

The Effect of Citrulline Malate Supplement Applied in Addition to Fitness Trainings on Hormone Metabolism of Athletes

Ercan Tizar^{1,*}, Ramazan Erdoğan² and Gönül Rezzan Tizar³

¹Dicle University School of Physical Education and Sports, Diyarbakır/Türkiye.

²Bitlis Eren University School of Physical Education and Sports, Bitlis/Türkiye.

³Inönü University Institute of Health Sciences, Malatya/Türkiye.

Corresponding author: Ercan Tizar (e-mail: ercantizar@gmail.com).

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Abstract This research is to determine the effect of citrulline malate supplement applied in addition to fitness training on the hormonal metabolism of athletes. 30 male athletes (15 Control group, 15 Experimental group) who are in the fitness branch and regularly participate in the research group voluntarily participated. A four-week, ninety-minute fitness training program three days a week was applied to the research group. Blood samples were taken from the athletes in the research group twice, before the start of the training program and at the end of the training. ACTH, Cortisol and Total Testosterone levels were determined in the blood samples taken. SPSS package program was used in the analysis of the data. Significance was accepted as $p < 0.05$. According to the research results; It was determined that there was a statistically significant difference between the pretest-posttest values of the experimental group's ACTH, cortisol and total testosterone levels ($p < 0.05$), while it was determined that there was a statistically significant difference between the pretest-posttest values of the control group's total testosterone levels ($p < 0.05$), there was no statistically significant difference between the pretest-posttest values of ACTH and cortisol levels ($p > 0.05$). According to the comparisons between the groups; It was seen that there was a significant difference between the cortisol and total testosterone levels post-test values of the control and experimental groups ($p < 0.05$), there was no significant difference between the pre-test values of ACTH pre-post-test, cortisol and total testosterone levels ($p > 0.05$). In conclusion; It has been observed that the citrulline malate supplement group applied in addition to the fitness training has a significant effect on the hormone metabolism and provides a greater increase compared to the group in which the fitness training is applied. In this context, we believe that the supplements to be applied in addition to routine training will contribute positively to the performance of the athletes.

Key Words citrulline malate (CM), fitness, hormone metabolism

1. Introduction

Physical deformation is a fact that athletes may suddenly encounter in a way they do not want. It is not possible for athletes and coaches to know when they will be injured. In such a case, the risk of deformation should be eliminated or minimized. While the athlete running nervously during the competition weakens, he may become injured by forcing his body during the performance that needs to be done. Sports science keeps sports alive with scientific studies by keeping up with the developing technology.

Ergogenic supplements can help athletes get tired late and recover earlier, as a result of research. Stimol consists of the malic acid-linked amino acid citrulline. When arginine and nitric oxide levels rise due to citrulline, it causes more blood flow to the muscles. More blood flow leads to higher oxygen

and nutrient transfer, so more muscle energy is produced. Citrulline is also critical for the removal of ammonia from the body [1]. Citrulline malate (CM) has gained attention in the last few years for its ability to prevent fatigue and increase skeletal muscle power output through reduction in metabolic byproduct reduction [2]. In particular, citrulline malate increases aerobic energy production during exercise and increases phosphocreatine (PCr) during exercise recovery, improves ammonia (NH₃) elimination during recovery from strenuous exercise, minimizes muscle damage after high-intensity resistance exercises, and improves recovery performance after repetitive high-intensity exercises. influences in the right direction [3]. In addition, citrulline malate (CM) is used as a performance-enhancing athletic dietary supplement and reduces muscle fatigue in a preliminary

clinical study [4]. Citrulline malate is a non-essential amino acid that improves exercise performance in men. However, based on physiological differences between the sexes, these results are unpredictable for females. The beneficial effects of CM may be related to both malate and citrulline, which interfere with the level of muscle energy metabolism. Malate is an intermediate of the tricarboxylic acid cycle (TCA) and its addition can increase energy production [5].

It has also been shown that citrulline accelerates plasma ammonium and lactate clearance and may be involved in the breakdown of muscle metabolism by-products, thus contributing to increased muscle function [6]. Nitric oxide (NO) produces citrulline malate (CM) in the NO synthase (NOS) pathway and improves exercise performance in youth. NO production decreases with age, and increased NO production may have beneficial effects on sports performance among veteran athletes. Citrulline malate is known to limit the detrimental effect of the asthenic state on muscle function, but its effect on the healthy state is poorly documented. Citrulline malate (CM) suggested an ergogenic effect during resistance exercise; however, there are few studies investigating these claims [7]. Although previous studies on the effect of CM metabolism have not yet been clarified, its effects on lactate metabolism are observed [8]. The main purpose of this research is to investigate the effect of citrulline malate supplement applied in addition to fitness training on the hormone metabolism of athletes.

2. Method

A. Research Group

The research group; 30 male athletes participating in the fitness branch participated voluntarily.

- Experimental Group (n:15): Group doing fitness training
- Control Group (n:15): Fitness antrenmanına ek olarak citrulline-malate takviyesi verilen grup

B. Training Program

A four-week, ninety-minute fitness training program three days a week was applied to the research group. Within the scope of the training, 5-10 minutes of warm-up time, 50-60 minutes of fitness training and 5-10 minutes of cooling exercises at the end of the training were made.

C. Collection and Analysis of Samples

Blood samples were taken from the athletes in the research group twice, before the start of the training program and at the end of the training. The athletes participating in the study were observed during the training and the athletes who had metabolic disorders or were taking drugs were excluded from the study. In the blood samples taken as a result of the training, the athletes; ACTH, Cortisol and Total Testosterone levels were determined. The blood samples taken from the athletes were taken by experts in the private hospital laboratory by means of a fully automatic hemogram named

Parameters	Pre-test	Post-test	t	p
ACTH	22,34±5,34	29,10±10,07	-7,112	0,12
Cortisol	6,87±2,20	10,73±2,22	-6,970	0,31
Total Testosterone	4,98±1,46	4,29±0,88	-,517	0,01*

Table 1: Hormonal changes of the control group before and after training

Parameters	Pre- test	Post-test	t	p
ACTH	22,72±6,64	35,61±7,46	-7,112	0,00*
Cortisol	8,96±3,48	13,44±2,08	-6,970	0,00*
Total Testosterone	5,25±1,81	6,44±1,26	-,517	0,01*

Table 2: Hormonal changes of the experimental group before and after training

“Coulter Stks”, while the athletes were sitting and resting, and analyzed.

D. Statistical Analysis

The data were analyzed using the SPSS statistical package program. Normality analysis of the data was made and parametric tests were used for the data determined to be normally distributed. In order to compare the research within the group, “Paired Samples t” test and “Independent Samples t” were applied. Significance level was taken as $p < 0.05$.

3. Results

When Table 1 was examined, it was determined that there was a statistically significant difference between the pretest-posttest values of the control group’s total testosterone levels ($p < 0.05$), while there was no statistically significant difference between the pretest-posttest values of ACTH and cortisol levels ($p > 0.05$).

When Table 2 was evaluated, it was determined that there was a statistically significant difference between the pretest-posttest values of ACTH, cortisol and total testosterone levels of the experimental group ($p < 0.05$).

When Table 3 was examined, it was seen that there was a significant difference between the cortisol and total testosterone levels post-test values of the control and experimental groups ($p < 0.05$), and there was no significant difference between the pre-test values of ACTH pre-post-test, cortisol and total testosterone levels ($p > 0.05$).

4. Discussion and Conclusion

Citrulline malate has been used in Europe for years to help with aging and muscle fatigue and produces more energy.

Parametreler		Control Group	Experimental group	t	p
ACTH	Pre- test	22,34 ±5,34	22,72±6,64	,175	0,86
	Post-test	29,10 ±10,07	35,61±7,46	2,008	0,05
Cortisol	Pre- test	6,87±2,20	8,96±3,48	1,963	0,06
	Post-test	10,73±2,22	13,44 ±2,08	3,449	0,00*
Total Testosterone	Pre- test	4,98±1,46	5,25±1,81	,435	0,66
	Post-test	4,29±0,88	6,44±1,26	5,388	0,00*

Table 3: Gruplar arası karşılaştırma analiz sonuçları

Under healthy conditions, it has an ergogenic effect associated with an improvement in muscle contraction efficiency. The changes in muscle metabolism produced by CM treatment indicate that CM can support aerobic energy production and have positive effects on hormone metabolism [5]. When the literature was reviewed, it was reported that a significant 40% reduction in muscle soreness was obtained in studies, especially 1 and 2 days after chest training, and a response percentage higher than 90% with CM supplementation. However, the only reported side effect was that 14.63% of the subjects felt an upset stomach. They concluded that the use of CM may be beneficial in improving athletic performance in high-intensity anaerobic exercises with short rest periods and in relieving post-exercise muscle fatigue. Thus, athletes who are in an intense preparation phase with high-level training or competition activities stated that they can gain from CM [9].

In today's studies, reducing fatigue during exercise has become extremely important in terms of making ongoing exercises healthier. Some studies suggest that CM actually increases energy in human and animal muscles. In a parallel study, researchers found that using 6 g of CM per day for 15 days resulted in a 20% increase in post-exercise creatine phosphate recovery, a 34% increase in fatigue during exercise, and a 34% increase in ATP production [10]. Glenn et al., [11] found that acute CM supplementation increased upper and lower body resistance exercise performance, decreased heart rate and perceived exertion during upper body exercise. In their study, Amirsasn et al., [12] found that a one-week CM, L-arginine and combination of these two supplements improved performance by reducing exercise-induced metabolic stress and fatigue index (lactate level) in male wrestlers. Bendahan et al. [5] found in their study that as a result of the effect of hormone metabolism in athletes as a result of CM supplementation, there was a significant decrease in the feeling of fatigue, a 34% increase in oxidative ATP production rate during exercise and a 20% increase in phosphocreatine recovery rate after exercise.

In conclusion, they declared that the changes in muscle metabolism produced by CM treatment showed that CM could promote aerobic energy production. In light of these results, athletes or sports scientists can improve their performance with CM during high-intensity anaerobic exercises. Parallel to this, it has been stated that CM can also be effective by increasing resistance to fatigue in infected mice. Rogers et al. [13] determined in their study that both Nitrisigine and CM increase endothelium-dependent vasodilation and that increased vasodilation leads to an increase in skeletal muscle blood flow, leading to potential improvements in exercise performance. In a different study, Hodges [14] found that acutely administered CM had no effect on mitochondrial function, oxygen saturation or desaturation, and performance of the hand grip critical strength test. Akbulut et al., [15] found in their study that vitamin E supplementation applied in addition to high-intensity interval training has a significant effect on hormonal metabolism. Jackson [10] found in his study that CM can help you do more reps in the gym or

stay in training longer. In addition, anecdotal evidence from athletes using CM products reveals powerful effects that reduce fatigue and improve performance.

In the study conducted by Farney et al., [16], they found that CM supplementation was not effective in improving performance and fatigue after a high-intensity exercise. Erdoğan et al., [17], in their study, determined that zinc supplementation applied in addition to regular exercises has a significant effect on glucose and fat metabolism. In addition, Wax et al. [7] said that CM supplementation may be beneficial in improving exercise performance during lower body multiple resistance exercise in men with advanced resistance training. CM may be useful in high-intensity anaerobic exercise with short rest periods to improve athletic performance and relieve post-exercise muscle soreness. For this reason, it is said that athletes in an intense preparation phase with high levels of training or competitive activities can profit from CM. It is also included in studies that citrulline malate intake significantly increases the amount of repetitions for each exercise. In the study conducted by Chappell et al., [18], they determined that acutely applied CM did not significantly affect anaerobic performance. Naimah et al. [19] stated in their study that acute CM supplementation would increase anaerobic performance by providing improvement in nitric oxide. In their study, Moradi et al. [20] found that CM supplementation applied in addition to 6-week HIIT training increased nitric oxide and anaerobic power in elite male wrestlers when compared to routine HIIT training.

In conclusion; It has been observed that the citrulline malate supplement group applied in addition to the fitness training has a significant effect on the hormone metabolism and provides a greater increase compared to the group in which the fitness training is applied. In this case, we can say that the Citrulline/Malate supplement can contribute positively to the performance of the athletes with its anti-fatigue effect.

Conflict of interest

The authors declare no conflict of interests. All authors read and approved final version of the paper.

Authors Contribution

All authors contributed equally in this paper.

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