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Testosterone hormone level changes in occlusion training applied with resistance exercise in young males

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ABSTRACT

This study aimed to examine the changes in the testosterone hormone level of occlusion training applied with resistance exercise in young males. The study consisted of 36 (age 19.71±1.31 years) healthy young male participants. Participants were randomly divided into three groups; experiment1 (continuous BFR, blood flow restriction, + resistance exercise), experiment2 (intermittent BFR+ resistance exercise), and control (resistance exercise only). Groups performed the squat exercise for six sets with 70% of their 1 RM, two repetitions in each set and a 3-minute rest interval between sets. For the testosterone hormone test, blood samples were taken from the participants before, after and 15 minutes after the exercise. Repeated measures analysis of variance (Repeated Measures ANOVA) was used to analyze the data. In statistical analysis, the level of significance was accepted as $p<.05$. According to the results of the research, there was an increase in testosterone levels in the groups with continuous and intermittent BFR compared to the control group.

KEYWORDS

Occlusion; exercise; testosterone; hormone.

1. INTRODUCTION

Resistance exercise is a traditional method for improving muscle strength and muscle mass (Cerqueira et al., 2019). Besides, the ability to withstand high mechanical loads on joints during heavy resistance exercise varies from person to person. High-intensity resistance exercise is considered a potent stimulant for hypertrophy and improvement in muscle strength, as well as increasing anabolic hormones (Campos et al., 2002; Monazzami et al., 2017). On the other hand, physical activity with 10-20% of maximum training intensity rarely causes an increase in anabolic hormones (Pullinen et al., 2002). Researchers tried to find a solution to minimize problems when performing high-intensity resistance exercises. They provided a resistance exercise model with fewer performance limitations than high-intensity resistance exercise (Sharifi et al, 2020).

This model of exercise, called blood flow-restricted exercises (BFR), is performed using a type of wrap device, or typically a pneumatic cuff, which is attached to the proximal part of the targeted muscles. Venous blood flow and arterial blood flow in the target muscle are restricted, and this is called occlusion (Lönne et al., 2011). These exercises, which are defined as BFR exercises, cause hypertrophy in a short time and increase muscle strength (Takarada et al. 2000; Patterson et al. 2013). The underlying factor is detected as the obstruction of venous outflow as well as the restriction of access to the arteries by pressure cuffs, resulting in local hypoxia, greater lactate accumulation, and sustained stimulation of the afferent nerves (Manini et al., 2009). Recent studies have shown that low-intensity resistance exercise, when combined with blood flow restriction, can increase muscle size and strength (Manini et al., 2009; Wernbom et al., 2008). Takarada et al., (2000) have found an increase in elbow flexor size and strength after 16 weeks of resistance training with restricted blood flow. They stated that the increase was significant and was higher than the group that did not use BFR. Contrary to this study, Burgomaster et al. (2003) stated that BFR did not affect elbow flexion strength. This type of exercise method is limited to the muscles of the upper or lower extremities. Because BFR is usually performed with elastic bands that compress the proximal parts of the upper arms or thighs. Various studies have shown that low-intensity resistance exercise, in which blood flow is restricted, is also effective for lower extremity muscles (Madarame et al., 2008; Takarada et al., 2002). While most studies focused on the response of BFR exercise to hypertrophy and muscle strength levels, some studies specifically aimed to determine the hormonal effects of this exercise method and its effect on anabolic hormones. Inhibition of venous blood flow during exercise causes the accumulation of a large number of metabolites in the body (Conceicao et al., 2018). This accumulation provides a significant stimulation of the receptors in the training system and the body. This leads to metabolic stress and increased lactic acid accumulation (Sharifi et al., 2020). An increase in lactic acid levels in the blood may result in an increased release of anabolic hormones such as testosterone (Madarame et al., 2010). Chen et al., (2022) investigated the effect of different BFR pressures on the testosterone hormone. As a result of the study, they observed that while the control group had the lowest testosterone level after exercise and 15 minutes later, the testosterone level of the BFR group increased.

Most of the studies in the literature applied resistance exercises with and without BFR. However, none of the previous studies has compared the effect of different blood flow restriction protocols and high-intensity resistance exercise on the hormone testosterone. Besides, the high cuff pressure used in BFR causes a decrease in tissue oxygenation and an increase in metabolic stress (Karabulut et al. 2011; Yasuda et al. 2010). Most studies of BFR have used high cuff pressure density (Karabulut et al., 2010; Fry et al., 2010). Some studies reported that participants could not complete resistance exercises with BFR due to the high intensity of the cuff pressure (Yasuda et al., 2008; Yasuda et al., 2009). Studies have indicated that severe muscle fatigue resulting from high-intensity cuff compression training with BFR should be avoided (Yasuda et al., 2013).

Therefore, this study aimed to investigate the changes in testosterone hormone in young males using different occlusion protocols with moderate-intensity cuff pressure.

2. METHODS

2.1. Participants

Thirty healthy young males (age 19.71±1.31 years) participated in the study voluntarily. Before starting the tests, a written information form was given to the participants about the study, and this information form was read verbally to all participants and informed about the study. Participants were approved by signing the voluntary participation acceptance document stating that they participated in this research voluntarily. The participants were questioned whether they had any health problems, regular drug use or a recent illness, and were included in the study by paying attention to these criteria. Ethics committee approval was received for this study. The research was conducted following the Declaration of Helsinki.

2.2. Experimental Design

Participants were randomly divided into three groups: experiment1 (continuous BFR+ resistance exercise, n=12), experiment2 (intermittent BFR+ resistance exercise, n=12), and the control group (only resistance exercise without BFR, n=12). Before the exercise, after the exercise and 15 minutes after the exercise, blood was taken by the specialist nurse and the free testosterone hormone values were determined.

2.3. Dating Session

Two days before the 1RM test, the participants were introduced to squat resistance exercise, the 1RM test method, and BFR. This introductory session consisted of a series of 10 repetitions at approximately 50% 1RM load, consistent with the individual strength training experience (Laurentino et al, 2012).

2.4. 1 Repetition Maximum Test

All participants determined starting weights according to their wishes before starting the resistance exercise. Particularly, it was recommended to start the 1RM test with 30-40% of the participant's body weight (Baechle et al., 2008). Thus, muscle injuries that may occur during the 1RM test were prevented. The free squat movement was applied with the weights determined by the participants. They were allowed to repeat the movement by adding 2.5-5 kg according to the weight they lifted. The weight-adding process was continued until the participants could not perform 1 repetition. The test was terminated when the participants said they could not lift it. All tests were tested and recorded in kg. The squat test was performed with a free barbell.

2.5. Exercise Protocol

All participants (continuous BFR, intermittent BFR, and control group) performed the squat resistance exercise protocol. In this study, occlusion bands were used for BFR. The pressure value of the BFR band was determined by the sensed pressure scale (Price et al., 1983). Participants were asked to rate the pressure they felt from the tapes. In the continuous BFR group, occlusion bands were attached to the proximal part of the leg before the exercise and were not removed until the end of the exercise. In the intermittent BFR group, bands were placed only during exercise and removed at rest intervals. The control group was asked to complete the set without using tapes. Care was taken to apply the 7.6 cm wide bands at medium pressure with a rating of 7 out of 10 on the pressure scale. In this way, it was confirmed that it caused venous rather than arterial occlusion in all participants (Wilson et al, 2013). During the experimental sessions, the participants performed the resistance exercise, which was planned as a squat exercise, in three different conditions: continuous BFR, intermittent BFR and without BFR. In 70% of their 1RMs, they performed the resistance exercise for a total of six sets, with two repetitions in each set and a 3-minute rest interval between sets.

2.6. Taking Blood Samples and Hormone Measurement

In the participants in the research group, blood was sample was taken by the specialist nurse three times in total before the exercise protocol, at the end of the exercise and 15 minutes after the exercise. Approximately 5 ccs of blood taken from the anticubital vein were transferred to the biochemistry tube. The blood taken into the biochemistry tubes was turned upside down 3-5 times. After the blood samples were left to rest for 30 minutes, they were centrifuged for 5 minutes in a refrigerated centrifuge at 4000 rpm. The obtained serum was transferred to microcentrifuge tubes and labelled by separating the serum portion for the analysis of biochemistry profiles. It was stored at -200C until the day of analysis. Free testosterone was studied in the medical biochemistry laboratory to determine the testosterone values.

2.7. Statistical Analysis

The data collected from the participants were checked one by one and transferred to the SPSS 23.0 package program. For statistical analysis, first of all, it was checked whether the data showed a normal distribution by examining the skewness and kurtosis values. After the analysis, it was determined that the values changed in the range of -2 and +7 (West et al., 1995). Repeated measures analysis of variance (Repeated Measures ANOVA) was used to analyze the data. In statistical analysis, the level of significance was accepted as $p<.05$.

3. RESULTS

When Table 1 was examined, the testosterone hormone measurements of the participants did not differ between the groups (F=1.121; p=.339). It was determined that the measurements means of the participants differed according to time (F=371.52; p=.000). Finally, the group time interaction was not significant (F=1.100; p=.345).

Table 1. Comparison of testosterone hormone measurements according to the groups and measurement times of the participants.

Testosterone	**n**	**Pre Exercise**	**Post Exercise**	**15 min from exercise then**	**Total**	**F**	**p**
		$\bar{X}$ ± **SS**	$\bar{X}$ ± **SS**	$\bar{X}$ ± **SS**	$\bar{X}$ ± **SS**		
Experiment1	12	.25±.04	.41±.17	29.90±4.33	10.19±.79	1.121	.339
Experiment2	12	.26±.04	.40±.19	27.85±7.22	9.50±.79		
Control	12	.25±.04	.40±.16	24.75±11.97	8.47±.83		
Total	36	.25±.04	.40±.17	27.75±8.34			
				F=371.52; p=,000		Group X Time interaction F=1.100; p=.345	

4. DISCUSSION

This study investigated changes in testosterone hormone in healthy males using resistance exercise with BFR protocols in moderate-intensity pressure. Considering the results of the research, no difference was found between the groups, but it was determined that the measurement means of the participants differed according to time.

Current research has shown that medium pressure BFR effectively stimulates the secretion of the muscle-enhancing hormone testosterone. A comparison of the three groups suggested that the amount of hormone secretion was associated with the use of blood flow restriction. To our knowledge, no studies were comparing the acute effects of different BFR methods (continuous and intermittent BFR) on the hormone testosterone. This study showed that testosterone levels in the group with moderate-intensity continuous BFR and intermittent BFR were significantly higher than the mean of the measurement compared to the control group. When we compared three different BFR protocols, it was seen that the testosterone hormone measured with medium pressure increased.

Testosterone is a type of steroid derived from cholesterol which plays an important role in supporting muscle growth and synthesis. Testosterone also has a reduced muscle protein breakdown and anti-cortisol response by inhibiting ubiquitin secretion (Amani-Shalamzari et al., 2020).

In this study, BFR gradually increased the level of testosterone secreted by the body, especially in the group using continuous BFR, probably because it caused vascular occlusion in the moving limbs. Rising testosterone levels can be caused by increased blood lactate levels. Previous studies in rats have shown that lactate increases cAMP production in rat testicles (Lu et al., 1997) and stimulates testosterone secretion of Leydig cells (Lin et al., 2001), while catecholamine increases testosterone production from beta2-adrenergic receptors of Leydig cells (Anakwe et al., 1984). However, it should be noted that the decrease in plasma volume after exercise also causes an increase in serum testosterone concentration (Kraemer and Ratamess, 2005). In fact, it has been previously reported that plasma volume is significantly reduced after both upper and lower extremity exercise with BFR (Sato et al., 2005). Yinghao et al. (2021) investigated the effect of BFR exercise on testosterone hormone levels under different cuff pressure. As a result of the study, no difference was detected between the groups. However, they found the effect of time on testosterone levels to be significant. They found that the mean testosterone level in the high-pressure group after exercise increased significantly compared to the low-pressure group. Moreover; they found that the hormone level of the group that applied low pressure was higher than the control group. When the groups were examined according to the measurement periods, they observed that the mean testosterone value in the high group was significantly higher than in the low and control groups 15 minutes after the exercise. No significant difference was detected in hormone levels measured 30 minutes after exercise for all groups. Madarame et al. (2008) stated that resistance training with BFR has an effect on testosterone hormone and that testosterone levels increase after exercise compared to pre-exercise. In another similar study, the same researcher investigated the effect of BFR and low-intensity resistance exercise on endocrine responses in the upper and lower extremities. They stated that time had a significant effect on testosterone concentrations, but that the experimental design protocol applied was higher in testosterone hormone after exercise than before (Madarame et al., 2010). Contrary to these studies, Sharifi et al. (2020) investigated the acute and chronic effects of resistance exercise on hormonal responses in sedentary young males with BFR. The study groups applied 4 different exercise protocols: one session of BFR exercise, two sessions of BFR, one session of without BFR, two sessions of resistance training without BFR, and the control group. As a result of the 6-week study, no significant increase was detected in testosterone hormone levels in the entire study group.

Several factors affect serum testosterone responses to acute resistance exercise. It was stated that the testosterone level during resistance exercise is affected by the relevant muscle mass(Volek et al., 1997; Hansen et al., 2001), the intensity and volume of the exercise applied (Gotshalk et al., 1997), the nutritional status (Kraemer et al., 1998), and the exercise experience (Tremblay et al., 2004). The most effective factor in acute effects and subsequent exercise adaptations is the stimulus of resistance exercise. Appropriate prescription of resistance exercise and manipulation of acute program variables provide an optimal neuroendocrine response (Kraemer et al., 2003; Kraemer et al., 2000). Recruitment of a greater number of muscle fibres results in greater hormone-tissue interactions involving a greater percentage of total muscle mass. As a result, tissue activation was a precursor to anabolism. Therefore, in addition to genetic predisposition, gender, fitness level and adaptation potential, the training program played an active role in the hormonal response to resistance exercise.

Some studies have reported that free testosterone levels are parallel to total testosterone (Tremblay et al., 2004; Ahtiainen et al., 2003; Durand et al., 2003). However, other studies showed a lack or decrease in response (Häkkinen, et al., 1987). It was found that large muscle mass exercise causes a greater increase in testosterone than small muscle mass exercises. These exercises, which included large muscle mass, were shown to be powerful metabolic stressors (Ratamess, 2003). As a potent metabolic component, it can stimulate the release of testosterone (Kraemer and Ratamess, 2005). Although testosterone was significantly increased in high-intensity exercise, the testosterone response to exercise with BFR was still not defined.

5. CONCLUSION

The results of this study revealed that the groups with continuous and intermittent BFR had significantly increased testosterone hormone levels after exercise compared to the control group.

In particular, the group with persistent BFR showed higher levels of testosterone secretion after exercise compared to the control group. These results emphasized that the combination of BFR with moderate-intensity pressure and high-load resistance exercise was more conducive to the secretion of testosterone levels. This study had some limitations. Only young males were included in the study. Therefore, whether the current results can be transferred to other populations is unknown. Besides, this research has not thoroughly examined other stress hormones. Studies in the literature mostly examined the effect of BFR at different pressures compared to the control group. While some studies have argued that exercise with BFR may increase testosterone (Madarame et al., 2010), other studies have stated that occlusion training does not affect testosterone (Sharifi et al., 2020). Therefore, future research should further explore the possible differences in the application of BFR in different populations and the acute and chronic effects of different BFR protocols. These results may provide trainers with options for different exercise protocols.

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CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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