The Effects of Quercetin Supplementation on Body Composition, Exercise Performance and Muscle Damage Indices in Athletes

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ABSTRACT

Background: Flavonoids comprise a large group of plant metabolites, 6,000 of which have been identified to date. Some studies have shown the increased aerobic performance and maximal oxygen consumption (VO_{2max}) and therefore fitness following quercetin intake as a result of elevated number of intracellular mitochondria caused by the flavonoid.

Methods: This double-blind clinical trial comprised 60 male students having an athletic history of at least 3 years. Body composition, exercise performance, and some blood biomarkers were analyzed. The individuals were selected by convenient sampling, and then were assigned into four groups of equal number by using permuted block randomization. The first to fourth groups received a 500 mg supplemental quercetin capsule plus a 250 mg vitamin C pill, a 500 mg supplemental quercetin capsule plus a 250 mg placebo vitamin C pill, a 500 mg placebo quercetin capsule plus a 250 mg vitamin C pill, and a 500 mg placebo quercetin capsule plus a 250 mg placebo vitamin C pill, respectively, daily for 8 weeks. The participants were asked to continue their routine diet and physical activity during the study and they were monitored through phone calls or text messages.

Results: Lean body mass, total body water, basal metabolic rate, and total energy expenditure increased significantly in the quercetin group after intervention. On the other hand, VO_{2max} increased in the "quercetin" and "quercetin + vitamin C" groups following the intervention, non-significantly.

Conclusion: Our findings suggest that supplementation with quercetin in athletes may improve some indices of performance.

Keywords: Athletes, quercetin, body composition, exercise performance, muscle damage

Original Article

INTRODUCTION

Flavonoids comprise a large group of plant metabolites, 6,000 of which have been identified to date.[1] Epidemiologic studies have pinpointed the relation between flavonoid intake and decreased

cardiovascular diseases incidence.[2,3] In addition, antioxidant effects of flavonoids have been proved *in vitro*.[2] Quercetin is a major natural flavonoid existing in the skin of many fruits and vegetables, as well as in leafy vegetables, berries, black tea, and various fruit juices. Since it can be found in many plant-derived foods, it is present in most people's diet.[1] Having many antioxidant, anticarcinogenic, anti-inflammatory, and heart-protecting effects, quercetin decreases the risk of cancers and various chronic diseases.[4] Thus, it is produced as a dietary supplement and is even added to some food and beverages.[5] Despite the large number of studies investigating the *in vitro* effects of quercetin, few have demonstrated its *in vivo* effects. There might be differences between the *in vivo* and *in vitro* effects of quercetin owing to its digestion, absorption, and metabolism effects.[6]

Several studies have shown quercetin to affect the oxidation process in the muscles. Some animal studies have described the observed increased endurance performance and maximal oxygen consumption (VO_{2max}) and therefore fitness following quercetin consumption as a result of elevated number of intracellular mitochondria caused by the flavonoid.[6-8] However, this association has not yet been proved in human studies.[8] The improved physical performance caused by quercetin reported by some studies might be attributable to the decreased membranes in muscles, which in turn reduces the negative and exhaustive effects of excessive oxygen radicals during physical activity.[7] Proving this hypothesis to be right would mean quercetin to be able to reduce muscular damage and soreness, as well as neuromuscular dysfunction following exercise. However, quercetin has been reported to have contrasting antioxidant effects. Although some studies found improved neuromuscular function and decreased soreness,[9,10] others only mentioned improved muscular strength as a result of long-term quercetin consumption.[11] Many previous studies have investigated the relation between body composition changes and quercetin intake. However, they did not find quercetin to have significant effects on these indices.[12,13]

As mentioned previously, although *in vitro* and animal studies have suggested quercetin to have positive effects on athletic performance, inflammatory indices, and muscular damage, a definite judgment cannot be made about its effects on athletes because of the fewer number of human studies and their contrasting findings. On the other hand, there is a growing interest in supplement use among athletes. Therefore, this study evaluated the effects of supplementary quercetin on athletic performance, muscular damage, and body composition in male athlete students.

METHODS

This double-blind clinical trial involved 60 male students at Isfahan University of Medical Sciences having an athletic history of at least 3 years. The subjects had not used antioxidant supplements during the past month. Available sampling was used to select the appropriate number of students.

The subjects were excluded if they followed less than 70% of the study procedure or were unwilling to continue. Persons with special diseases requiring treatment were also excluded.

The trial was approved by the Research and Ethics Committee, Faculty of Nutrition, Isfahan University of Medical Sciences, Isfahan, Iran, and registered in IRCT. Ir (number: IRCT201112055062N4). The participants were first explained about the objectives and methods of the study. After obtaining written informed consents, the demographics questionnaire was completed for all subjects.

Body composition indices were measured by clinical examination. Height was measured to the nearest 0.5 cm by a tape meter in standing position without shoes. Weight was measured in light clothing without shoes by a scale with an accuracy of 100 g, following which Body mass index (BMI) was calculated as weight divided by squared height (kg/m^2). A bioimpedence device was used to measure body water percentage and fat-free mass percentage.

To evaluate body performance indices, exercise test was performed for all participants using the Bruce protocol and HP cosmos treadmill (Mercury, Germany). At the end of the test, VO_{2max} and the distance covered were measured by a gas analyzer.

The individuals were then assigned into four groups of 15 using permuted block randomization. The first to fourth groups received a 500 mg supplemental quercetin capsule plus a 250 mg vitamin C pill, a 500 mg supplemental quercetin capsule plus a 250 mg placebo vitamin C pill, a 500 mg

placebo quercetin capsule plus a 250 mg vitamin C pill, and a 500 mg placebo quercetin capsule plus a 250 mg placebo vitamin C pill, respectively, daily for 8 weeks. The participants were asked to continue their routine diet and physical activity during the study and they were monitored through phone calls or text messages. At the end of the intervention period, the remainder of the pills was evaluated to assess supplement intake. Placebo capsules contained lactose and looked exactly the same as real capsules. Due to the double-blind nature of the study, neither the researchers nor the participants were aware of the content of the capsules. The indices measured in the beginning of the study were reassessed at the end.

Statistical analysis

Data were analyzed by paired *t*-test, analysis of covariance (ANCOVA), and repeated measure analysis of variance (ANOVA) in $SPSS_{15}$.

RESULTS

Since four individuals were excluded due to unwillingness or other reasons, a total number of 56 participants were studied. Mean ages of subjects in groups 1 to 4 were 20.93 ± 1.53, 21.50 ± 2.17, 21.21 ± 1.52, and 20.46 ± 1.18 years, respectively ($P > 0.05$).

Table 1 shows the body composition indices among the four groups before and after the

Table 1: The comparison of body composition indices between four groups

	Total	Quercetin+ Vitamin C	Quercetin+ Placebo	Placebo+ Vitamin C	Placebo+ Placebo	*P* value*	*P* value**
Weight (kg)							
Before	67.48±10.81	65.92±10.051	70.79±12.66	69.95±9.61	63.66±10.24	0.241	0.234
After	66.96±10.47	66.19±9.99	70.64±13.26	68.30±9.69	62.85±7.92	0.277	
P value***	0.975	0.465	0.98	0.023	0.154		
LBM							
Before	55.42±6.42	55.23±6.12	55.70±7.51	57.66±4.85	53.12±6.80	0.324	0.264
After	55.95±6.28	56.38±6.53	56.33±8.10	57.67±5.34	53.14±4.14	0.329	
P value***	0.000	0.004	0.217	0.364	0.016		
TBW							
Before	39.91±4.62	39.78±4.42	40.09±5.41	41.524±3.48	38.25±4.88	0.324	0.263
After	40.28±4.52	40.59±4.69	40.56±5.82	41.53±3.85	38.25±2.98	0.326	
P value***	0.000	0.004	0.199	0.369	0.017		
BMI (kg/m^2)							
Before	22.24±3.31	21.41±3.00	23.52±3.82	22.82±3.49	21.35±2.67	0.211	0.268
After	21.98±3.28	21.29±2.56	23.36±4.05	22.21±3.53	21.16±2.74	0.281	
P value***	0.228	0.556	0.91	0.053	0.349		
WHR							
Before	0.76±0.06	0.74±0.06	0.79±0.05	0.76±0.06	0.77±0.04	0.077	0.093
After	0.75±0.06	0.73±0.06	0.79±0.06	0.74±0.06	0.76±0.05	0.109	
P value***	0.002	0.047	0.665	0.039	0.063		
BMR							
Before	1569.57±113.70	1572.53±114.44	1568.92±124.69	1605.50±82.79	1531.14±127.23	0.399	0.263
After	1577.22±105.86	1588.80±118.39	1577.76±130.39	1609.15±76.76	1527.58±78.04	0.266	
P value***	0.001	0.017	0.402	0.155	0.086		
TEE							
Before	2417.15±175.09	2421.60±176.17	2416.28±192.09	2472.42±127.47	2358.00±195.98	0.400	0.264
After	2428.90±163.06	2446.73±182.30	2429.61±200.97	2478.07±118.14	2352.58±120.28	0.267	
P value***	0.001	0.018	0.414	0.156	0.08		

*ANCOVA, **Repeated measure ANOVA, ***Paired *t* test, LBM: Lean body mass, TBW: Total body water, BMI: Body mass index, WHR: waist-to-hip ratio, BMR: Basal metabolic rate, TEE: Total energy expenditure

Table 2: The comparison of body performance indices between four groups

	Total	Quercetin+ Vitamin C	Quercetin+ Placebo	Placebo+ Vitamin C	Placebo+ Placebo	*P* value*	*P* value**
VO_{2max} (L/min)							
Before	2.68±0.55	2.72±.529	2.52±0.645	2.81±0.61	2.68±0.42	0.616	0.173
After	2.88±0.43	2.99±0.321	2.72±0.49	3.08±0.42	2.69±0.38	0.047	
P value***	0.001	0.024	0.123	0.02	0.55		
Distance (m)							
Before	1192.028± 206.50	1297.76± 208.09	1108.36± 220.89	1206.46± 214.57	1133.63± 134.76	0.10	0.37
After	1217.23± 205.09	1289.07± 221.74	1092.84± 201.21	1233.92± 209.85	1250.08± 135.46	0.07	
P value***	0.950	0.31	0.197	0.50	0.004		
Functional capacity (METs)							
Before	15.26±1.55	15.97±1.67	14.77±1.50	15.32±1.76	14.8±0.90	0.19	0.103
After	15.78±1.46	16.01±1.62	15.00±1.56	16.20±1.24	15.90±1.18	0.16	
P value***	0.144	0.628	0.343	0.07	0.08		

*ANCOVA, **Repeated measure ANOVA, ***Paired *t* test, METs: Metabolic equivalent

study. As seen, Lean body mass (LBM), total body water (TBW), basal metabolic rate (BMR), and total energy expenditure (TEE) increased significantly in the first group.

As presented in Table 2, body performance indices shows VO_{2max} in group 1 significantly increased after the intervention. In addition, as the results of ANCOVA after excluding the initial effects of VO_{2max} suggested, VO_{2max} increased in the first and third groups following the intervention. However, repeated measure ANOVA did not reveal the differences to be significant. Although the distance covered significantly increased in group 4, ANCOVA and repeated measure ANOVA did not show significant differences.

DISCUSSION

This randomized clinical trial comprised four groups who were evaluated to determine the effects of quercetin intake on physical and body performance and muscle injury. The results revealed significant differences in lactate dehydrogenase (LDH), VO_{2max}, TEE, TBW, and LBM among the quercetin and vitamin C groups. However, after eliminating confounding effects of initial variables, only VO_{2max} changes remained significant.

Our study is in line with the study of Cureton *et al.*, who assessed the ergogenic effects of quercetin on 30 non-athletic men in a double-blind clinical trial. During 7 to 16 days, they administered 1 g of daily quercetin to the intervention group and the same amount of placebo to the control group. Finally, they did not find significant changes either in ergogenic indices, such as phosphocreatine recovery time constant, VO_{2max}, and perception of effort, during submaximal exercise test, or in the total work during a 10-min cycling with maximum power.[5] Similarly, Ganio *et al.* performed a double-blind clinical trial on 11 non-athletic inactive participants (five males and six females). Although their intervention and control groups received, respectively, 1,000 mg of daily quercetin and placebo for 22 weeks, no significant differences were observed in terms of VO_{2max} between the two groups.[14] Utter *et al.* also compared the effects of 250 mg of daily quercetin for 3 weeks with placebo among marathon runners and cyclists. They did not report any significant difference in the ratings of perceived exertion between the two groups.[15] A crossover clinical trial by MacRae *et al.* compared the effects of quercetin and a combination of quercetin and vitamins on 11 male cyclists during a 6 week period. Although their results did not reveal significant differences in the total time of a 30 km ride and VO_{2max} after the intervention, a significant increase was observed in peak power among the second group of cyclists.[7] In a clinical trial, Davis *et al.* evaluated the effects of quercetin on exercise performance among 12 volunteers. They divided the participants into two

groups of intervention (500 mg daily quercetin) and control (500 mg daily placebo). Unlike in other studies, they found significant improvements in time to fatigue, VO_{2max}, and endurance among non-athletic individuals during a 30 km bicycle ride.[16]

Most previous studies did not report significant differences in body composition among quercetin consumers. Similar to the present study, Knab *et al*. designed a clinical trial in which quercetin and vitamin C were used. They performed a 12 week treatment with two doses of quercetin along with vitamin C and niacin on 941 male and female subjects aged 18-85 years. The participants were randomly divided into three groups of 500 mg daily quercetin, 1,000 mg daily quercetin, and placebo. Their results did not show any significant differences between the intervention and placebo groups in terms of BMI or any other body composition indices.[12] Egert *et al*. investigated the effects of quercetin consumption on 93 obese subjects aged 25-65 in a crossover study. The participants received 6 weeks of 150 mg daily quercetin followed by a 5 week washout and a course of placebo. However, CRP and body composition indices, including weight, waist circumference, body fat mass, and fat-free mass, did not significantly change after the intervention period.[13] Another study by Egert *et al*. evaluated 35 healthy subjects in three groups of 50, 100, and 150 mg of daily quercetin. The study did not indicate any significant difference in resting energy expenditure or weight after a 2 week quercetin supplementation.[17]

Similar to previous studies, the present study did not show any significant differences between the quercetin and placebo groups. The only significant changes were observed in quercetin and vitamin C groups.

CONCLUSION

Therefore, it might be concluded that quercetin alone does not affect body composition and body performance indices. Although different studies have used various doses of quercetin during various periods of time, we selected a dose within their range. However, higher doses might be able to make significant differences in the above-mentioned indices.

Since the findings of the present and previous studies are in contrast with *in vitro* and animal studies, a longitudinal research with long follow-up is suggested to evaluate the effects of quercetin. Moreover, studies assessing the effects of quercetin on cardiovascular disease risk factors, endothelial dysfunction, and atherosclerosis incidence might reveal beneficial effects of this flavonoid. Clinical trials with larger sample sizes of athletes and non-athletes are also recommended.

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