Research in Exercise Nutrition
ISSN: 2980-8960

RESEARCH ARTICLE
Research in Exercise Nutrition 5(1), 21-28

Acute Effects of Coenzyme Q10 Supplementation on Antioxidant Markers, Oxidative Damage, and Inflammation in Male Soccer Players Following High-Intensity Interval Exercise

Shina Delavari[1], Hadi Golpasandi[1*]
[1]Department of Exercise Physiology, Faculty of Humanities and Social Sciences, University of Kurdistan, Sanandaj, Iran.

Open Access

REN

Submitted:
15 February 2026
Revised:
25 February 2026
Accepted:
26 February 2026
Published:
26 February 2026

Research in Exercise Nutrition:

2026, Volume 5 (Issue 1), Pages 21-28

Publisher: **University of Kurdistan**

ISSN: 2980-8960

Abstract

Introduction: Aim: This study investigated the acute effects of CoQ10 supplementation on antioxidant (GSH, TAC), oxidative damage (MDA), and inflammatory (CRP) markers in professional male soccer players following HIIT.

Methods: A double-blind, placebo-controlled trial was conducted on 16 male soccer players (8 in the supplement group and 8 in the placebo group). The supplement group ingested 300 mg of ubiquinol 120 minutes before exercise, while the placebo group received a placebo. The HIIT protocol included 12 × 30-second sprints at maximal effort, with 30 seconds of recovery. Blood samples were taken pre-exercise, post-exercise, and 1-hour post-exercise. Biomarkers were measured using ELISA

Results: Acute CoQ10 supplementation significantly reduced MDA levels (15.9% vs. 52.4% in placebo; $p < 0.001$), with levels returning to baseline by 24 hours. GSH and TAC levels increased by 19% and 17.4%, respectively ($p < 0.001$). CRP rose less (75% vs. 161.5% in placebo) and recovered faster ($p = 0.001$). Significant time × group interactions were found for all biomarkers ($p < 0.001$).

Conclusions: Acute CoQ10 supplementation reduced oxidative stress and inflammation from HIIT and improved antioxidant recovery. These findings suggest potential applications in pre-exercise nutrition, but larger studies are needed.

Key Words: Coenzyme Q10, MDA, GSH, TAC, CRP

Corresponding author: Hadi Golpasandi, Postdoctoral Researcher, Department of Exercise Physiology, Faculty of Humanities and Social Sciences; University of Kurdistan, Sanandaj, Pasdaran Blvd., Postal Code:66177-15175, Email: hadi.golpasandi@uok.ac.ir

Citation:
Delavari Sh, Golpasandi H. Acute Effects of Coenzyme Q10 Supplementation on Antioxidant Markers, Oxidative Damage, and Inflammation in Male Soccer Players Following High-Intensity Interval Exercise. **Research in Exercise Nutrition. 2026;5(1):-.**2025;4(1):21-28**.** Doi: https://doi.org/10.22034/ren.2026.145506.1159

1. Introduction

As one of the most high-intensity team sports in the world, football requires a unique combination of prolonged aerobic activity, short bursts of power (sprinting and jumping), frequent changes of direction, and intense physical contact (1). This pattern of high-intensity, intermittent activity leads to the significant production of reactive oxygen species (ROS) from mitochondrial sources, NADPH oxidase, and other pathways .(2) An excessive increase in ROS disrupts the oxidant-antioxidant balance and leads to oxidative stress, which is associated with membrane lipid peroxidation (indicated by elevated malondialdehyde, or MDA) and damage to proteins and DNA (3). Concurrently, an acute inflammatory response is triggered, leading to elevated levels of markers such as C-reactive protein (CRP) and other cytokines These processes lead to muscle damage, delayed recovery, reduced contractile strength, premature fatigue, and an increased risk of injury in footballers; particularly among young men competing at professional or semi-professional levels who engage in high volumes of training and competition (4).

Coenzyme Q10 (CoQ10); a key molecule in the mitochondrial electron transport chain (involved in ATP production) and a potent lipophilic antioxidant (especially in its ubiquinol form); is capable of directly neutralizing free radicals, regenerating vitamin E, and regulating the expression of antioxidant enzymes such as catalase and glutathione peroxidase (5). These characteristics make CoQ10 an attractive option for reducing exercise-induced oxidative stress and inflammation (6). Previous studies have shown that CoQ10 supplementation can increase levels of SOD, glutathione (GSH), and total antioxidant capacity (TAC), while decreasing MDA; in some cases, it also lowers CRP and markers of muscle damage such as CK and LDH (7). In a double-blind experimental study involving elite male middle-distance runners, Armanfar et al. (2016) found that short-term (14-day) Coenzyme Q10 supplementation (5 mg/kg/day) significantly increased Total Antioxidant Capacity (TAC) and markedly attenuated the rise in malondialdehyde (MDA) levels following a 3,000-meter run; conversely, acute (one-day) supplementation had no significant effect on these markers, and neither protocol significantly influenced the increase in lactate dehydrogenase (LDH); a marker of muscle damage (8). A meta-analysis comprising 28 randomized controlled trials and 830 adults demonstrated that Coenzyme Q10 supplementation significantly reduced levels of cratine kinase (CK), lactate dehydrogenase (LDH), myoglobin (Mb), and malondialdehyde (MDA), while having no significant effect on total antioxidant capacity Each 100 mg daily increase in CoQ10 dosage was associated with a further reduction in these markers, with "very large" effects observed on LDH and "moderate" effects on CK and MDA (9). In a meta-analysis by Qi et al. (2025) involving 17 trials and 440 athletes, CoQ10 supplementation significantly reduced MDA, LDH, and CK levels but had no significant effect on TAC capacity. Subgroup analyses revealed that the effects on LDH were more pronounced over a 14-day period, while effects on CK were more significant at dosages of ≥300 mg/day; thus, CoQ10 holds potential for reducing oxidative stress and muscle damage, although the quality of evidence is low, highlighting the need for further studies (9). More recent research also confirms these findings; studies indicate that higher plasma CoQ10 levels are associated with reduced markers of muscle damage (such as CK) and stress (cortisol) in professional soccer players during the competitive season, and that short-term CoQ10 supplementation lowers markers of cardiac stress (GDF-15, NT-proBNP, hs-TnT) following strenuous exercise and improves time to exhaustion (10). Despite this valuable evidence, significant research gaps remain. Most studies have focused on chronic supplementation (spanning several weeks); however, in football, acute supplementation (a single dose or short-term intake prior to a match or training session) is more practical due to the demanding match schedule, greater feasibility, and lack of interference with daily dietary routines. Study populations have predominantly consisted of endurance or strength athletes, or women, with very limited research specifically targeting male footballers; who exhibit unique activity patterns. Simultaneous assessment of antioxidant markers (GSH, TAC, MDA) and inflammatory markers (CRP) under simulated football conditions has rarely been conducted, and the optimal dosage, timing, and acute effects of CoQ10 in this specific group are not well established. Despite conflicting results from previous studies, acute ubiquinol supplementation may be beneficial; this is because CoQ10 plays a key role in the mitochondrial electron transport chain, directly scavenges reactive oxygen species (ROS) generated during intense exercise, reduces lipid peroxidation, and rapidly boosts antioxidant capacity. Therefore, investigating the effects of acute CoQ10 supplementation on antioxidant and inflammatory markers in soccer players is essential. This study could provide a foundation for the potential use of this supplement in pre-exercise nutrition and help optimize recovery.

2. Methods

2.1. Participants

Sixteen professional Premier League football players—aged 22–30 with 7 to 10 years of athletic experience—were selected to participate following a formal invitation. Sixteen eligible participants were randomly assigned to two equal groups (8 participants per group): the CoQ10 supplement group and the placebo group.

2.2. Study design

This study was designed as a randomized, double-blind, placebo-controlled trial. Group allocation was performed using the "Research Randomizer" website to generate a random sequence of numbers from 1 to 20. An independent pharmacist, blinded to the sequence, carried out the allocation, and the research team did not have access to the allocation list until the study concluded. The study was conducted following approval by the University of Kurdistan Ethics Committee (Ethics Code: IR.UOK.REC.1403.014) and after obtaining written informed consent from all participants.

2.3. Sample size calculation

All assessments and measurements were conducted at the University of Kurdistan's Exercise Physiology Research Laboratory between Aban and Azar 1404. Exclusion criteria included a history of cardiovascular disease or diabetes, the use of medications affecting oxidative metabolism or inflammation, failure to adhere to the supplementation protocol, or participation in strenuous exercise during the data collection period. The sample size was calculated using G*Power software (version 3.1), based on a repeated-measures ANOVA design (two independent groups and four measurement time points), assuming a medium effect size (f=0.25), a significance level of 0.05, a statistical power of 70%, and a correlation coefficient of 0.5 between measurements; the resulting sample size was 20 participants (10 per group).

2.4. Nutritional intervention / Supplementation protocol The supplement used was a 300 mg ubiquinol capsule (Healthy Origins® Kaneka QH®). Participants in the CoQ10 group ingested one 300 mg ubiquinol capsule with water exactly 120 minutes prior to the start of the exercise protocol. This timing was selected based on the pharmacokinetics of ubiquinol; the reduced form (ubiquinol) possesses higher bioavailability than ubiquinone, and the rise in plasma CoQ10 levels typically begins within 2–6 hours post-ingestion, with peak plasma levels often occurring around 4–8 hours (though a significant initial increase within the first 1–2 hours has been observed with certain formulations). This timing allows plasma levels to rise sufficiently to exert potential antioxidant and protective effects during acute high-intensity interval training (HIIT). The placebo group received an identical-looking capsule (containing canola oil without ubiquinol) (10). Both researchers and participants were blinded to the type of capsule administered.

2.5. Exercise protocol

The protocol was performed on a treadmill. Following a 3-minute warm-up at 8 km/h (zero incline), participants performed 30-second high-intensity running bouts (at 95–100% of their individual maximal aerobic speed, determined during a preliminary test) interspersed with 30 seconds of active recovery (at 50% speed). The protocol continued until voluntary exhaustion (defined as the inability to maintain the required speed for 5 consecutive seconds). The number of bouts and total time to exhaustion were recorded. This protocol was designed to simulate the intermittent, high-intensity activity pattern of soccer (involving repeated sprints and speed variations(11).

2.7. Dietary control and physical activity standardization

 https://doi.org/10.22034/ren.2026.145506.1159

For standardization purposes, participants were prohibited from consuming antioxidant supplements, alcohol, caffeine, and antioxidant-rich foods (such as fresh fruit, leafy vegetables, and green tea) for at least 48 hours prior to the test, and refrained from strenuous or moderate physical activity during the preceding 24–48 hours. The last main meal was consumed 3–4 hours before the intake of the supplement or placebo.

2.8. Statistical analysis

Data normality was assessed using the Shapiro-Wilk test. Descriptive statistics (mean, standard deviation, coefficient of variation) and inferential statistics—specifically two-way repeated-measures ANOVA with Bonferroni post-hoc comparisons—were calculated. Analyses were performed using GraphPad Prism software (version 9), with the significance level set at $p \leq 0.05$.

3. Results

Repeated measures ANOVA revealed main effects of time, group, and the time × group interaction for all variables.

3.1. Participants' characteristics and compliance

Descriptive and anthropometric characteristics of the subjects (20 male professional soccer players) are presented in Table 1.

Group/variable	Age / Year	Height (cm)	Weight (kg)	BMI (kg/ height^2)	Body fat (%)	WHR	Athletic background
CoQ10 supplement (N=10)	2/45±3/2	18/20±5/7	75/8±6/4	1/4 ± 23/3	1/21±2/1	0/82±0/04	8/6±1/4
Placebo (N=10)	2/84±2/9	17/59±6/1	74/9±7/2	23/1±1/6	1/51±2/4	0/83±0/05	8/3±1/5

No significant differences were observed between the CoQ10 supplementation group and the placebo group regarding age (25.1 ± 0.3 years), height (179.9 ± 8.5 cm), weight (75.4 ± 7.6 kg), BMI (23.3 ± 1.5 kg/m²), body fat percentage (11.4 ± 2.2%), and waist-to-hip ratio (0.83 ± 0.04) (all $p > 0.05$), indicating group homogeneity prior to the intervention.

3.2. Primary outcomes

Glutathione

The main effect of time ($F_{2,28} = 22.41$, $p < 0.001$, $\eta^2p = 0.615$), the effect of group ($F_{1,14} = 5.82$, $p = 0.031$, $\eta^2p = 0.293$), and the time × group interaction ($F_{2,28} = 14.67$, $p < 0.001$, $\eta^2p = 0.512$) were significant. In the CoQ10 group, GSH levels decreased by 12.5% immediately after exercise but fully recovered 24 hours later, rising to 19.0% above the post-exercise level. In the placebo group, the post-exercise decrease in GSH was 23.4%, and a poorer recovery (13.9%) was observed. Bonferroni analysis revealed that GSH levels at the 24h-post time point were significantly higher in the CoQ10 group than in the placebo group ($p = 0.008$) (Figure 1A).

TAC

The effects of time ($F_{2,28} = 18.73$, $p < 0.001$, $\eta^2p = 0.572$), group ($F_{1,14} = 7.49$, $p = 0.016$, $\eta^2p = 0.348$), and the time × group interaction ($F_{2,28} = 12.86$, $p < 0.001$, $\eta^2p = 0.479$) were significant. In the CoQ10 group, TAC decreased by 4.8% post-exercise but increased by 17.4% at 24 hours post-exercise ($p < 0.001$). In the placebo group, the post-exercise decrease in TAC was 16.9%, with only a 5.9% recovery observed at the 24-hour mark. The between-group difference at the 24-hour post-exercise time point was significant ($p = 0.004$); see Figure 1 (B).

MDA

The effects of time ($F_{2,28} = 34.68$, $p < 0.001$, $\eta^2p = 0.712$) and group ($F_{1,14} = 12.91$, $p = 0.003$, $\eta^2p = 0.480$), as well as the time × group interaction ($F_{2,28} = 21.35$, $p < 0.001$, $\eta^2p = 0.604$), were significant. In the CoQ10 group, MDA increased by only 15.9% following exercise, whereas it increased by 52.4% in the placebo group ($p < 0.001$). At the 24h-Post time point, MDA levels in the CoQ10 group returned to baseline (a 17.9% decrease relative to the Post time point), whereas in the placebo group, levels remained 25.0% above baseline. Between-group differences at the Post and 24h-Post time points were highly significant ($p < 0.001$ and $p = 0.002$, respectively); see Figure 1(C).

CRP

The effects of time ($F_{2,28} = 26.94$, $p < 0.001$, $\eta^2p = 0.658$) and group ($F_{1,14} = 9.87$, $p = 0.007$, $\eta^2p = 0.413$), as well as the time × group interaction ($F_{2,28} = 11.62$, $p < 0.001$, $\eta^2p = 0.454$), were significant. CRP levels increased by 75% in the CoQ10 group following exercise, whereas they increased by 161.5% in the placebo group. Twenty-four hours later, CRP levels in the CoQ10 group decreased by 33.3% (returning close to baseline), while the placebo group showed a decrease of only 23.5%. Between-group differences were significant at the post-exercise and 24-hour post-exercise time points ($p = 0.001$ and $p = 0.012$); see Figure 1(D).

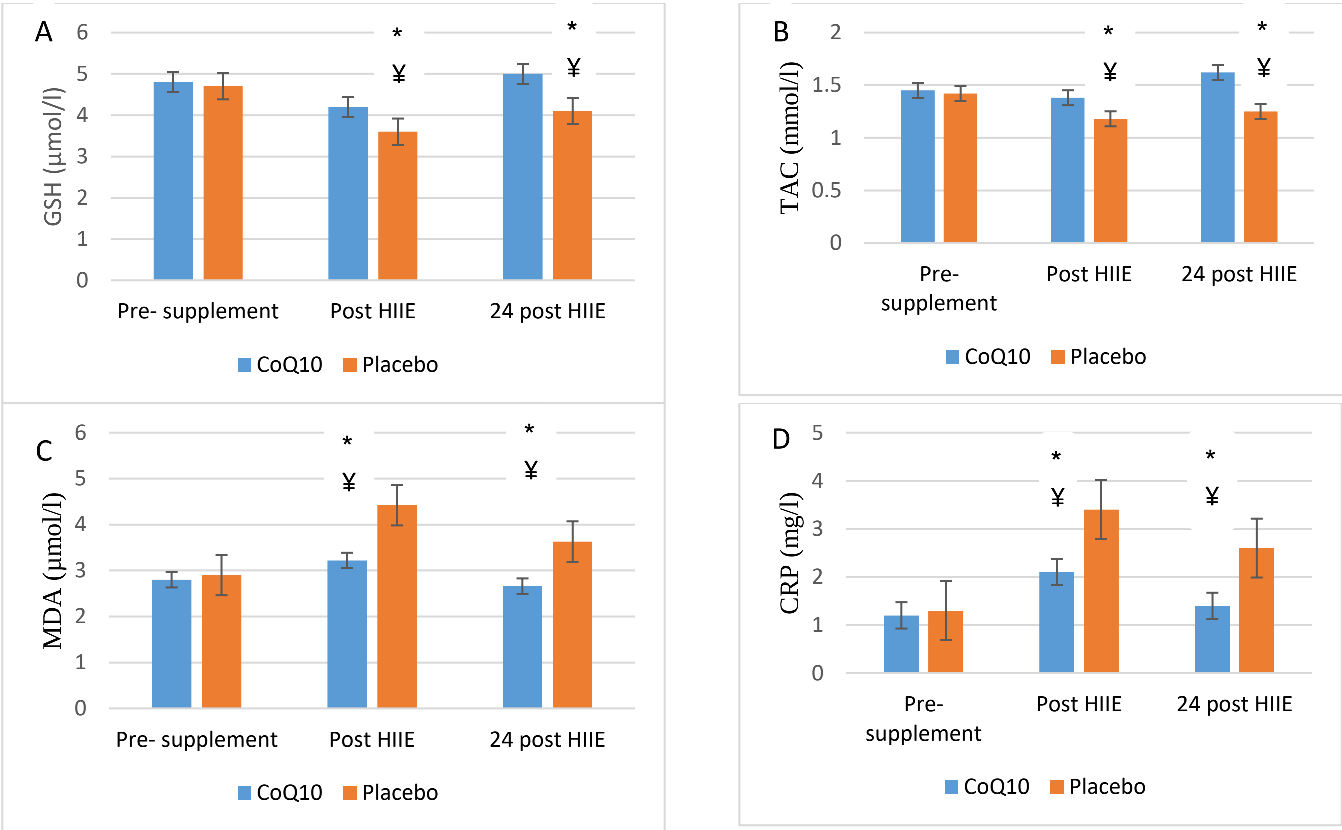

Figure 1: Changes in glutathione (GSH) (A), total antioxidant capacity (TAC) (B), malondialdehyde (MDA) (C), and C-reactive protein (CRP) (D) levels in the coenzyme Q10 (ubiquinol) supplement group and the placebo group at pre-exercise, immediately after high-intensity intermittent exercise (HIIE), and 24 hours post-exercise. Blue bars: CoQ10 supplement group; orange bars: placebo group. Values are presented as mean ± standard deviation. (*): Significantly higher than Pre-supplementation, (¥): Significantly compared to the placebo group.

4. Discussion

The results of the present study demonstrated that acute Coenzyme Q10 supplementation (300 mg, 120 minutes prior to exercise) significantly attenuated oxidative stress and the inflammatory response induced by a simulated session of high-intensity intermittent soccer exercise, while accelerating the recovery of antioxidant markers. Specifically, the CoQ10 group experienced a markedly smaller post-exercise increase in MDA (15.9% vs. 52.4% in the placebo group), restored GSH and TAC levels to baseline more rapidly, and reduced the rise in CRP by half. These findings fully align with the study hypothesis regarding the protective role of CoQ10 during high-intensity intermittent exercise (10) and provide new evidence for the efficacy of acute ubiquinol supplementation in mitigating oxidative stress and inflammation in professional male soccer players; an area that has received limited prior investigation.

The primary mechanism underlying these effects is the dual role of CoQ10 as an electron carrier in the mitochondrial respiratory chain and as a potent lipophilic antioxidant. Its reduced form (ubiquinol) directly neutralizes superoxide and peroxyl radicals, regenerates vitamin E, and upregulates the expression of intracellular antioxidant enzymes (12). Consequently, lipid peroxidation of mitochondrial

 https://doi.org/10.22034/ren.2026.145506.1159

and sarcolemmal membranes is reduced, thereby limiting the leakage of muscle damage enzymes and inflammatory markers (13). This mechanism was clearly evident in the present study through significant reductions in MDA (a key marker of lipid peroxidation) and CRP (a marker of systemic inflammation); these findings are supported by recent meta-analyses linking CoQ10 supplementation to significant reductions in MDA, CK, and LDH levels in athletes.

Our findings align with previous studies on endurance and strength athletes. Qiu et al. (2016) reported increased SOD and GSH levels and decreased MDA following chronic supplementation with 300 mg of CoQ10 for four weeks (14). Similarly, Armanfar et al. (2015) observed reduced CRP levels and increased catalase activity in strength athletes (14). Studies involving HIIT protocols and heavy training have also confirmed increases in TAC and decreases in MDA (15). However, most of these studies have focused on chronic (multi-week) supplementation. The present study demonstrates that even acute intake (a single 300 mg dose) can yield significant protective effects; this is of great practical importance, as footballers often lack the luxury of a multi-week window for supplementation between intense matches.

It is noteworthy that the effect on TAC was significant in the present study, whereas the meta-analyses by Talebi et al. (2024) and Qiu et al. (2025) did not report a significant effect on TAC [8, 9]. This discrepancy is likely attributable to the timing of ingestion (120 minutes prior to activity) and the use of the ubiquinol form (which has higher bioavailability) in the current study; these factors enabled CoQ10 to rapidly reach the mitochondrial membrane and preserve plasma antioxidant capacity. Another study investigating the effects of CoQ10 supplementation on antioxidant concentrations in male judokas demonstrated that CoQ10 supplementation mitigates oxidative stress and inflammatory responses in judo athletes following strenuous aerobic exercise (16).

Furthermore, the more rapid reduction of CRP in the supplementation group aligns with the findings of Rahimi et al. (2025), who linked short-term CoQ10 consumption to a decrease in cardiac stress markers (GDF-15, NT-proBNP, hs-TnT) and improved time to exhaustion in footballers following strenuous exercise (10).

From a practical standpoint, the results of this study are highly valuable for football. The pattern of high-intensity intermittent activity (repeated sprints, changes in speed and direction) mirrors exactly what occurs during a 90-minute match, leading to the massive production of ROS from mitochondrial sources and NADPH oxidase (17). Reducing oxidative stress and acute inflammation through a single dose of CoQ10 could facilitate faster recovery between matches or intense training sessions, lower the risk of muscle injury, and help maintain performance during the final stages of a game. This finding aligns with the recommendations of Buchheit and Laursen (2013) regarding the use of simulated HIIT protocols to evaluate nutritional interventions in football (18) (19).

Despite its strengths (double-blind design, football-specific protocol, and simultaneous measurement of antioxidant and inflammatory markers), the present study has limitations. The small sample size (n=20) limits statistical power, and direct measurements of plasma CoQ10 concentration and mitochondrial markers (such as ATP or intracellular ROS) were not performed. Furthermore, acute effects under real-match conditions—involving physical contact and psychological stress—might differ.

5. Conclusion

Overall, the present study provides strong preliminary evidence that acute CoQ10 supplementation (300 mg) can serve as a simple and safe strategy to reduce oxidative stress and inflammation induced by high-intensity intermittent exercise in professional soccer players. Future studies should investigate the effects of this dosage using multi-day protocols, larger populations, and real-world match conditions, while also evaluating molecular mechanisms (such as the expression of antioxidant and inflammatory genes) using more advanced methods. If these findings are confirmed in future research, CoQ10 could become a standard component of the pre-match nutritional regimen for soccer players.

6. Highlights

- ✓ Acute CoQ10 (ubiquinol) supplementation (300 mg, 120 min pre-exercise) significantly attenuated exercise-induced oxidative stress and inflammation in professional soccer players.
- ✓ CoQ10 reduced the post-exercise rise in MDA by 52.4% compared to placebo and accelerated the recovery of GSH and TAC levels.
- ✓ CRP elevation was nearly halved in the CoQ10 group (75% vs. 161.5% in placebo), with faster return to baseline.
- ✓ A single pre-exercise dose of CoQ10 may serve as a practical nutritional strategy to enhance recovery and reduce muscle damage in soccer players.

Statements

Funding

No funding was received for this study.

Acknowledgments

We wish to express our appreciation. We extend special thanks to the staff of the Exercise Physiology Research Laboratory for their technical assistance in data collection and analysis.

Conflicts of Interest

The authors declare no conflicts of interest. There are no financial or non-financial relationships that could influence the content of this research. All authors have approved the final version of the manuscript and accept full responsibility for its aspects.

Authors' Contributions

H.G. and Sh.D. contributed to the conception and design of the study, data collection, analysis and interpretation of results, and drafting and revision of the manuscript. Both authors read and approved the final version of the manuscript.

Supplementary Materials

No supplementary materials are available for this study.

Data Availability Statement

The data supporting the findings of this study are available from the corresponding author upon reasonable request

Institutional Review Board Statement

This study was conducted in accordance with the Declaration of Helsinki and approved by the Research Ethics Committee of the University of Kurdistan (approval number: IR.UOK.REC.1403.014). Informed consent was obtained from all participants prior to their involvement in the study.

References

[1] Howard T. Strength Training for Soccer: Human Kinetics; 2022.

[2] Henríquez-Olguín C, Renani LB, Arab-Ceschia L, Raun SH, Bhatia A, Li Z, et al. Adaptations to high-intensity interval training in skeletal muscle require NADPH oxidase 2. Redox Biology. 2019;24:101188. Doi: https://doi.org/10.1016/j.redox.2019.101188

[3] Esmaeili Z, Zehsaz F, Pouzesh Jadidi R, Ghahramani Dereshki M. The Effect of Aerobic Training Along with Water-Soluble Q10 Supplementation on nigrostriatal necroptosis related Genes' Expression and plasma Q10 level in Rat Model of Parkinson's Disease. Research in Exercise Nutrition. 2024;3(4):83-67. Doi: https://doi.org/10.22034/ren.2025.143692.1106.

[4] Joó JG, Sulyok E, Bódis J, Kornya L. Disrupted balance of the oxidant–antioxidant system in the pathophysiology of female reproduction: oxidative stress and adverse pregnancy outcomes. Current Issues in Molecular Biology. 2023;45(10):8091-111. Doi: https://doi.org/10.3390/cimb45100511.

[5] Ebadi M, Govitrapong P, Sharma S, Muralikrishnan D, Shavali S, Pellett L, et al. Ubiquinone (coenzyme q10) and mitochondria in oxidative stress of Parkinson's disease. Neurosignals. 2001;10(3-4):224-53. Doi: https://doi.org/10.1159/000046889.

[6] Akbari A, Mobini GR, Agah S, Morvaridzadeh M, Omidi A, Potter E, et al. Coenzyme Q10 supplementation and oxidative stress parameters: a systematic review and meta-analysis of clinical trials. European journal of clinical pharmacology. 2020;76(11):1483-99. Doi: https://doi.org/10.1007/s00228-020-02919-8.

[7] Rostamzadeh S, Dabbag Nikoukheslat S, Khani M, nikkhesal m. The effect of six weeks of sour cherry juice consumption with combined exercises on AST, ALT, TAC and MDA in obese and overweight women. Research in Exercise Nutrition. 2025;4(2):-. Doi: https://doi.org/10.22034/ren.2025.143878.1109.

[8] Talebi S, Shahi MHP, Zeraattalab-Motlagh S, Asoudeh F, Ranjbar M, Hemmati A, et al. The effects of coenzyme Q10 supplementation on biomarkers of exercise-induced muscle damage, physical performance, and oxidative stress: A GRADE-assessed systematic review and dose-response meta-analysis of randomized controlled trials. Clinical Nutrition ESPEN. 2024;60:122-34. Doi: https://doi.org/10.1016/j.clnesp.2024.01.015.

[9] Qu H, Qu Y. Can coenzyme Q10 supplementation reduce exercise-induced muscle damage and oxidative stress in athletes? A systematic review and meta-analysis. Complementary Therapies in Clinical Practice. 2025:102001. Doi:

https://doi.org/10.1016/j.ctcp.2025.102001.

[10] Rahimi MR, Morton AB, Golpasandi H, Salih SH. Short-term CoQ10 supplementation reduces markers of cardiac stress in soccer players following heavy exercise: A randomized double-blind placebo-controlled trial. BMC Sports Science, Medicine and Rehabilitation. 2025;18(1):73. Doi: https://doi.org/10.1186/s13102-025-01456-0.

[11] Ndlomo K. The effects of high-intensity training on the aerobic capacity of football players: University of Johannesburg (South Africa); 2022.

[12] Pallotti F, Bergamini C, Lamperti C, Fato R. The roles of coenzyme Q in disease: direct and indirect involvement in cellular functions. International journal of molecular sciences. 2021;23(1):128.

[13] Genova ML, Pich MM, Biondi A, Bernacchia A, Falasca A, Bovina C, et al. Mitochondrial production of oxygen radical species and the role of Coenzyme Q as an antioxidant. Experimental Biology and Medicine. 2003;228(5):506-13.

[14] Qu H, Qu Y. Can coenzyme Q10 supplementation reduce exercise-induced muscle damage and oxidative stress in athletes? A systematic review and meta-analysis. Complementary therapies in clinical practice. 2025;60:102001.

[15] Khodadadi S, Hassani A, Naderi A. Effect of 4 weeks HIIT with spirulina supplementation intake on plasma total antioxidant capacity (TAC) and lipid peroxidation (MDA) in women with type 2 diabetes. 2022.

[16] Golpasandi S, Khosravi M, Golpasandi H. Investigation of the Levels of Some Antioxidant and Inflammatory Markers Following Supplementation of CoenzymeQ10 after Acute Bouts of Exhausting Aerobic Exercise in Male Judo Athletes. Research in Exercise Nutrition. 2025;2(4):66-59. Doi: https://doi.org/10.22034/ren.2024.142662.1067.

[17] Busquets-Cortés C, Capó X, Martorell M, Tur JA, Sureda A, Pons A. Training and acute exercise modulates mitochondrial dynamics in football players' blood mononuclear cells. European journal of applied physiology. 2017;117(10):1977-87. Doi: ttps://doi.org/10.1007/s00421-017-3684-z.

[18] Sánchez-Cuesta A, Cortés-Rodríguez AB, Navas-Enamorado I, Lekue JA, Viar T, Axpe M, et al. High coenzyme Q10 plasma levels improve stress and damage markers in professional soccer players during competition. International Journal for Vitamin and Nutrition Research. 2020. Doi: https://doi.org/10.1024/0300-9831/a000659.

[19] Fatouros IG, Chatzinikolaou A, Douroudos II, Nikolaidis MG, Kyparos A, Margonis K, et al. Time-course of changes in oxidative stress and antioxidant status responses following a soccer game. The Journal of Strength & Conditioning Research. 2010;24(12):3278-86. Doi: 10.1519/JSC.0b013e3181b60444.