Effect of 14-day Coenzyme Q_{10} Supplement in Male Skiers on VO2max and Respiratory Parameters

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Abstract

This study was carried out in order to examine the effect of 14-day Coenzyme Q_{10} (CoQ_{10}) supplement in male skiers on pre- and post-exercise maximal oxygen consumption (CO2max) as well as respiratory parameters. The study was conducted on volunteer 15 male skiers. The sportsmen were divided into three groups including one control group (n = 5) and two study groups, one of which was given 100 mg (n = 5) CoQ_{10}, and the other one was given 200 mg (n = 5) CoQ_{10}. For 14 days, the sportsmen were given CoQ_{10} before their exercise programs. Their blood samples were drawn before and after exercise. VO2max, Forced Expiration Volume (FEV_1), Forced Vital Capacity (FVC), Maximum Voluntary Ventilation (MVV) and Vital Capacity (VC) were measured.

The results revealed an increase in FEV_1, MVV values of the control group as well as in CoQ_{10}, VO2max, FVC, FEV_1, MVV and VC values of the study groups at the levels of ($p<0,05$; $p<0,01$) respectively when the pre- and post-exercise periods of the groups who had exercise after CoQ_{10} supplement were compared. A significant increase ($p<0, 05$) was detected when post-exercise VO2max values of the control and the study groups were compared. When their post-exercise respiratory parameters were examined, there was no significant difference between the MVV values of the control and the study groups, although their FVC, VC and FEV_1 values increased at the following levels respectively: ($p<0,05$; $p<0,01$).

Consequently, it can be said that 14 days of regular exercise and CoQ_{10} supplement had an impact on the skiers' post-exercise CoQ_{10}, VO2max and respiratory parameters.

Key Words: Exercise, Coenzyme Q_{10}, respiratory parameters, Maximum Oxygen Consumption

Introduction

CoQ_{10} was first discovered in 1957 by Dr Frederick Crane. It is a benzoquinone compound naturally made and synthesized by human body (Kawamukai, 2002). The principal role of CoQ_{10} is that it is a part of mitochondrial respiration chain and an important component of cellular energy generation. In addition to its central role in mitochondrial respiration chain, CoQ_{10} also takes part in various parts of cellular metabolism, and is present in mitochondria. Cellular respiration, which releases energy and ATP, takes place in mitochondria (Frederick and Crane, 2001; Genova et al, 2003; Turunen et al, 2004).

During exercise, oxygen and energy needs of muscles increase together with the necessity of removing metabolites and carbon dioxide. As a result of the increases in such necessities, chemical, mechanical and thermal stimuluses cause changes in metabolic, cardiovascular and respiratory functions. With lifting, quite sharp changes occur within the organism. Changes such as muscular contractions, respiration, heart rate, sweating, energy use, enzyme actions etc. impact homeostasis (Burton et al, 2004). During muscular activity, O_2 use in active muscles increases, and together with this, nutrients are needed for satisfying the energy need of active muscles. More waste products are formed with the increase of metabolic activities. Besides, respiratory rate increases too. Present in mitochondria and contributing to energy or ATP generation in order for the organism to tolerate such changes, CoQ_{10} is a fundamental catalyser for enabling adaptation to highly physiologic activities in muscle tissues (Eric et al, 1992; Scott et al, 2008).

In some recent studies; In a 1997 study in Finland, the effects of CoQ_{10} supplements at 90 mg daily were studied in a double-blind cross-over study of 25 cross-country skiers. The results showed that all subjects significantly improved indexes of physical performance (Ylikoski, 1997). More recent work indicates an improvement in muscle CoQ_{10} level, oxygen consumption, and treadmill time to exhaustion in adults following only 14 days of supplementation at 200 mg daily (Cooke et al, 2008). Since CoQ_{10} is directly associated with cellular energy flow and generation, it carries electrons to cellular molecules, and helps derive energy from ATP by contributing to the energy generation process carried out in mitochondria. As a lipophilic substance, CoQ_{10} constitutes an integral part of the respiratory chain reactions in mitochondria membrane. In this process, hydrogen is carried to oxygen, during which energy is released in the form of oxidative phosphorylation, and stored in the form of ATP (Frederick and Crane, 2001; Saller et al, 2006).

Functional state of respiratory system is classically determined through the measurement of pulmonary volume and capacity (Atan et al, 2013). Moreover, an increase occurs in O_2 consumption rate in tissues, which is called VO2max. Through the exercise taken, sportsmen supply their body with much more oxygen than they actually need. Therefore, what is important is to increase the usability of oxygen, or in other words, VO2max through the exercise program applied (Tamer, 1995). While it is known that regular exercise programs have positive impact on respiratory and circulatory systems, studies conducted on respiratory parameters of sportsmen bring about different opinions. While some of these studies indicate that intensive physical exercises have an increasing impact on the respiratory parameters (Açıkada, 1982; Gelecek et al, 2000), some others point out that such an increase occurs depending on the developmental characteristics of the group of age (Ergen, 1983; Hagberg et al, 1988). Through this study, it was aimed to investigate the effect of a 14-day CoQ_{10} supplement on pre- and post-exercise VO2max values as well as respiratory parameters in male skiers.

Materials And Methods

15 male skiers, who are university students, attended the study on a voluntary basis. Ages (21,66 ± 0,58), weights (64,93 ± 2,80) and heights (1,76 ± 0,01) of the subjects are stated respectively. Approval of the local ethical committee was obtained as a part of the study conducted pursuant to the relative directive stated in Helsinki Declaration, the subjects were informed about the objective of the study before measurements. The subjects were divided into three groups, including one control group as well as two study groups, one of which takes 100 mg, and the other

200 mg CoQ_{10}. During the study, an exercise program with 70-80% lifting was applied to each of the 3 groups once a day for 2 hours during the 14-day period. The exercise program was systematically organized specific to each group. 100 and 200 mg of CoQ_{10} preparations were given to subjects 30 mins. after breakfast. For 14 days, exercises were repeated as stated within the program.

Table 1: Daily Exercise Program of the Male Skiers

Day 1	**30 min running (Basic Endurance (TD) + Power Training 3x30 min**
Day 2	12km walking (General Endurance (GD) / Specific Endurance (ÖD) +Medicine ball warm-up
Day 3	10 min warm-up+ Traditional technique with cross-skating + 20 min. training without baton
Day 4	Baton walking + Running (TD/GD)
Day 5	Traditional technique + 30 min. running without baton
Day 6	Skating techniques (TD) +30 min. running without baton
Day 7	20 min. running + Static power training
Day 8	Traditional technique (TD) + 6x2 km interval (ÖD)
Day 9	20 min. running (TD) + 40 min. Medicine ball warm-up + 3x20 min. power training
Day 10	Traditional technique (TD) + 20 min. training without baton + 10 min. running
Day 11	Traditional technique (TD) + 6x2 km interval (ÖD)
Day 12	Traditional technique with cross-skating (TD) + 10 min. warm-up+ 10km training without baton (GD) +15 min. running
Day 13	Traditional technique with cross-skating (TD) + 10 min. warm-up+ 10km training without baton (GD) +15 min. running
Day 14	Traditional technique + 20 min warm-up + 1 hour GD

Blood Sample Drawing

Blood samples of the sportsmen were drawn once before the exercises, and immediately after exercises during the two-week period into tubes with Lithium Heparin and anticoagulant. After the blood samples drawn centrifuged at 4000 rpm for 15 mins. in cooling centrifuge machine, the parts with plasma left at the top were put into polypropylene tubes, and stored in deep freezer at - 20 ◦C until their CoQ_{10} analyses were carried out.

Detection of CoQ_{10} Levels

50 µl 1,4-benzoquinone solution was added to 200 µl of plasma (2mg/ml), which was then vortexed for 10 seconds. 1ml n-propanol was added after 10 minutes. After being vortexed for 10 seconds, the tube was centrifuged at 10.000 rpm for 2 minutes in order to settle protein. 200 microliters of supernatant was injected to HPLC. The supernatant, which can maintain its activity for 3 days at room temperature (22 C) was transferred into a lidded test tube. After the generation of mobile phase with ethanol-methanol (65-35%), flow rate became 1 ml/minute. UV measurement was performed at 275 nm (Mosca et al, 2002).

Measurement of Respiratory Parameters

Forced Expiration Volume (FEV1), Forced Vital Capacity (FVC), Maximum Voluntary Ventilation (MVV) and Vital Capacity (VC) were measured by means of a spirometer, and recorded using a Data Logger and Telemetry Physiology Monitoring System-Bioharness device.

Measurement of VO2max Values

12 minutes run-walk test (Cooper), an indirect method, was carried out in order to determine maximal oxygen consumption (VO2max). The results were calculated by multiplying each tour distance (400 m) by the number of tours run and adding the distance of the incomplete tour (in meters) to the result of multiplication. VO2max values were determined by Balke formula (Balke, 1961). VO2max ml/kg-min. = 33.3+(X-150)x 0.178 ml/kg-min. X= the distance run in 1 minute (Tamer, 2000).

Statistical Analysis

The statistical analysis of the data was conducted on the SPSS 17.0 software. The data were expressed as mean ± standard deviation. Comparisons were performed between the variables among groups through the t-test and between in-group variables through the paired t-test. P values lower than 0.05 were regarded as significant.

Results

Ages, weights and heights of the athletes who participated in the study and who were all male were compared among the groups which are control and CoQ_{10}. At the end of the comparison, the groups did not demonstrate a significant difference in terms of their ages, weights and heights (p>0,05).

There was an increase in FEV_1, MVV values of the control group as well as in CoQ_{10}, VO2max, FVC, FEV_1, MVV and VC values of the study groups at the levels of (p<0,05; p<0,01) respectively when the pre- and post-exercise periods of the groups who had exercise after CoQ_{10} supplement were compared.

Table 2: Comparison of Pre- and Post-exercise CoQ_{10}, VO2max and Respiratory Parameters of the Groups (Median and Standard Deviation Values [±SD]).

Variables	Control Group		100 mg CoQ_{10} Group		200 mg CoQ_{10} Group	
	Pre-exercise X± SD	Post-exercise X± SD	Pre-exercise X± SD	Post-exercise X± SD	Pre-exercise X± SD	Post-exercise X± SD
CoQ10 (µmol/L)	1,42 ± 0,17	1,5 ± 0,28	1,43 ± 0,18	2,4 ± 0,45*	1,44 ± 0,19	4,2 ± 0,21**
VO2max (mg/kg-min)	65,24 ± 0,61	65,66± 0,47	65,18 ± 0,53	66,20± 0,67*	65,16 ±0,61	67,08± 1,06**
VC (lt)	4,58 ± 0,21	4,82 ± 0,22	4,56 ± 0,22	5,35 ± 0,22**	4,58 ± 0,11	5,97 ± 0,27**
FVC (lt)	4,91 ± 0,43	5,14 ± 0,43	4,87 ± 0,54	5,88 ± 0,39**	4,89 ± 0,53	6,43 ± 0,20**
FEV_1 (lt)	3,95 ± 0,40	4,23 ± 0,49*	3,92 ± 0,50	4,69 ± 0,32*	3,91 ± 0,69	5,34 ± 0,36*
MVV (lt)	141,3 ±5,22	149,7±3,62*	136,4±9,91	153,4±5,68**	136,8±11,7	155,2±7,89**

** p<0.01, * p<0.05, Before Exercise (Pre-exercise), After Exercise (Post-exercise) coenzyme Q_{10} (CoQ_{10}), Maximal Oxygen Consumption (VO2max), Forced Expiration Volume (FEV_1), Forced Vital Capacity (FVC), Maximum Voluntary Ventilation (MVV) and Vital Capacity (VC)

When post-exercise VO2max values of the control group were compared with those of 100 mg CoQ_{10} and 200 mg CoQ_{10} groups, a significant increase ($p<0,05$) was detected. However, when the post-exercise values of 100 mg CoQ_{10} and 200 mg CoQ_{10} groups were compared, no significant difference ($p>0,05$) could be found (Figure 1).

When their post-exercise respiratory parameters were examined, there was no significant difference between the MVV values of the control and the study groups, although their FVC increased at ($p<0,01$). On the other hand, while there was no significant difference between the post-exercise VC values of the control group and 100mg CoQ_{10} group, a significant increase ($p<0,01$) was seen in the VC values of the 200mg CoQ_{10} group. Furthermore, an increase at the level of $p<0,05$ was detected in the post-exercise values of 100mg and 200mg CoQ_{10} control groups. A significant increase ($p<0,05$) was seen in the post-exercise FEV1 values of the control group as well as the group taking 200mg CoQ_{10} (Table 3).

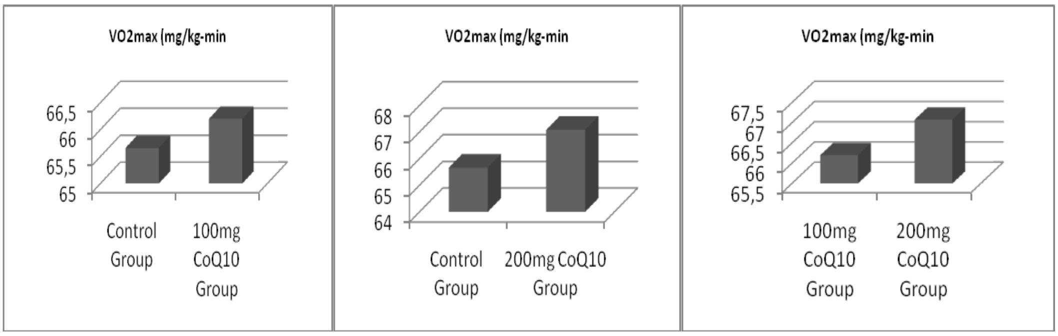

Figure 1. Changes in the VO2max Values of the Groups Given CoQ_{10}

Table 3: Comparison of Post-exercise VO2max values and Respiratory Parameters of the Groups (Median and Standard Deviation Values [±SD]).

Variables	Post-exercise		Post-exercise		Post-exercise	
	Control Group X± SD	100 mg CoQ_{10} Group X± SD	Control Group X± SD	200 mg CoQ_{10} Group X± SD	100 mg CoQ_{10} Group X± SD	200 mg CoQ_{10} Group X± SD
VO2max (mg/kg-min)	65,66± 0,47	66,20± 0,67*	65,66± 0,47	67,08± 1,06*	66,20± 0,67	67,08± 1,06
VC (lt)	4,82 ± 0,22	5,35 ± 0,22	4,82 ± 0,22	5,97 ± 0,27**	5,35 ± 0,22	5,97 ± 0,27*
FVC (lt)	5,14 ± 0,43	5,88 ± 0,39**	5,14 ± 0,43	6,43 ± 0,20**	5,88 ± 0,39	6,43 ± 0,20**
FEV_1 (lt)	4,23 ± 0,49	4,69 ± 0,32	4,23 ± 0,49	5,34 ± 0,36*	4,69 ± 0,32	5,34 ± 0,36
MVV (lt)	149,7±3,62	153,4±5,68	149,7±3,62	155,2 ± 7,89	153,4±5,68	155,2 ± 7,89

** p<0.01, * p<0.05, Before Exercise (Pre-exercise), After Exercise (Post-exercise) Maximal Oxygen Consumption (VO2max), Forced Expiration Volume (FEV_1), Forced Vital Capacity (FVC), Maximum Voluntary Ventilation (MVV) and Vital Capacity (VC)

Discussion

Through this study, it was aimed to investigate the effect of a daily CoQ_{10} supplement on pre- and post-exercise VO2max values as well as respiratory parameters in male skiers. According to our findings, when pre- and post-exercise values of the groups which perform exercise after being given CoQ_{10} supplement, there was no change in the control group's CoQ_{10}, VO2max values, while a significant increase was seen in those of the study groups. In a study carried out

(Gharahdaghi et al, 2013), it was determined that CoQ_{10} supplement taken for 4 weeks increased the performance and VO2max levels of footballers.

Other authors studied the effect of CoQ_{10} supplement on functional aspects and VO2max in cyclists. According to this, both groups (control and supplement) showed improvements in performance and there was no distinction between the two groups (Braun et al, 1991). In another study, the use of this supplement caused 7 percent increase in VO2max and 33 percent increase in functional capacity (Koga et al, 1997). Because of CoQ_{10} functions in the respiratory electron transport chain and plays a pivotal role in energy generating processes (Aussel et al, 2014). In addition to its role as a component of the mitochondrial respiratory chain and our only endogenously synthesized lipid-soluble antioxidant, in recent years CoQ_{10} has been found to have an increasing number of other important functions required for normal metabolic processes (Bentinger et al, 2010). CoQ_{10} is also an antioxidant that specifically prevents the oxidation of lipoproteins and the plasma membrane (González-Mariscal et al, 2014).

During exercise, oxygen and energy needs of muscles increase together with the necessity of removing metabolites and carbon dioxide. As a result of the increases in such necessities, chemical, mechanical and thermal stimuluses cause changes in metabolic, cardiovascular and respiratory functions. In consideration of this information, since CoQ_{10} is directly associated with cellular energy flow and generation, it carries electrons to cellular molecules, and helps derive energy from ATP by contributing to the energy generation process carried out in mitochondria (Demirci, 2015). Therefore, increasing muscular contractions during exercise and lifting enhance energy consumption and metabolic activity considerably. It can be asserted that increased metabolic speed certainly enhances the oxygen consumption in heart and locomotive muscles along with other tissues as well as the oxygen intake to skeletal muscles.

According to our findings, an increase in FEV_1, MVV values of the control group as well as in FVC, FEV_1, MVV and VC values of the study groups was observed when the pre- and post-exercise periods of the groups who had exercise after CoQ_{10} supplement were compared. In another study conducted, it was observed that 8-week swimming exercise caused a significant increase in FEV_1, FVC, VC and MVV parameters of sedentary males (Gökhan et al, 2011). Moreover, in another similar study carried out by Doherty M. and Dimitriou L. on 159 swimmers, 130 athletes and 170 sedentary people, the values of the swimmer and athlete groups were found to be higher than the control group (Doherty and Dimitriou, 2007). These studies parallel our study. Similarly, in the study conducted by Wells G.D. et al., as a result of the preliminary and final tests of VC, FVC and FEV_1 parameters of 17 elite swimmers, 17 performance swimmers (12-15) and a control group of 17 subjects (12-15), the increases in elite and performance group parameters was found statistically significant, while the increase in control group was not significant (Wells et al., 2005). As result of a 6-month study conducted by Kubiak and Janczaruk E. on 12 - 14 years old 310 elite swimmers, preliminary and final test values of VC, FVC and FEV1 parameters were found significant (Kubiak-Janczaruk, 2005). In another study carried out, 300mg CoQ_{10} was administered to 7 young male and 9 young female swimmers for 22 days, and it was seen in the end that their respiratory functions were in normal boundaries (Leelarungrayub et al, 2010).

Based on these findings, CoQ_{10} has the potential to improve energy production in mitochondria by bypassing effective components in the respiratory chain as well as by reducing the effects of, optimal amounts can be beneficial for a wide variety of complaints, symptoms and diseases. There is no evidence of any significant risks to humans taking CoQ_{10}. As long as it has been carefully and rigorously purified, it appears to be safe as a nutritional supplement (Altınterim, 2013). Physical exercise causes muscle fatigue and therefore oxidative damage by increasing metabolic activity and oxygen consumption. However, it is suggested that CoQ_{10} increases physical performance and decreases fatigue by enhancing energy generation in mitochondria. Therefore, higher FVC, FEV_1, MVV and VC values compared to control group suggest that exercise and CoQ_{10} usage have positive impact on respiratory system.

Since ski races and trainings are difficult exercises with intensive tempo, it is stated that they cause lactate aggregation in muscles and fatigue. In order for the organism to tolerate such changes as the decrease in ATP generation due to exercise, CoQ_{10}, which is found in mitochondria and participates in energy or ATP generation, works as an important catalyser and ensures adaptation to highly physiological activities (Littarru and Tiano, 2010). In a study carried out, it was reported that exercise did not have any impact on MVV values (Hancox et al, 1985). In a similar study, Kutlu and Cicioğlu examined the respiratory parameters of Star Wrestlers of the National Team in 4 different periods during a season of 9,5 months. While they found the difference between FVC averages of 4 periods significant, it was reported by them that the difference of FEV_1 and MVV values were not significant (Kutlu and Cicioğlu, 1995). These reportings support our findings. In our study, when respiratory parameters were examined after exercise, we did not find significant differences in MVV values of the control group and the study groups either, while there was an increase observed in FVC. So, when oxygen decreases or is consumed totally, glucose is turned into lactic acid through anaerobic respiration, which causes fatigue. However, it is possible to say that during such moments CoQ_{10} enhances physical performance and decreases fatigue through increasing energy generation in mitochondria by carrying electrons to them.

With physical training, a significant change occurs in the volume and frequency of respiration. Also, with physical training, the O2 utilization rate in maximal aerobic metabolism in tissues, which is called MaxVO2, increases. With 7-13 weeks of training, an increase of over 10% occurs in MaxVO2 (Tamer, 1995). In our study, there was a significant increase observed when post-exercise VO2max values of the control group and 100mg CoQ_{10} group as well as the control group and 200mg CoQ_{10} group are compared; however, there was no significant difference between the post-exercise values of the study groups taking 100mg and 200mg CoQ_{10}. On the other hand, while there was no significant difference between the control group and the group using 100mg CoQ_{10} in terms of post-exercise VC value, there was a significant increase in the VC values of the group using 200mg CoQ_{10} compared to the control group. On the other hand, there was no significant increase observed when the study groups using 100mg and 200mg CoQ_{10}. Similarly, there was a significant increase observed when the post-exercise FEV_1 values of the group using 200mg CoQ10 and the control group were compared. Therefore, increasing need of oxygen in active muscles as well as the changes that occur with exercise lead to the higher oxygen need of myocardium (Topol, et al, 2002). Oxygen and energy needs of muscles increase during exercise. Changes occur in respiration functions with increased demands. On the other hand, since CoQ_{10} works in mitochondria membrane as an electron donor / a proton acceptor, it can be concluded that CoQ_{10} plays a role in energy generation process as a fundamental factor.

In conclusion, it can be said that 14-day regular exercise and CoQ_{10} supplement have an impact on pre- and post-exercise CoQ_{10}, VO2max and respiration parameters of skiers. With reference to the available findings, it can be said that 100 mg and 200 mg CoQ_{10} supplement may increase exercise performance in a short while. Moreover, it can also be said that exercises performed with CoQ_{10} supplement can increase oxygen use and impact respiration performance significantly in addition to VO2max.

Conflict of Interest

The author has not declared any conflict of interest.

Ethics Committee Approval: Thesis Protocol was accepted by Kafkas University Faculty of Medicine Ethics Committee with approval dated 09.06.2009 and numbered B.30.2.KAÜ.0.20.71.00.

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