

# Does quercetin and vitamin C improve exercise performance, muscle damage, and body composition in male athletes?

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**Background:** quercetin is a bioflavonoid occurs in many food items. Some previous studies on quercetin showed the inconsistent results on exercise performance and muscle damage in athletes. The aim of this study was to determine the effects of 8 weeks of quercetin supplementation on exercise performance and muscle damage indices in student athletes. **Methods:** this placebo-controlled, double-blind clinical trial was conducted on 60 male students for 8 weeks. The subjects were randomly assigned to one of the four groups: a) quercetin (500 mg/day quercetin + 200 mg/day placebo), b) quercetin+ vitamin C (500 mg/day quercetin + 200 mg/day vitamin C), vitamin C (500 mg/day placebo + 200 mg/day vitamin C), and placebo (500 mg/day placebo + 200 mg/day placebo). Time to exhaustion (TTE) for measuring performance, aspartate transaminase (AST), and creatine kinase (CK) for measuring muscle damage and body fat percent (BFP) were measured before and after intervention. **Results:** CK levels reduced in group 1 significantly ( $P=0.045$ ) and BFP reduced in group 1, 3, and 4, significantly, too ( $P=0.018$ ,  $P=0.013$ , and  $P=0.043$ , respectively). Whereas statistically significant changes between groups were not observed for TTE, AST, CK, and BFP after 8 weeks of intervention. **Conclusions:** supplementation with quercetin and vitamin C for 8 weeks did not improve exercise performance but reduced muscle damage and body fat percent in healthy subjects.

**Key words:** body composition, muscle damage, performance, Quercetin, vitamin C.

## INTRODUCTION

Quercetin is one of the most prominent natural bioactive flavonoids found in a wide variety of plant foods, including nuts, grapes, apples, berries, onions, kale, broccoli, and black tea.<sup>[1]</sup>

Some studies have shown that quercetin supplementation results in enhancement in mitochondrial biogenesis and exercise performance, too.<sup>[2-5]</sup>

In one study, exercise performance increased in male cyclists result from quercetin supplementation in comparison with placebo intake by 1.7%.<sup>[6]</sup> Also, in the Davis study, treadmill run time to exhaustion increased by 37% in sedentary mice that fed with quercetin (12.5 and 25 mg·kg<sup>-1</sup>) for 7 days.<sup>[4]</sup>

Additionally, MacRae and Mefferd (2006) indicated that administration of quercetin (600 mg twice a day) for 6 weeks resulted in performance improvement in cyclists.<sup>[6]</sup>

In contrast, in another study, no effect of quercetin supplementation (1000 mg·d<sup>-1</sup>) was observed on cycling time trial performance in elite cyclists.<sup>[7]</sup>

Although, this bioflavonoid has been shown to have multiple physiological properties including anti-inflammatory,<sup>[8-10]</sup> antioxidative,<sup>[11,12]</sup> and gene regulatory<sup>[13,14]</sup> activities.

Free radical generation is elevated during physical exercise in skeletal muscle, which has been indicated to increase fatigue and muscle damage.<sup>[15]</sup> However, supplementation with an antioxidant, including quercetin, may reduce oxidative stress, muscle damage, and exhaustion.<sup>[6,15,16]</sup>

On the other hand, one study by “Quercegen Pharma Inc.” indicates that quercetin bioactive effects are increased by cosupplementation with vitamin C and niacin.<sup>[17]</sup>

As per our knowledge, this is the first time that the effects of both quercetin and vitamin C on performance, muscle damage and body composition were carried out on human subjects.

Therefore, the purpose of this study was to measure the influence of 8 weeks of quercetin supplementation

(500 mg/day) with or without vitamin C (200 mg) on time to exhaustion (TTE), creatine kinase (CK), and aspartate transaminase (AST) levels, and body fat percent (BFP) in male athletes.

## METHODS

Sixty male athletes volunteered for this investigation. These athletes were active, but not involved in professional sports. At first, all athletes were informed of all procedures of the study and signed an informed consent. None of the participants had consumed quercetin, or any other dietary supplements, for a minimum of 3 months before the initiation of the study. Athletes were asked to abstain from exhaustive exercise 24 h before trial initiation and to keep their current physical activity and dietary intakes. After pre-testing, the subjects were randomly assigned to one of the four groups: 1) quercetin+ vitamin C (500 mg/day quercetin + 200 mg/day vitamin C), 2) quercetin (500 mg/day quercetin + 200 mg/day placebo), 3) vitamin C (500 mg/day placebo + 200 mg/day vitamin C), and 4) placebo (500 mg/day placebo + 200 mg/day placebo). Quercetin and its placebo and on the other hand Vitamin C and its placebo were same in appearance, and ingested after meal for 42 days before post-testing. Fifty six subjects completed all experiments, and there were few complaints of gastro-intestinal side-effects of the supplements, for four subjects.

This study was a randomized, placebo-controlled, double-blind clinical trial. Participants were supplemented orally for 8 weeks with quercetin (Solaray®, USA, Inc), vitamin C (Razi, Iran, Inc), or placebo (Pharmacy Faculty, Isfahan University of Medical Sciences, Iran). The study was approved by the medical ethics committee of Isfahan University of Medical Sciences. Supplements were provided in capsules of 500 mg quercetin or tabs of 200 mg vitamin C and were administered each day after meals. Venous blood samples were obtained from all participants between 5:00 and 6:00 p.m., after intensive endurance exercising, at the baseline and after intervention. All measurements were done before the start of the supplementation (Pre) and after the intervention (Post). Prior to and following the intervention, participants performed a continuous graded exercise test (GXT) on a HP cosmos treadmill (Mercury, Germany), connected to a Gas Analyzer (Ganshorn, Germany) using Bruce protocol to determine time to exhaustion (TTE).

Body fat percent was measured using a body composi-

tion analyzer (PlusAvis 333, Korea).

Plasma samples were obtained for the determination of plasma AST and CK concentrations.

AST and CK concentrations were determined by ELISA method, according to the manufacturers' protocol. These ELISA kits were obtained from Bender Medsystems GmbH (Vienna, Austria). Dietary analyses were performed using Nutritionist IV software. Statistical analyses were conducted using the Statistical Program for the Social Sciences (SPSS version 13, Inc., Chicago, IL) computer software package. The results are presented as mean  $\pm$  standard error. One-way multivariate analysis of covariance (MANCOVA) controlling for the pretest differences, followed by Dunnett's post-hoc comparison was used for multiple between group comparisons. Within group comparisons were done using paired samples t-test. Due to non-normality of the studied variables (positive skewed distribution), logarithmic transformation was done and homogeneity of covariance matrix has been tested via Box'M statistics. Analyses were performed with the SPSS version 16 (SPSS Inc, Chicago, IL) statistical package. Meanwhile the registration number of this clinical trial is IRCT201112055062N4.

## RESULTS

General mean  $\pm$  SD for all study sample for age (years), weight (kg) and body mass index (BMI, kg / m<sup>2</sup>) was (21.0  $\pm$  1.6), (67.5  $\pm$  10.8) and (22.3  $\pm$  3.3), respectively.

Table 1 shows the mean  $\pm$ SD values of time to exhaustion (TTE), aspartate transaminase (AST), creatine kinase (CK), and body fat percent (BFP) for the pre- and post-supplementation.

We did not observe any significant changes in TTE and AST between groups and in four groups before and after supplementation. On the other hand, 8 weeks of supplementation demonstrated a significant decrease in plasma C.K. levels ( $P=0.045$ ) only in "Quercetin+Vitamin C" group but significant changes were not observed in other treatments.

However, BFP decreased significantly in "Quercetin+Vitamin C," "Vitamin C," and "placebo" groups ( $P=0.018$ ,  $P=0.013$ , and  $P=0.043$ , respectively) [Table 2]. Although, BFP did not change significantly between groups after 8 weeks of intervention.

**Table 1: The comparison of exercise performance and muscle damage indices between four groups.**

	Quercetin + Vitamin C	Quercetin + Placebo	Placebo + Vit C	Placebo + Placebo	P value*
T.T.E (min)					
Before	14.84±1.29	13.96±2.57	13.73±1.40	13.84±1.01	
After	14.45±1.83	13.17±1.55	13.93±1.34	14.09±1.14	0.24
P value**	0.4	0.34	0.54	0.325	
A.S.T (IU/L)					
Before	12.76±9.31	11.63±7.61	16.61±12.01	14.81±5.54	
After	12.23±5.61	14.63±5.06	15.90±7.07	16.45±6.28	0.27
P value**	0.77	0.16	0.65	0.41	
C.K. (IU/L)					
Before	343.46±379.78	144.27±75.79	420.81±488.28	216.35±215.87	
After	132.23±88.19	198.45±143.06	212.27±263.31	144.25±80.15	0.81
P value**	0.045	0.36	0.14	0.46	

\*:MANCOVA

\*\*:Paired t-test

TTE: time to exhaustion, AST: aspartate transaminase, CK: Creatine kinase.

## DISCUSSION

Findings of our study showed that supplementation with quercetin and vitamin C did not improve the endurance exercise performance as measured by the TTE.

In contrast to our study, Dumke *et al.*, using a randomized, crossover trial, observed a small but significant improvement in exercise performance with 2-week of 1000 mg/day quercetin (2.9%) compared with placebo (-1.2%) administration on 26 untrained men.<sup>[7]</sup> One of the possible reasons may be using of different dosages of quercetin, in two study.

One of the factors responsible for enhanced exercise performance followed by quercetin ingestion might be an augment in muscle mitochondrial biogenesis,<sup>[4]</sup> but

the 8 weeks of intervention in our study perhaps was not enough for the needed mitochondrial changes.

On the other hand, Davis *et al.* (2009) showed that mice fed with a similar composition of formula with 12.5 and 25 mg/kg quercetin and Tang for seven consecutive days indicated increased cytochrome c and citrate synthase activity and endurance run time to exhaustion.<sup>[5]</sup>

One possibility is that 8 weeks of administration may have been inadequate for the biological effects in humans in comparison with the changes seen in mice after 7 days.

Quercetin is a natural polyphenolic flavonoid that is being studied for its various health benefits. These

**Table 2: The comparison of body composition indices between four groups.**

	Quercetin + Vitamin C	Quercetin + Placebo	Placebo + Vitamin C	Placebo + Placebo	P value*
Weight (kg)					
Before	65.92±10.051	70.79±12.66	69.95±9.61	63.66±10.24	
After	66.19±9.99	70.64±13.26	68.30±9.69	62.85±7.92	0.234
P value**	0.465	0.98	0.23	0.154	
B.M.I (kg/m <sup>2</sup> )					
Before	21.41±3.00	23.52±3.82	22.82±3.49	21.35±2.67	
After	21.29±2.56	23.36±4.05	22.21±3.53	21.16±2.74	0.268
P value**	0.556	0.91	0.53	0.349	
B.F.P (%)					
Before	16.31±5.90	20.63±5.23	17.27±6.28	17.31±4.51	
After	14.99±5.20	19.81±4.72	15.63±5.97	16.49±5.26	0.264
P value**	0.018	0.17	0.013	0.043	

\*:MANCOVA

\*\*:Paired t-test

BMI: body mass index, BFP: body fat percent.

benefits have generally been ascribed to its antioxidant and anti-inflammatory activities<sup>[1]</sup> that may be beneficial for muscle damage reduction.

Albeit, in our study supplementation with quercetin did not cause the reduction in muscle damage as measured by the plasma AST and CK concentrations. One of the possible mechanisms is that the glycon form of quercetin may be conjugated into several metabolites by the liver, after ingestion that maybe are less active.<sup>[18]</sup>

However, in this study BFP were decreased after intervention. If mitochondrial biogenesis is stimulated by quercetin ingestion, so fat may be oxidized as a preferential fuel source, which may result in changes in fuel utilization and thus, decrease in body fat percent (BFP).<sup>[7]</sup> Nevertheless, another possible reason for BFP reduction may be physical activity enhancement in all groups.

In summary, intake of quercetin with vitamin C, may not improve the exercise performance and muscle damage but can reduce the body fat percent, probably. Thus, future studies should emphasize longer periods of supplementation and larger doses that may increase quercetin's bioactive effects.

The limitations of this study were the small sample size and different physical activity history of subjects and the strengths of this study were humane nature of samples and accurate follow up.

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