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THE EFFECT OF THE USE OF COENZYME Q_{10} ON LACTIC ACID AND TOTAL ANTIOXIDANT CAPACITY IN PROFESSIONAL SKIERS

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ABSTRACT

This study aims to prevent lactic acid (La) deposition of coenzyme Q_{10} (CoQ_{10}) supplement in professional skiers and to investigate its effect on total antioxidant capacity (TAC). The study group consisted of 15 voluntary male skiers. The athletes were categorized into three groups as control group, experimental groups using 100 mg and 200 mg CoQ_{10}. During the study, 70-80% loading training program was applied on each of three groups. This program was applied for 2 hours once in a day during 1 week. Blood samples were taken from athletes both before and after training. HPLC was used to determine CoQ_{10} levels, lactate assay kit II was used to determine La levels and TAC kit was used to determine TAC levels. Lactate, TAC and plasma CoQ_{10}values were compared before and after training. Accordingly, an increase was observed in lactate values of control group $p<0.01$ and a significant decrease ($p<0.01$) was found in plasma lactate groups using 100 and 200 mg CoQ_{10} compared to the values before the training. A significant increase ($p<0.01$) was observed in CoQ_{10} and TAC values of experimental groups. Groups were compared by days during a week and it was found that plasma lactate levels of control group increased; no change occurred at CoQ_{10} and TAC levels; plasma lactate levels of experimental groups decreased and these levels significantly increased in TAC and CoQ_{10} groups ($p<0.01$). In conclusion, it is believed that due to its degree correlation with cellular energy flow and energy generation, CoQ_{10} increases physical performance on one hand anddecrease La deposition, increase TAC and delays fatigue on the other hand.

Key words: Ski, Antioxidant, CoQ_{10}, Lactate, Training

1. INTRODUCTION

As a benzoquinone component created and synthesized naturally by human body, CoQ_{10} is found in skeleton or cardiac muscle tissues, liver, kidney, brain and such organs in which high physical activities occur (1). Coenzyme Q_{10} (2-methyl-5,6-dimethoxy-1,4- benzoquinone), soluble natural fat quinine, is aubiquitous and endogenous lipid-soluble antioxidant found in plant as well as in humans and animal organisms. CoQ_{10} is crucial to optimal biological function. It is a component of the oxidative phosphorylation process in mitochondria that converts the energy in fatty acids and carbohydrates into ATP to drive cellular synthesis (2). As a result, due to its first degree correlation with cellular energy flow and energy generation, CoQ_{10} transfers electron to cellular molecules and helps to generate energy from ATP by means of contributing to mitochondria to generate energy (3, 4).

Muscular contraction requires energy and muscle is a mechanism that transforms chemical energy into mechanic one (5). Vital functions of human organism, especially the conduction of nerve impulses are related to energy generation that results from chemical reactions such as muscular contraction. Therefore, energy requirement of people increase with exercise and the decrease in muscle glycogen stores results in loss of weight and it gets harder to maintain training (6). In dense training (maximal and supramaximal), exceeding aerobic metabolism increases glycolysis rate and lactic acid (La) emerges inevitably. When the intensity of exercise exceeds oxygen supply capacity of body, La system is used as fuel, La deposition in blood reduces pH and fatigue occurs as a result of enzymatic activity (7). As a result, many reactive oxygen types such as superoxide, hydrogen peroxide and hydroxyl radicals emerge (8). For this reason, various defense mechanisms called as antioxidant defense systems or shortly antioxidants develop in organism in order to prevent adverse effects of free radicals. As a major antioxidant, the fundamental role of CoQ_{10} is to be a part of mitochondrial respiration chain and a major component of cellular energy generation. In addition, it is believed that the use of CoQ_{10} helps to generate energy in mitochondria by means of decreasing oxidative stress and increasing physical performance and reducing fatigue (9, 10). It has been claimed that increased ROS production and metabolic stres attenuate CoQ10 levels in muscle tissue, and this decrease negatively affects exercise performance. Coenzyme Q10 supplement ation should increase CoQ10 concentration in muscle tissue, thus elevating freeradical–scavenging activity period. Therefore, CoQ10 supplementation could normalize and even increase the exercise performance in athletes (11, 12).

This study aims to prevent lactic acid deposition of coenzyme Q_{10} (CoQ_{10}) supplement in professional skiers and to investigate its effect on total antioxidant capacity.

2. METHODS

Study Protocol was confirmed by 09.06.2009 dated and B.30.2.KAU.0.20.71.00 numbered decision of Ethics Committee of Medicine Faculty at Kafkas University. Each participant was informed about rules, materials and tests to be used before the study and all participants signed informed consent form. The study population consisted of 15 voluntary male skiers. The athletes were categorized into three groups as control group (n=5), experimental groups using 100 mg (n = 5) and 200 mg (n = 5) CoQ_{10}. Age, weight and height averages of participants were (21.60 ± 0.51 year, 64.20 ± 3.14 kg, 1.76 ± 0.02 cm) in control group, (21.80 ± 0.73 year, 66.80 ± 2.97 kg, 1.76 ± 0.01 cm) in 100 mg CoQ_{10} group and (21.60 ± 0.51 year, 63.80 ± 2.31 kg, 1.75 ± 0.01 cm) in 200 mg CoQ_{10} group.

During the study, 70-80% loading training program was applied on each of three groups. This program was applied for 2 hours once in a day during 1 week. The training program started 10 a.m. and it was prepared systematically and specifically to each group so as to obtain the most reliable effect physiologically. Exercises were repeated for a week in the same way as in the first day. Blood samples were taken from athletes before training once and after training during a week. HPLC (13) was used to determine CoQ10 levels, lactate assay kit II was used to determine lactic acid levels and TAC Assay Kit (Rel Assay Diagnostics, Clinical Chemistry Solutions, Gaziantep, Turkey) was used to determine total antioxidant levels.

3. ANALYSIS

SPSS 18.0 program was used to conduct statistical analysis of the data. The data were defined as the mean ± standard deviation. Matched t-test was used to determine any difference between data before and after substance. SAS 9.2 Proc GLM procedure was used to determine any difference between Lactate and CoQ_{10} values of 3 groups within 7 days and the results were compared in accordance with LSD procedure (14). Lower P value than 0.05 was regarded to be significant.

4. RESULTS

Comparing lactate, TAC and plasma CoQ10 values before and after training, an increase was observed in lactate values of control group p<0.01 and a significant decrease (p<0,01) was found in plasma lactate groups using 100 and 200 mg CoQ10 compared to the values before the training. However, it was found that the decrease in plasma lactate values of the experimental group using 200 mg CoQ_{10} was more significant than 100 mg CoQ_{10} group.Comparing $CoQ_{10}$and TAC values before and after training, no significant difference was found in control group and p<0.01 increase was found in experimental groups (Table 1).

Table 1. The Mean Lactate (nmol), CoQ_{10} (μmol/L) and TAC (nmol) Values ($\overline{X}$) and Standard Deviation (sd) Values of Groups Before and After Training

		Control Group (n = 5)	100 mg CoQ10 group (n = 5)	200 mg CoQ10 group (n = 5)
Variables		$\overline{X}$ ± Sd	$\overline{X}$ ± Sd	$\overline{X}$ ± Sd
Lactate	B.T.	2.15 ± 0.11	2.29 ± 0.49	2.27 ± 0.22
	A.T.	4.40 ± 0.67	1.21 ± 0.19	0.55 ± 0.1
CoQ10	B.T.	1.43 ± 0.18	1.42 ± 0.34	1.43 ± 0.46
	A.T.	1.50 ± 0.28	2.40 ± 0.45	4.20 ± 0.21
TAC	B.T.	1.25 ± 0.18	1.52 ± 0.31	1.86 ± 0.59
	A.T.	1.26 ± 0.18	3.56 ± 0.97	4.59 ± 0.98

Before Training (B.T.), After Training (A.T.)

During one-week training, groups were compared. Accordingly, an increase was found in plasma lactate levels of control group and a decrease was found in experimental groups. This decrease was not found to be significant between control and 100 mg CoQ_{10} group on the 1st day, it was significant in 200 mg CoQ_{10} group at p<0.05 level. From second day to 7th day, decreases and increases on plasma lactate levels were found to be significant (p<0.01), (Table 2).

Table 2. Mean ($\bar{X}$) and Standard Deviation (sd) Values of the Changes in Plasma Lactate Levels (nmol) of Control Group, 100 and 200 mg CoQ_{10} Groups by Days

	1th Day:	2th Day:	3th Day:	4th Day:	5th Day:	6th Day:	7th Day:
Groups	$\bar{X}$ ± Sd	$\bar{X}$ ± Sd	$\bar{X}$ ± Sd	$\bar{X}$ ± Sd	$\bar{X}$ ± Sd	$\bar{X}$ ± Sd	$\bar{X}$ ± Sd
Control	2.1 ± 0.11[a]	2.5± 0.29[a]	2.6± 0.34[a]	2.94 ± 0.34[a]	3.38 ± 0.61[a]	3.72± 0.62[a]	4.41±0.6[a]
1st Group	2.19± 0.49[a]	1.65± 0.12[b]	1.66± 0.36[b]	1.39 ± 0.22[b]	1.31 ± 0.23[b]	1.3 ± 0.3[b]	1.18±0.1[b]
2nd Group	1.31± 0.22[b]	1.22± 0.14[c]	1.09± 0.25[c]	0.91 ± 0.12[c]	0.77 ± 0.31[c]	3.97± 0.12[c]	0.53± 0.1[c]

** The difference between groups indicated with different letters is significant (p<0.05)*

Comparing plasma CoQ_{10} levels of experimental groups with the first day of control group, no difference was found in levels of 100 mg CoQ_{10} group until 3rd day and significant increases started to be observed on 4th day. In addition, plasma CoQ_{10} levels of 200 mg CoQ_{10} group started to increase clearly on 1st day (p<0.01), (Table 3).

Table 3. Mean ($\bar{X}$) and Standard Deviation (sd) Values of the Changes in Plasma CoQ_{10} Levels (nmol) of Control Group, 100 and 200 mg CoQ_{10} Groups by Days

	1th Day:	2th Day:	3th Day:	4th Day:	5th Day:	6th Day:	7th Day:
Groups	$\bar{X}$ ± Sd	$\bar{X}$ ± S	$\bar{X}$ ± S	$\bar{X}$ ± S	$\bar{X}$ ± S	$\bar{X}$ ± S	$\bar{X}$ ± Sd
Control	1.43±0.18[a]	1.69±0.52[a]	1.65±0.38[a]	1.59±0.25[a]	1.86 ± 0.58[a]	1.62±0.43[a]	1.5±0.28[a]
1st Group	1.83±0.34[a]	1.75±0.54[a]	2.03±0.33[a]	2.11±0.44[b]	2.02 ± 0.4[b]	2.22±0.36[b]	2.4±0.45[b]
2nd Group	2.75±0.46[b]	3 ± 0.72[b]	3.4 ± 0.32[b]	3.31 ± 0.5[c]	3.7 ± 0.28[c]	3.97±0.53c	4.2±0.21[c]

** The difference between groups indicated with different letters is statistically significant (p<0.05).*

Comparing plasma TAC levels of experimental groups with control group, no difference was found in levels of 100 mg CoQ_{10} group until 3rd day and significant increases started to be observed on 4th day. In addition, plasma TAC levels of 200 mg CoQ_{10} group started to increase clearly on 1st day (p<0.01) (Table 4).

Table 4. Mean ($\bar{X}$) and Standard Deviation (sd) Values of the Changes in Plasma TAC Levels (nmol) of Control Group, 100 and 200 mg CoQ_{10} Groups by Days

	1th Day	2th Day	3th Day	4th Day	5th Day	6th Day	7th Day
Groups	$\bar{X}$ ± Sd	$\bar{X}$ ± Sd	$\bar{X}$ ± Sd	$\bar{X}$ ± Sd	$\bar{X}$ ± Sd	$\bar{X}$ ± Sd	$\bar{X}$ ± Sd
Control	1.25±0.18[a]	1.26±0.16[a]	1.39±0.10[a]	1.41±0.17[a]	1.34 ± 0.12[a]	1.46±0.34[a]	1.47±0.34[a]
1[st] Group	1.32 ±0.36[a]	1.42±0.62[a]	1.85±0.43[a]	2.87±0.57[b]	3.13 ± 0.36[b]	3.16±0.62[b]	3.61±0.16[b]
2[nd] Group	1.76 ± 0.59[b]	2.68± 0.50[b]	3.15±0.34[b]	3.67± 0.49[c]	3.89 ± 0.11[c]	4.17±0.19[c]	4.42±0.31[c]

** The difference between groups indicated with different letters is statistically significant (p<0.05).*

5. DISCUSSION

In dense training, exceeding aerobic metabolism increases glycolysis rate and lactic acid emerges inevitably. The lactate that accumulates in muscles and blood results in fatigue. This case requires resting to remove the lactate from body (15). In some studies (16, 17, 18), it has been shown that oral CoQ10 supplementation has no effects on physical performance in healthy athletes and/or untrained individuals. On the contrary, some researchers (19, 20) suggest that aerobic power, anaerobic threshold, or exercise performance increased after CoQ10 supplementation. In a research (21), a total of 25 people being 19 trained and 6 untrained, performed short-term bicycle ergometer and it was found that 12 and 60 minutes later, La levels increased in both groups. It was observed that La levels of untrained group was lower than those of trained group. In another study (9), bicycle ergonometer was performed for 2 weeks. 100 mg and 200 mg CoQ_{10} was orally given to 17 healthy voluntary participants. After exercise, it was found that lactate values significantly decreased. These findings support the findings of the present research (Table 1). Furthermore, in a similar study conducted on 25 elite skiers (19), it was found that CoQ_{10} supplement decrease muscle lactic acid level and increased plasma CoQ_{10} level. As a result, due to its first degree correlation with cellular energy flow and energy generation, CoQ_{10} transfers electron to cellular molecules and helps to generate energy from ATP by means of contributing to mitochondria to generate energy. For that reason, we can say that the use of CoQ_{10} prevents lactate deposition in muscles and thus reduces fatigue.

Weston et al. (22) gave 1 mg/kg CoQ_{10} to 18 voluntary male athletes for 28 days in order to investigate the effect of CoQ_{10} on aerobic capacity, strength and plasma CoQ_{10}. This study showed that plasma CoQ_{10} levels significantly increased and no change occurred in VO_2max levels. Bonetti et al. (23) gave CoQ_{10} to middle-aged participants and those ride bicycle at least for 1000 km for 8 weeks and significant increase was observed in plasma CoQ_{10} levels. Similarly in this study, comparing lactate, TAC and plasma CoQ10 values before and after training, an increase was observed in lactate values of control group $p<0.01$ and a significant decrease ($p<0.01$) was found in plasma lactate groups using 100 and 200 mg CoQ10 compared to the values before the training. However, it was found that the decrease in plasma lactate values of the experimental group using 200 mg CoQ_{10} was more significant than 100 mg CoQ_{10} group.Comparing $CoQ_{10}$and TAC values before and after training, no significant difference was found in control group and $p<0.01$ increase was found in experimental groups. It can be said that the reason for the increase in plasma levels of CoQ_{10}which is a powerful antioxidant is to decrease free radicals increasing due to mitochondrial oxidative phosphorylation in muscles and to meet the decreasing energy need. Low concentrations of CoQ_{10} during energy generation in bloods of skiers indicate that CoQ_{10} supplement is needed to improve physical performance in such sport branches (24).

The reasons for the La deposition during exercise are as follow: the higher anaerobic glycolysis rate than the rate of pyruvate transmission to mitochondria membrane, incompetency of buffer systems to buffering La hydrogen, less amount of hydrogen transmitting from muscle to blood than La amount produced in tissue. Porter et al. (25) made untrained males perform bicycle ergonometer for 2 months and gave 150 mg CoQ_{10} per day and a significant decrease was observed in lactate levels. In another study (9) supporting this findings, bicycle ergonometer was performed for 2 weeks. 300 mg CoQ_{10} was orally given and it was found that lactate values significantly decreased. Moreover, it was observed that there is a negative relationship between the increase in CoQ_{10} amounts and plasma lactate values. Similarly, Cookeet al. (12), made 22 trained and 9 untrained males and females perform exercises for 14 days and they reported that 100 mg CoQ_{10} supplement twice a day resulted in significant increase in plasma CoQ_{10}levels. Because it can be said that, low CoQ_{10} concentration of athletes during exercises plays a major role in energy generation process as an electron receiver-supplier at mitochondria wall. Comparing $CoQ_{10,}$ TAC and plasma lactate levels of groups by days during a week and it was found that plasma lactate levels of control group increased; no change occurred at CoQ_{10} and TAC levels; plasma lactate levels of experimental groups decreased and these levels significantly increased in TAC and CoQ10 groups. Therefore, CoQ_{10} taking place in mitochondria of cells and leading to energy and ATP generation, has an important catalyzer role which ensures adaptation to high physiologic activities in muscle tissues and it is in this manner that organism can tolerate changes such as the decrease in ATP generation that results from metabolic loading (26). Moreover, when oxygen decreases/ is completely consumed, glycolysis anaerobic turns into lactic acid in respiration and this leads to fatigue. However, we can say that transmission of electron to mitochondria by CoQ_{10}increase energy generation in muscles and decrease lactate deposition and thus improve physical performance (27).

Conclusions, it can be said that physical exercise increases oxygen consumption and also generation of reactive oxygen types; leads to muscle fatigue and thus to oxidative damage. On the other hand, the use of CoQ_{10} contributes to energy generation process in mitochondria, decreases La deposition in muscles, increases TAC capacity and thus improves physical performance.

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