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ORIGINAL ARTICLE

The Effect of Citrulline/Malate on Blood Lactate Levels in Intensive Exercise

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Abstract The purpose of this study was to examine the effects of Citrulline/Malate supplementation with intensive training on blood lactate level in active handball players. The athletes were subjected to intense training for 4 weeks, 4 days a week, mainly pre-season strength and technique training. In this training period, stimol group ($n = 11$) athletes were given stimol 3 times a day as 1 g for breakfast, 1 g for lunch, and 1 g for dinner while the placebo group ($n = 11$) athletes were given only placebo in the same dosage and the same color at the same time. Blood lactate levels in athletes were measured 4 times, prior to and after a 1-month program as follows: rest (R), end effort (EE), recuperation 5 min (R5 m), and recuperation 20 min (R20 m). Blood lactate levels were compared both as intra-group and between the groups. In intra-group comparison, no change was observed in blood lactate levels in placebo group while a significant difference was found in the levels of stimol group as $p < 0.05$ with a 49.8% decrease in blood lactate level. In the measurements between groups, in the post-test measurements made after the training period, significant differences as $p < 0.05$ were found with a 60.7% decrease in blood lactate level EE. Considerable decline was seen especially immediately after exercise in blood lactate levels of the athletes being given stimol supplement. In this case, we can say that Citrulline/Malate supplementation may contribute positively to the performance of athletes and may help postpone fatigue at excessive or prolonged activity.

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Introduction

Deformation is the reality that a sportsman can suddenly encounter. It is impossible that the sportsmen and trainers know when they will become invalid. In such a case, the risk of deformation should be eliminated or minimized. While the sportsman who races strained during the competition gets weak, he/she can disable by enforcing his/her body during the performance that should be done. The science of sport upholds sport with the scientific works by keeping in step with the developing technology. Ergogenic supplements can assist in that the sportsmen can tire late and rally 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 leads to more blood flow to muscles. More blood flow leads to high oxygen and nutrient transfer, so more muscle energy is produced. Citrulline is also critical for the removal of ammonia from the body (Perine and Stoppani 2010). Citrulline malate (CM) is used as a performance-enhancing athletic dietary supplement and it reduce muscle fatigue in a preliminary clinical trial (Crenn et al. 2000).

Citrulline malate is a nonessential amino acid that increases exercise performance in males. However, based on physiological differences between genders, these results cannot be extrapolated to females. Therefore, the purpose of this investigation was to evaluate effects of acute CM supplementation on upper- and lower-body weightlifting performance in resistance-trained females (Glenn et al. 2015).

The beneficial effects of CM may be related to both the malate and the citrulline interfering with the muscle energy metabolism level. Malate is an intermediate of tricarboxylic acid cycle (TCA) and its addition could increase energy production (Bendahan et al. 2002; Wagenmakers 1998). Also citrulline has been shown to expedite the clearance of plasma ammonium and lactate, and might be involved in the destruction of muscle metabolism by-products thereby paying to the enhancement of muscle function (Briand et al. 1992; Verleye et al. 1995).

Nitric oxide (NO) produces citrulline malate (CM) in the NO synthase (NOS) pathway and increases exercise performance in young. With age, NO production decreases and augmented NO production may provide beneficial effects on sports performance among masters' athletes (Glenn et al. 2016).

A single dose of L-citrulline or watermelon juice as a pre-exercise addition appears to be unproductive in improving exercise performance; however, greater doses of L-citrulline have been shown to be innocent and are currently left unexamined (Cutrufello et al. 2015).

Citrulline malate is known to limit the harmful effect of asthenic state on muscle function, but the effect on healthy condition is poorly documented (Giannesini et al. 2011). Citrulline malate (CM) suggested an ergogenic effect during resistance exercise; however, there are a small number of studies investigating these claims (Wax et al. 2016). Although previous studies are not yet clear on the effect of CM

metabolism, the effects on the metabolism of lactate are observed (Fornaris et al. 1984).

The main aim of this study was to examine the effects of Citrulline/Malate supplementation on blood lactate level in active handball players.

Subjects and Methods

Ethical Statement

An institutional review board for human experimentation approved the protocol (Ataturk University Faculty of Medicine Ethics Committee, authorization number B.30.2.ATA.0.01.00/9). Informed consent was obtained from each participant, and the processes followed were in agreement with the ethical standards of the responsible committee on human experimentation and with the Helsinki Declaration of 1975, as revised in 2008.

Athletes

Twenty-two athletes who were active players in the First Handball League of Turkey participated voluntarily in the study. Athletes were divided into two separate groups as Placebo (P, $n = 11$) group and Stimol group (S, $n = 11$). Antropomorphometric and physiological variables of the athletes are shown in Table 1.

Methods

The athletes were subjected to intense training for 4 weeks, 4 days a week, mainly pre-season strength and technique training. In this training period, stimol group athletes were given stimol 3 times a day as 1 g for breakfast, 1 g for lunch, and 1 g for dinner while the placebo group athletes were given only placebo in the same dosage and the same color at the same time. Blood lactate levels in athletes were measured 4 times, prior to and after a 1-month program as follows: rest (R), end

Table 1 Antropomorphometric and physiological variables of the athletes

Parameters	Citrulline malate group Mean ± Std	Placebo group Mean ± Std
Age (year)	21.57 ± 4.58	18.00 ± 2.00
Height (cm)	179.86 ± 5.73	179.27 ± 10.55
Weight (kg)	70.59 ± 7.08	79.35 ± 7.08
BMI (kg/m^2)	21.84 ± 1.88	24.34 ± 3.49
BMR	1816.43 ± 131.94	1987.64 ± 307.00
FAT (%)	6.91 ± 3.16	9.28 ± 4.12
FATMASS	5.00 ± 2.47	7.95 ± 5.46
FFM	65.67 ± 8.85	71.40 ± 15.51
TBW (%)	48.05 ± 4.30	52.26 ± 11.36

effort (EE), recuperation 5 min (R5 m), and recuperation 20 min (R20 m). Physiological characteristics of the athletes were determined at the beginning and at the end of the program by Tanita TBF-300 body analyzer.

Statistics

Statistical significance in changes of response variables was attained using within group Wilcoxson and between groups Mann–Whitney *U*. Differences were considered significant at $p < 0.01$ and $p < 0.05$ (SPSS, Ver. 17.0, Chicago, IL, USA).

Discussion

The study showed that supplement of stimol efficiently decreases in blood lactate level especially immediately after exercise in sportsmen (Table 2). Plasma lactate levels were compared both as intra-group and between the groups. In intra-group comparison, no change was observed in lactate levels in placebo group while a significant difference was found in the levels of stimol group as $p < 0.05$ with a 49.8% decrease in blood level. In the measurements between groups, in the post-test measurements made after the training period, significant differences as $p < 0.05$ were found with a 60.7% decrease in plasma lactate level immediately after exercise (Table 2).

Citrulline malate is used in Europe for years to help with aging and muscle fatigue and produces more energy (Jackson 2004). Under healthy conditions, it has an ergogenic effect associated with an improvement in muscle contraction efficiency (Giannesini et al. 2011). The changes in muscle metabolism produced by CM treatment indicate that CM may promote aerobic energy production (Bendahan et al. 2002).

Significantly decrease of 40% in muscle soreness at 1 and 2 days after the pectoral trainings and a higher percentage response than 90% was achieved with CM supplementation. The only side effect reported was that 14.63% of the subjects felt stomach ailments. Perez-Guisado and Jakeman (2010) have come to the conclusion that using CM might be beneficial increase athletic performance in high-intensity anaerobic exercises with short resting period and to relieve post-exercise muscle fatigue. Thus, athletes who are in intensive preparatory stages with high level of training or competitive events have stated that they will be able to earn profits from CM.

Today, reducing fatigue during exercise is extremely important in terms of making the ongoing workouts healthier. Some studies have suggested that CM actually enhances energy in human and animal muscles. In the study, researchers found that using CM 6 g daily for 15 days had a 20% increase in creatine phosphate recovery after exercise, a feeling of fatigue during exercise and a 34% increase in ATP production (Jackson 2004).

On the other hand, single dose of L-citrulline or watermelon juice as a pre-exercise supplement is said to be ineffective without improving exercise

Table 2 The effects of Citrulline/Malate (stimol) supplementation on blood lactate level in active male athletes

Blood lactate	Time	Citrulline malate group				Placebo group				Between groups	
Measurement		Mean ± SE	z	$p<$	% change	Mean ± SE	z	$p<$	% change	z	$p<$
Rest	Pre	1.83 ± 0.18	0.542	–	5.5	1.80 ± 0.22	1.402	–	31.9	0.000	–
	Post	1.93 ± 0.30				2.64 ± 1.39				0.743	
End effort	Pre	13.44 ± 8.18	2.366	0.05	−50.2	11.62 ± 3.36	0.770	–	−5.3	0.136	0.05
	Post	6.69 ± 3.88				11.03 ± 3.03				2.225	
Recuperation 5 min	Pre	10.04 ± 5.35	0.000	–	−8.7	7.88 ± 2.31	1.719	–	12.7	0.589	–
	Post	9.17 ± 5.42				9.03 ± 4.11				0.583	
Recuperation 20 min	Pre	2.19 ± 0.35	1.367	–	−4.1	2.74 ± 0.76	0.105	–	1.4	1.1772	–
	Post	2.10 ± 0.43				2.78 ± 0.95				1.570	

performance; however, more doses of L-citrulline have been shown to be safe (Cutrufello et al. 2015).

Short-term oral administration of L-CM in some patients, not only in sports, decreased pulmonary arterial hypertension (PAH) slightly and improved exercise capacity and quality of life in patients with PAH without serious side effects (Kashani et al. 2014). The faster recovery of the physical capacity after acute illnesses was confirmed by double-blind, placebo-controlled studies (Creff 1982; Dauverchain 1982; Commandré 1978).

Bendahan et al. (2002) found out in their study that there were a significant reduction in the feeling of fatigue, a 34% increase in the rate of oxidative ATP production during exercise, and a 20% increase in the rate of phosphocreatine recovery after exercise. In conclusion, they declared that changes in muscle metabolism produced by CM treatment indicate that CM may promote aerobic energy production.

Athletes or sportsmen can raise their performances by CM during the high-intensity anaerobic exercises. CM is also effective by increasing the resistance to fatigue in infected rats (Perez-Guisado and Jakeman 2010).

According to the data obtained in the study conducted, it is revealed that CM reinforcement under healthy conditions has an ergogenic effect related to improvement of muscle contraction efficiency (Giannesini et al. 2011). In a similar conclusion, Wax et al. (2016) found that CM increased performance of upper body resistance in males in the age of educated college. Consuming the pre-competitive CM has the potential to improve the performance of tennis players in tennis athletes (Glenn et al. 2016). Previous oral L-citrulline administration during a cycling improves NO synthesis for oxidative burst without oxidative damage and the use of plasma arginine (polymorph nuclear neutrophils) for PMNs (Sureda et al. 2009). During the upper body exercises, acute CM supplementation in the teeth reduced upper- and lower-body resistance exercise performance. This demonstrates that athletes competing with sports-strength-based needs can potentially increase performance by acutely reinforcing CM (Glenn et al. 2015).

CM may be useful to increase athletic performance in high-intensity anaerobic exercises with short rest periods and to alleviate muscle pain after exercise. For this reason, athletes at an intensive preparatory stage with a high level of training or competitive activities are said to be able to make profits from the CM (Perez-Guisado and Jakeman 2010). It is also in the research that citrulline malate intake significantly increases the amount of repetition for each exercise (Wax et al. 2016).

Although decrease in stimol group and increase in placebo group were determined in lactate levels at Recuperation 5 min and Recuperation 20 min after exercise, this was not statistically significant (Table 2). Our findings are in line with previous studies conducted in activity of CM on the metabolism of lactic acid (Fornaris et al. 1984). The reason for this might be associated with the person's fitness level of recovery time. On the other hand, Vanuxem et al. (1990) showed that CM enhances elimination of NH3 during the recovery period therefore; serum lactate levels did not differ between placebo and CM groups.

Jackson said that CM may help you get more reps in the gym or go longer on the training. Additionally, anecdotal evidence from athletes using CM products reveals

strong fatigue-diminishing and performance-enhancing effects (Jackson 2004). Besides of this, Wax et al. (2016) said that CM supplementation may be beneficial in improving exercise performance during lower-body multiple-bout resistance exercise in advanced resistance-trained men.

Results

As a result of our research, there was no difference at the time of resting; there was a noticeable decrease end of effort and no difference at the time of recuperation 5 min and 20 min in plasma lactate levels of athletes given stimol supplement. In this case, we can say that Citrulline/Malate supplement can make a positive contribution to the performance of the athletes with fatigue-retarding effect.

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