muscle mass. However, high-intensity resistance training may be difficult for some individuals and specific groups. In addition, most people are not encouraged to engage in high-intensity resistance training. Therefore, an alternative intervention is needed to solve this problem.

Objectives: The aim of this study was to compare the acute hormonal responses to high and low-intensity resistance exercise with blood flow restriction in young wrestlers.

Methods: Thirty young wrestlers (age: 16.51 $\pm$ 2.1 years, weight: 53.23 $\pm$ 7.13 kg, height: 165.14 $\pm$ 8.42 cm, body mass index (BMI): 18.64 $\pm$ 1.35 kg/m^2) participated in a quasi-experimental research. The subjects were randomly divided into three groups of resistance training: Low-intensity (LI), high-intensity (HI), and low-intensity with blood flow restriction (LI-BFR). The training protocol included three exercises: Leg extension, arm curl, and bench press. Blood samples were collected before and 30 minutes after the training sessions.

Results: The results showed that the creatine kinase level in the HI group, as well as the cortisol level in the HI and LI-BFR groups, increased significantly after resistance training ($P < 0.05$). In addition, testosterone/cortisol ratio decreased significantly in all groups ($P < 0.05$). However, testosterone levels did not change significantly in any groups ($P > 0.05$).

Conclusions: Based on the results of the present study, it can be concluded that blood flow restriction training with the same anabolic effects, lower muscle damage index, less fatigue, and lower intensity is a better choice for training compared to high-intensity resistance training.

Keywords: Traditional Strength Training, Blood Flow Restriction, Wrestling, Resistance Training

1. Background

Today, the science of training and conditioning of athletes is in progress along with the other sciences. Sports scientists are looking for new ways to raise the level of athletes' performance. Meanwhile, resistance training is always used as one of the methods for increasing the strength, endurance, and hypertrophy in athletes in different fields (1). It has been reported that resistance training improves strength and power in young athletes (2, 3). However, there are major concerns about doing resistance training by the youth. On the one hand, the probability of musculoskeletal injuries due to intense exercise training and on the other hand, the inability to perform intense training by special age groups such as children and the elderly (4) have led sports scientists to seek new ways to increase the level of athletes fitness.

In recent years, the use of less intense exercises with blood flow restriction (BFR) has been considered an alternative training method (5). The training with blood flow restriction is a type of resistance training that increases the strength and muscle mass despite its low intensity (20% - 50% of one-repetition maximum (1RM)) compared to traditional resistance training (more than 70% of 1RM). This type of low-intensity resistance training restricts blood flow to active muscles by compressing the tissue and avoiding the use of heavy loads and exerts stress to create hypertrophy and increase strength; therefore, it can be an acceptable alternative to intense resistance training (6).

Several studies have investigated the effect of resistance training on hormonal responses. They have focused on hormones involved in growth and tissue repair (testosterone, growth hormone, and insulin-like growth factor) and stress response (cortisol and catecholamines) (1). The functions of these hormones have been investigated in various studies, demonstrating an important role in the physiological processes of growth and development, body metabolism, and regeneration (7-9). Chen et al. investigated the effect of vibration training with blood flow restriction on neuromuscular and hormonal responses (10). They reported that BFR exercise largely increased the level of muscle activity and metabolic responses, with no effect on hormonal responses. A study conducted by Reeves et al. showed that the response of free testosterone and total testosterone to resistance training with blood flow restriction was not significantly different from that of traditional strength training (three sets of single-arm biceps curls and three sets of single-leg calf extensions) (8). Other studies investigated the cortisol response to resistance training with blood flow restriction and reported no significant difference when compared to traditional strength training (7, 11, 12). In addition, after acute resistance exercise with blood flow restriction, no significant increase was observed in serum creatine kinase (CK) (13).

It has been shown that high loads are required for significant adaptation in resistance exercises (to at least 70% of 1RM) (14). However, evidence suggests that blood flow restriction (BFR) combined with low-load resistance exercise increases the level of physical fitness and strength of individuals. Based on the knowledge of the authors and a review of the literature about resistance training, it seems that no study has been conducted on obstructive training and its comparison with resistance training in young wrestlers. In addition, the results of research on traditional resistance training are somewhat contradictory, and there is a need for further research in this area. Performing new and more effective training techniques can be useful in preventing the waste of time, cost, and energy of athletes and will have better results.

2. Objectives

Therefore, the purpose of the present study was to compare the acute hormonal responses to high and low-intensity resistance training with blood flow restriction in young wrestlers.

3. Methods

This research was carried out in a semi-experimental and experimental design with pretest and posttest measures. A total number of 30 young wrestlers (age: 16.51 ± 2.1 years, weight: 53.23 ± 7.13 kg, height: 165.14 ± 8.42 cm, body mass index (BMI): 18.64 ± 1.35 kg/m^2) voluntarily participated in the present study. The subjects were randomly divided into three groups of resistance training: High-intensity (HI, 10 subjects), low-intensity with blood flow restriction (LI-BFR, 10 subjects), and low-intensity without blood flow restriction (LI, 10 subjects). The criteria for entering the study were the lack of regular exercise and no use of supplements in the last six months and the absence of musculoskeletal, cardiac, and infectious diseases confirmed by a physician. The athletes' diet was also controlled 24 hours before the test to prevent caffeine consumption. The subjects were also asked to do no physical activity 24 hours before the main test. The study was approved by the research ethics committee of the University of Tehran.

In the first session, the subjects' individual information including age, height, weight, and BMI were measured and the subjects were familiarized with the study procedure. All the subjects gave their written consent for participation in the study. Three days later, 1RM was measured in three exercises (arm curl, knee extension, and bench-press). The interval between the maximum dynamic strength test and the main test was at least one week. In addition, blood samples were collected once before the beginning and again after the completion of the exercises.

The submaximal test was used to measure the maximum strength of the subjects. If a person performed more than 10 repetitions, he would rest prior to performing the next set with a higher load. The Brzycki formula [1RM = weight (kg) $\times$ (1.0278 - (0.0278 $\times$ repetitions)] was used to calculate the maximal strength based on the submaximal repetitions (15). Blood samples were withdrawn from the middle cubital vein by a laboratory technician for the determination of blood CK, Testosterone, Cortisol, and T/C ratio. The serum levels of the factors were measured by the ELISA method (IBL international GMPH kit, Germany) and ELISA reader (StatFax, 4200, USA).

To determine the partial occlusion, blood pressure was measured at 8:00 to 9:00 a.m. in the supine position. Blood pressure restriction was set at 20 mmHg below systolic blood pressure in arms while it was chosen as 20 mmHg higher than the systolic blood pressure in thighs (16, 17). A blood pressure cuff (Model HS 201Q1, Easy Life Co.) was used to restrict blood flow. An oximeter (Beurer PO30 Pulse Oximeter, Germany) was used after each series to ensure the maximum blood flow was not completely interrupted. If the oximeter detected no pulse on the finger, the cuff pressure was reduced by 5 - 10 mmHg.

3.1. Exercise Interventions

The session of strength training exercise consisted of elbow flexion, knee extension, and bench press. The subjects were asked to refer to the laboratory between 8:00 and 10:00 a.m. After the initial warm-up of two sets of 15 repetitions with 50% of 1RM for each exercise (training volume was the same in all groups [(30 + 15 + 15 + 15) × 30% 1RM = (10 + 10 + 10) × 75% 1RM], all groups performed the training protocol as shown in Tables 1 and 2.

3.2. Statistical Analysis

All descriptive data are expressed as means ± SD. The normal distribution of pretest data was checked using the Kolmogorov-Smirnov test. The correlation *t*-test was used to examine intra-group variations and one-way ANOVA with LSD post hoc test to examine the between-group differences. The Cohen's D test was used to estimate the effect size; a value of less than 0.2 indicated a negligible effect size, between 0.2 and 0.5 a small effect size, between 0.5 and 0.8 a moderate effect size, and greater than 0.8 a large effect size. The statistical analysis was conducted using SPSS 22.0 for Windows.

4. Results

Individuals' information including age, weight, height, and BMI is presented in Table 3. Table 4 reports the levels of creatine kinase, testosterone, cortisol, and testosterone/cortisol ratio in pretest and posttest.

The results showed that the level of CK in response to one session of resistance training increased only in the HI group (P = 0.005), but not in the LI-BFR (P = 0.072) and LI (P = 0.274) groups. In addition, the results of post hoc test showed that CK changes were significantly different between the HI and groups LI (P = 0.001), LI-BFR and LI groups (P = 0.02), and HI and LI-BFR groups (P = 0.043). The changes in the testosterone level were not significant in response to one resistance session in the HI (P = 0.653), LI-BFR (P = 0.203), and LI (P = 0.281) groups. In addition, the results showed no significant difference in testosterone changes between the groups (P = 0.253). The results also showed that the cortisol level significantly increased in response to one resistance session in the HI (P = 0.025) and LI-BFR (P = 0.017) groups, but not in the LI group (P = 0.505). In addition, the results of the post hoc test showed that cortisol changes were significantly different between the HI and LI (P = 0.008) and LI-BFR and LI (P = 0.023) groups; however, there was no significant difference between the HI and LI-BFR groups (P = 0.264). The results of this study showed that T/C ratio in response to one resistance session significantly increased in the HI (P = 0.001), LI-BFR (P = 0.002), and LI (P = 0.11) groups. In addition, the results of the post hoc test showed that T/C changes were significantly different between the HI and LI groups (P = 0.001) and LI-BFR and LI groups (P = 0.02), but the difference was not significant between the HI and LI-BFR groups (P = 0.063).

5. Discussion

The results of the present study showed that HI training caused a greater increase in the CK level (18.61%) when compared to IL-BFR (2.63%) and LI training (1.32%). The elevated blood CK levels may indicate myopathy or exercise-induced muscle damage (18). Excessive exercise and eccentric muscle contractions often cause damage to the sarcomere. A sudden increase in CK occurs when sarcolemma and Z-line are damaged (19). The studies showed that exercise could increase circulating CK in adolescents (20-22). In another study, Brancaccio et al. showed a significant increase in CK in a strength-training group and suggested that these elevated levels were probably associated with exercise intensity (18). In addition, in research by Pullinen et al. no significant increase in CK was reported in adolescent subjects that performed a low-intensity resistance-training program (23). Moreover, Pope et al. did not observe any significant increases in serum CK after resistance training with blood flow restriction in adult males (13), which was probably due to less mechanical stress induced by BFR training. The results of the present study are consistent with these studies.

The results showed that resistance exercise increased testosterone levels in IL-BFR and HI groups (by 13.98% and 25.03%, respectively) and decreased testosterone levels in the LI group (by 3.33%). A possible reason for the acute increase of testosterone in low-intensity exercise with blood flow restriction may include the increased lactate and catecholamine concentration (both indicators usually increase with this type of exercise) (13). In line with the present study, Fujita et al. investigated the effect of low-intensity exercise training with blood flow restriction on muscle protein synthesis and reported a significant increase in testosterone levels in response to four sets (30 – 15 – 15 - 15) of knee extension exercise with blood flow restriction (20% of 1RM), but this increase was not significant (24).

Kraemer and Ratamess reported that the acute testosterone response to resistance training varies depending on the intensity or volume of exercise (7). Small and non-significant increases in this hormone are probably due to a failure to respond or fewer responses in adolescent boys due to the smaller size of the testicles, less or different Leydig cells (24), or less coordination in the hypothalamic-pituitary-gonad axis in this age group (25). Pullinen et al. reported the increased level of testosterone after acute resistance exercise in adolescent boys, but this increase was not significant (23). It should be noted that these contradictory observations in the acute testosterone response to resistance training are due to variations in the intensity and volume of exercise (7, 25). Moreover, Reeves et al. showed that the response of testosterone to resistance

Table 1. Exercise Interventions in the HI Group

Exercise	Sets	Repetitions	Rest Between Sets, min	Rest Between Exercises, min
Bench press	3	10 - 10 - 10	2	5
Knee extension	3	10 - 10 - 10	2	5
Elbow flexion	3	10 - 10 - 10	2	5

Table 2. Exercise Interventions in the LI-BFR and LI Groups

Exercise	Sets	Repetition	Rest Between Sets, s	Rest Between Exercises, s
Bench press	4	30 - 15 - 15 - 15	45	3
Knee extension	4	30 - 15 - 15 - 15	45	3
Elbow flexion	4	30 - 15 - 15 - 15	45	3

Table 3. Individual Information of Subjects

Groups	Age, y	Height, cm	Weight, kg	BMI, kg/m^2
HI	17.58 ± 1.23	164.02 ± 4.57	55.24 ± 3.68	17.94 ± 1.87
LI-BFR	16.36 ± 1.12	169.09 ± 4.17	58.49 ± 2.47	18.03 ± 1.21
LI	17.49 ± 1.79	165.13 ± 6.43	56.22 ± 3.14	18.23 ± 1.76

Table 4. The Levels of Variables in Pretest and Posttest in All Groups

Groups	Pretest	Posttest	P Value of Intergroup	Cohen's d	Percentage Changes	P Value of Between Groups
CK, U/L						0.001
HI	219.12 ± 4.63	269.23 ± 6.13[a,b]	0.005	9.22	18.61	
LI-BFR	218.42 ± 2.12	224.34 ± 8.27[c,d]	0.072	0.98	2.63	
LI	217.54 ± 8.87	220.46 ± 10.67	0.274	0.39	1.32	
Testosterone, ng/mL						0.253
HI	2.55 ± 0.58	2.65 ± 0.74	0.653	0.01	3.77	
LI-BFR	2.46 ± 0.43	2.86 ± 0.65	0.203	0.72	13.98	
LI	2.70 ± 0.89	2.61 ± 0.55	0.281	0.12	-3.33	
Cortisol, ng/mL						0.017
HI	142.35 ± 23.31	221.49 ± 33.48[a,c]	0.025	2.74	35.73	
LI-BFR	141.78 ± 19.16	209.33 ± 45.71[a,d]	0.017	1.92	32.26	
LI	144.32 ± 33.12	148.89 ± 65.81	0.505	0.08	3.06	
T/C Ratio						0.002
HI	1.79 ± 0.07	1.19 ± 0.08[a,b]	0.001	2.98	-33.51	
LI-BFR	1.73 ± 0.03	1.36 ± 0.06[a,d]	0.002	2.80	21.38	
LI	1.87 ± 0.12	1.75 ± 0.1[a]	0.011	1.08	-6.41	

[a] A significant difference between pretest and posttest.
[b] A significant difference between HI and LI groups.
[c] A significant difference between HI and LI-BFR groups.
[d] A significant difference between LI-BFR and LI groups.

training with blood flow restriction was slightly higher compared to the traditional resistance training in elderly men, but this difference was not significant (8).

The results showed that serum cortisol levels increased after resistance exercise in the HI (35.73%), LI-BFR (32.26%), and LI (3.06%) groups. Cortisol increases protein breakdown and decreases protein synthesis in skeletal muscle (7). In resistance exercise, the catabolic role of cortisol is considerable (26). In addition, the acute response of cortisol to exercise is generally an exercise-induced stress response (7); therefore, it should be noted that the non-significant increase of cortisol in the LI group and the significant increase in the other groups could be related to a difference in the intensity of exercise. Most studies reported a similar increase in cortisol levels after a resistance training session (25). Reeves et al. (8) and Kon et al. (9) reported that there were no significant differences in the cortisol response to resistance training with blood flow restriction and traditional resistance training. More increases in cortisol levels in response to exercise in adolescents might be the result of a stronger stress response (23, 27), as well as higher metabolic stress in this age (28).

The results of the study showed that the T/C ratio decreased in the HI and LI groups (2.80 and 1.08%, respectively), but it increased in the LI-BFR group (2.80%). The T/C ratio is used as an index of the anabolic or catabolic state of skeletal muscles in resistance training (7). It has been shown that high volume training programs are more suitable than single-set programs when a significant increase in the T/C ratio is desired (26). A higher catabolic response (cortisol level) and less anabolic response (testosterone level) show low hypertrophic adaptation in response to resistance training in adolescents compared to adults (25).

5.1. Conclusions

In general, the present study showed that one session of low-intensity training with blood flow restriction increases testosterone levels more than high-intensity resistance training does; however, the cortisol response is similar in the two programs, which shows a higher T/C ratio and the anabolic state in LI-BFR training. Additionally, low-intensity training with blood flow restriction shows a lower cell injury index. Based on the results of the present study, it can be concluded that blood flow restriction training with the same anabolic effect, lower muscle damage index, less fatigue, and lower intensity is a better choice for training compared to high-intensity resistance training.

Footnotes

Conflict of Interests: The authors confirm that there is no known conflict of interests associated with this publication.

Ethical Considerations: The study was approved by the Research Ethics Committee of the University of Tehran. 247-31IR.

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