Quercetin Supplementation Does Not Attenuate Exercise Performance and Body Composition in Young Female Swimmers

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ABSTRACT

Background: Quercetin is a health-enhancing antioxidant bioflavonoid (1-3). This flavonoid occurs in variety of natural fruits and vegetables such as apple, cranberry, onion, broccoli, and teas. Many studies have shown that quercetin has possible positive effects on exercise performance. The aim of this study is the evaluation of effects of quercetin supplementation on VO_{2max} and exercise performance in female athletes.

Methods: This study was done on 26 young female swimmers. Participants were assigned in to groups and supplemented orally for 8 weeks with either Quercetin (Solaray®, USA, Inc) or placebo (dextrose). Before and after intervention, athletes performed a continuous graded exercise test (GXT) on an electronically braked cycle ergometer (Lode, The Netherlands) to determine VO_{2max} and time to exhaustion (TTE).

Results: Participants in the quercetin group consumed higher energy and protein and lower carbohydrates and fats. There was no significant differences in VO_{2max}, TTE, lactate, and body fat between pre- and post-supplementation neither in the placebo group nor in the quercetin group.

Conclusions: It is concluded that quercetin supplementation (1000 g/day) for 8 weeks in female athletes didn't show any significant association with exercise performance.

Keywords: Performance, quercetin, swimmers

Original Article

INTRODUCTION

Dietary supplements are becoming popular among athletes and being used for different reasons. Although supplements are necessary to acquire sufficient amount of essential nutrients such as vitamins and minerals for some athletes especially those using weight loss diet for weight-control sports, Sport supplements are being used for performance enhancement by many athletes.[1] In recent years, a large number of these supplements have been increasingly developed and are being used by athletes. Some of these supplements are classified as drug but most of them are nutritional supplements such as amino acids, protein, vitamins, minerals, and herbals. It has been hypothesized that Quercetin as

a phytochemicals which currently exists as a sport supplement may improve physical performance, enhance fitness, and increase energy.[2]

Dietary flavonols like quercetin have healthful properties such as antioxidant, free radical scavenging, anti-inflammatory, anti-carcinogenic and cardio-protective,[3] reduce the risk of chronic diseases and cancer,[4] and decrease the vulnerability to viral infection.[5,6] Biosynthesis of quercetin motivates by sunlight, so it collects in the external and above ground tissues such as leaves and skin. Flavonoids are found in most of the vegetables and fruits but the main food sources for quercetin are apples, berries, onions, tea, peppers, red grapes, and green vegetables.[7] As a result of quercetin's benefits, it is added to beverages and foods as a nutritional supplement.[8] During exercise, inflammation, oxidative stress, muscle microtrauma and other immune changes occur in human body,[9] and quercetin may have positive effect on these exercise-induced events and could decrease oxidative damage in muscles. Quercetin could be absorbed sufficiently by human subjects[10] and may particularly be accumulated in the liver, heart, thymus, lungs, kidney, testes, and muscle.[5] Studies on human and animal indicated that quercetin supplementation does not have negative effect or adverse symptoms and support the safety of quercetin supplement.[3,11,12]

Recent investigation in mice indicated that quercetin positively affected endurance performance, enhanced mitochondrial biogenesis mRNA and DNA in skeletal muscle and brain.[13] The result of another study demonstrate that quercetin could affect aerobic capacity, skeletal muscle, and endurance performance[14] and may have ergogenic effect in humans. Another study indicated that however *in vitro* investigation quercetin had antioxidant action, quercetin supplementation didn't protect against exercise-induced inflammation and oxidative stress.[15] Limited data available on the ergogenic effect of quercetin supplementation in humans, these findings are unclear.[8] Finding from a study on adult male subjects demonstrated a small but non-significant raise in some indicators of mitochondrial biogenesis.[16] It has also been assumed that antioxidant properties of quercetin may progress physical performance. As a possible mechanism it has been believed that antioxidant supplementation minimize damage to proteins and membranes of skeletal muscles during exercise, thus limit the harmful effects of raised reactive oxygen generated.[17] However, it is uncertain if antioxidants affect exercise performance.[18] Several studies investigated the effect of quercetin supplementation on VO_{2max} on untrained participants. Although some studies showed small but significant raise in VO_{2max} and cycling time before tiredness,[16,19] others found no significant effect.[8,20] However, few data are available in this regard and these data are controversial. Therefore, we examined the effect of 8 weeks quercetin supplementation (1000 mg per day) in a case control study on VO_{2max} and exercise performance in Iranian young female swimmers.

METHODS

Participants

This case-control study was conducted in Isfahan, Iran in 2011. 26 young female swimmers with convenience non-random sampling procedure volunteered for this investigation. Participants were asked to abstain from exercise 24 h before trial initiation and to maintain their current physical activity and dietary patterns. Participants were randomly assigned to one of two groups: (a) Quercetin (1000 mg/day) $n = 14$, (b) placebo (1000 m g dextrose per day) $n = 12$. Cases and controls were matched for age and weight.

Research design

Participants were supplemented orally for 8 weeks with either Quercetin (Solaray®, USA, Inc) or placebo (dextrose). The study was approved by the Ethics Committee (Esfahan Sport Medicine Association, Iran). Supplements were provided in capsules of 500 mg and were administered each day as two divided single doses, with at least 6 h in between ingestions. Thus, daily doses consisted of 1000 mg/day during the study.

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 supplementation protocol, participants performed a continuous graded exercise test (GXT) on an electronically braked cycle ergometer (Lode, The Netherlands) to determine VO_{2max} and time to exhaustion (TTE).

For each GXT, the primary power output was set at 30 watts and elevated 30 watts every 2 minutes until

the participant couldn't maintain the required power output at a pedaling rate of 70 rpm due to fatigue.

Lactate was analyzed using a Lactometer (Lactate ProLT-1710, Canada). Body fat percent was measured by Bio Impedance Analyzor (BIA) (JAWON IOI 353, Korea). Dietary analyses were performed using Nutritionist IV software.

Statistical methods

Statistical analyses were conducted using the Statistical Program for the Social Sciences (SPSS version 13, Inc., Chicago, IL) computer software package. Data are presented as means ± standard deviation. The independent *t* test was used to analyze the differences in performance between the trials. Paired *t* test was used to analyze before and after test data for each group differences. An alpha level of $P < 0.05$ was considered statistically significant.

RESULTS

A total of 26 young female swimmers participated in this study. General characteristics and dietary intakes of study participants separately by case and control groups before intervention have been showed in Table 1. There was no difference in age and weight of two groups; however, participants in the quercetin group consumed higher energy and protein and less amount of carbohydrates and fats. Table 2 compared exercise performance indices in quercetin and placebo groups between pre- and post-supplementation. There is no significant differences in VO_{2max}, TTE, lactate, and body fat between pre- and post-supplementation neither in the placebo group nor in the quercetin group.

DISCUSSION

The main purpose of current study was to realize the effect of quercetin supplementation on exercise performance indexes including VO_{2max}, TTE, lactate, and body fat in young female swimmers. The results of this study do not support the theory that quercetin could increase exercise performance in trained individuals. Quercetin, as a natural polyphenolic flavonol, frequently is found in the diet. Dietary records showed that Quercetin was consumed between 5 and 500 mg based on frequency of vegetable and fruit consumption. Several experimental studies indicated the health beneficial effects of flavonoids. Quercetin, because of its biological properties, has been known for its performance benefits, ergogenic and health effects in animal models. It has also been indicated that quercetin supplementation could affect aerobic capacity, exercise performance and skeletal muscle practically the same as exercise training.[14] The combination of anti-inflammatory and antioxidant activity was approved for these beneficial effects however recent studies recommended that mitochondrial biogenesis may be also responsible.[13]

Our finding from the present study failed to find any significant effect of 1000 mg quercetin supplementation for 8 weeks on exercise performance indices including VO_{2max}, TTE, lactate, and body fat in young female swimmers. Albeit, little is known regarding the effect of quercetin in humans, finding

Table 1: General characteristics and dietary intakes of study participants separately by case and control groups before intervention[1]

Variables	Case (Quercetin) (*n*=14)	Control (Placebo) (*n*=12)	*P*
Age (years)	16.1±2.5	15.7±1.5	
Weight (kg)	47.8±8.8	45.9±8.3	
BMI (kg/m^2)			
Energy (kcal)	1925±420	1,887±525	<0.01
Protein (g)	125±27	107±18	<0.01
Carbohydrates (g)	251±82	254±152	<0.01
Fat (g)	47±26	49±34	<0.05

[1]Data are means±standard deviation, BMI=Body mass index

Table 2: Comparison of exercise performance indices, pre-and post-supplementation[1]

variables	Case (Quercetin) (*n*=14)			Control (Placebo) (*n*=12)		
	Pre	Post	*P* value	Pre	Post	*P* value
VO_2max (L/min)	2.02±0.34	1.98±0.73	0.35	2.05±0.47	2.01±0.59	0.28
TTE (sec)	433.6±107.4	426.4±98.5	0.4	417.5±112.8	395.5±103.5	0.3
Lactate (mg/dl)	11.5±4.2	10.9±6.4	0.19	8.8±5.1	9.2±6.6	0.15
Body fat (%)	18.7±6.6	18.5±5.4	0.54	17.4±7.5	17.02±7.1	0.26

[1]Data are means±standard deviation, TTE=Time to exhaustion

no significant effect of quercetin supplementation in our study is in line with the most of previous studies. Previous studies on trained individuals couldn't find any improvement on physical performance.[17,21,22] MacRae in a study couldn't find any improvement in cyclist performance after 600 mg/day quercetin supplementation for 6 weeks.[17] In another study, 1 g/day supplementation for 3 weeks in marathon runners had not any effect on race time.[22] Likewise, acute supplementation (2 g/day) on cyclists couldn't improve athlete's performance.[23] Moreover, having no change in muscle oxidative capacity and VO_{2max} had been reported in preceding studies.[8,16,20,24] Furthermore, in another study on moderately trained military persons, quercetin supplementation (1 g/day) for 6 weeks didn't advanced exercise performance or VO_{2max}.[25] However, other studies using 1 g/day quercetin supplementation for 1-2 weeks found a small significant improvement in physical performance in untrained or moderately trained individuals.[16,19] Similarly, quercetin supplementation (1 g/day) for 5-9 days slightly enhanced VO_2max.[19] Several mechanisms may explain the possible effects of quercetin on improving VO_{2max} and exercise performance. Based on a possible mechanism exercise performance would be supposedly improved by quercetin through reducing damage to skeletal muscle and contractile proteins, so quercetin could reduce muscle damage, tenderness, fatiguing, and negative effects of increased reactive oxygen production following exercise;[17] however, the evidences are contradictive.[26,27] Another theory explained that quercetin practically the same as caffeine, by reducing the sensitivity of pain, may influence exercise performance.[28] Additionally, positive effects of quercetin on skeletal muscles may partially elucidated via increases in mitochondrial protein, stimulating mitochondrial biogenesis and increasing oxidative enzyme activity.[29-31] Failure to find a significant improvement in exercise performance indices in trained individuals in the current study could be reasoned that supplement of quercetin may improve endurance performance in untrained people.[21] In trained subjects, mitochondrial biogenesis in skeletal muscles and endurance performance has already improved as a result of exercise and no further improvement would happen due to supplementation. In addition, these results attributed to insufficient dosage for quercetin supplementation. Conversely, higher dosage of antioxidants may lead to negative antioxidant effect which could interfere with gene activation that inaugurate mithochondrial biogenesis.[6] Dietary quercetin may also be responsible for this result. Besides, several limitations should be considered in this study. First of all, we didn't evaluate the dietary quercetin intake in participants. It is possible that quercetin supplement could affect individuals with lower intake of dietary quercetin. Moreover, we couldn't evaluate the blood quercetin level. Additionally a limited number participated in this study, so the power of this study may be insufficient to find significant differences. Increasing the power of the study may find tiny differences between groups.

To sum up, quercetin supplementation at the level of 1000 g/day for 8 weeks in swimmer females didn't have any significant association with exercise performance indices. However, further studies with larger sample size and different dosage is suggested.

CONCLUSION

Additionally, positive effects of quercetin on skeletal muscles may partially elucidated via increases in mitochondrial protein, stimulating mitochondrial biogenesis and increasing oxidative enzyme activity. Failure to find a significant improvement in exercise performance indices in trained individuals in the current study could be reasoned that supplement of quercetin may improve endurance performance in untrained people.

REFERENCES

1. Rodriguez NR, DiMarco NM, Langley S. Position of the American Dietetic Association, Dietitians of Canada, and the American College of Sports Medicine: Nutrition and athletic performance. J Am Diet Assoc 2009;109:509-27.
2. Williams MH. Sports supplements: Quercetin. ACSM's Health Fit J 2011;15:17.
3. Harwood M, Danielewska-Nikiel B, Borzelleca JF, Flamm GW, Williams GM, Lines TC. A critical review of the data related to the safety of quercetin and lack of evidence of *in vivo* toxicity, including lack of genotoxic/carcinogenic properties. Food Chem Toxicol 2007;45:2179-205.
4. McAllister RM, Terjung RL. Training-induced muscle adaptations: Increased performance and oxygen consumption. J Appl Physiol 1991;70:1569-71.
5. de Boer VC, Dihal AA, van der Woude H, Arts IC,

Wolffram S, Alink GM, *et al*. Tissue distribution of quercetin in rats and pigs. J Nutr 2005;135:1718-25.
6. Ristow M, Zarse K, Oberbach A, Klöting N, Birringer M, Kiehntopf M, *et al*. Antioxidants prevent health-promoting effects of physical exercise in humans. Proc Natl Acad Sci 2009;106:8665-70.
7. Chun OK, Chung SJ, Song WO. Estimated dietary flavonoid intake and major food sources of US adults. J Nutr 2007;137:1244-52.
8. Cureton KJ, Tomporowski PD, Singhal A, Pasley JD, Bigelman KA, Lambourne K, *et al*. Dietary quercetin supplementation is not ergogenic in untrained men. J Appl Physiol 2009;107:1095-104.
9. Chen JC, Ho FM. Inhibition of iNOS gene expression by quercetin is mediated by the inhibition of I [kappa] B kinase, nuclear factor-kappa B and STAT1, and depends on heme oxygenase-1 induction in mouse BV-2 microglia. Eur J Pharmacol 2005;521:9-20.
10. Moon YJ, Wang L, DiCenzo R, Morris ME. Quercetin pharmacokinetics in humans. Biopharm Drug Dispos 2008;29:205-17.
11. Utesch D, Feige K, Dasenbrock J, Broschard TH, Harwood M, Danielewska-Nikiel B, *et al*. Evaluation of the potential *in vivo* genotoxicity of quercetin. Mutat Res 2008;654:38-44.
12. Askari G, Ghiasvand R, Karimian J, Feizi A, Paknahad Z, Sharifirad G, *et al*. Does quercetin and vitamin C improve exercise performance, muscle damage, and body composition in male athletes? J Res Med Sci 2012;4:328-31.
13. Davis JM, Murphy EA, Carmichael MD, Davis B. Quercetin increases brain and muscle mitochondrial biogenesis and exercise tolerance. Am J Physiol Regul Integr Comp Physiol 2009;296:R1071-7.
14. Holloszy JO, Coyle EF. Adaptations of skeletal muscle to endurance exercise and their metabolic consequences. J Appl Physiol 1984;56:831-8.
15. McAnulty SR, McAnulty LS, Nieman DC, Quindry JC, Hosick PA, Hudson MH, *et al*. Chronic quercetin ingestion and exercise-induced oxidative damage and inflammation. Appl Physiol Nutr Metab 2008;33:254-62.
16. Nieman DC, Williams AS, Shanely RA, Jin F, McAnulty SR, Triplett NT, *et al*. Quercetin's influence on exercise performance and muscle mitochondrial biogenesis. Med Sci Sports Exerc 2010;42:338-45.
17. MacRae HS, Mefferd KM. Dietary antioxidant supplementation combined with quercetin improves cycling time trial performance. Int J Sport Nutr Exerc Metab 2006;16:405-19.
18. Powers SK, Deruisseau KC, Quindry J, Hamilton KL. Dietary antioxidants and exercise. J Sports Sci 2004:81-94.
19. Davis JM, Carlstedt CJ, Chen S, Carmichael MD, Murphy EA. The dietary flavonoid quercetin increases VO ($_{2max}$) and endurance capacity. Int J Sport Nutr Exerc Metab 2010;20:56-62.
20. Ganio MS, Armstrong LE, Johnson EC, Klau JF, Ballard KD, Michniak-Kohn B, *et al*. Effect of quercetin supplementation on maximal oxygen uptake in men and women. J Sports Sci 2010;28:201-8.
21. Nieman DC, Henson DA, Maxwell KR, Williams AS, McAnulty SR, Jin F, *et al*. Effects of quercetin and EGCG on mitochondrial biogenesis and immunity. Med Sci in Sports Exerc 2009;41:1467-75.
22. Nieman DC, Henson DA, Davis JM, Dumke CL, Gross SJ, Jenkins DP, *et al*. Quercetin ingestion does not alter cytokine changes in athletes competing in the Western States Endurance Run. J Interferon Cytokine Res 2007;27:1003-11.
23. Cheuvront SN, Ely BR, Kenefick RW, Michniak-Kohn BB, Rood JC, Sawka MN. No effect of nutritional adenosine receptor antagonists on exercise performance in the heat. Am J Physiol Regul Integr Comp Physiol 2009;296:R394-401.
24. Katch VL, Sady SS, Freedson P. Biological variability in maximum aerobic power. Med Sci Sports Exerc 1982;14:21-5.
25. Bigelman KA, Fan EH, Chapman DP, Freese EC, Trilk JL, Cureton KJ. Effects of six weeks of quercetin supplementation on physical performance in ROTC cadets. Mil Med 2010;175:791-8.
26. Kanter M. Free radicals and exercise: Effects of nutritional antioxidant supplementation. Exerc Sport Sci Rev 1995;23:375-97.
27. Powers SK, Deruisseau KC, Quindry J, Hamilton KL. Dietary antioxidants and exercise. J Sports Sci 2004;22:81-94.
28. Cureton KJ, Warren GL, Millard-Stafford ML, Wingo JE, Trilk J, Buyckx M. Caffeinated sports drink: Ergogenic effects and possible mechanisms. Int J Sport Nutr Exerc Metab 2007;17:35-55.
29. Lagouge M, Argmann C, Gerhart-Hines Z, Meziane H, Lerin C, Daussin F, *et al*. Resveratrol improves mitochondrial function and protects against metabolic disease by activating SIRT1 and PGC-1 [alpha]. Cell 2006;127:1109-22.
30 Liu Y, Dalal K. Review of cost-effectiveness analysis of medical treatment for myocardial infarction. Int J Prev Med 2011;2:64-72.
31 Azghadi S, Amander T. Epigenetically reprogramming of human embryonic stem cells by 3-deazaneplanocin A and sodium butyrate. Int J Prev Med 2011;2:187.

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