Tun J Sport Sci Med 2024; 2(2):11-16

10.61838/kman.tjssm.2.2.2

Tunisian Journal of Sports Science and Medicine

Original Research

Acute Changes in Plasma Lipid Levels after an Endurance Triathlon Competition in Young Physical Education Students

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Received: 2024-04-20 **Reviewed:** 2024-05-29 **Revised:** 2024-06-04 **Accepted:** 2024-06-07 **Published:** 2024-06-11

Abstract

Background: Exercise is associated with changes in lipids that may protect against coronary heart disease. Although triathlon is a popular multi-disciplinary exercise that could influence general health, there is limited evidence in the literature to adequately report its association with lipid profile metabolism.

Objectives: This study aimed to assess the effects of a short-distance triathlon competition on serum lipid profile.

Methods: Fourteen recreational triathletes (age: 21±1.18 years, height: 178.5±5.4 cm, body mass: 24.1±2.1 kg/m²), all physical education students, completed a short-distance triathlon (750 m swimming, 20 km cycling, and 5 km running). Blood samples were collected from an antecubital forearm vein one hour before the race and immediately after the competition.

Results: Compared to rest, exercise was associated with decreased levels of triglycerides (TGL) (22.9%, $p < 0.001$), total cholesterol (TC) (2.5%, $p < 0.01$), and low-density lipoprotein cholesterol (LDL-C) (3.3%, $p < 0.05$), and increased levels of high-density lipoprotein cholesterol (HDL-C) (8%, $p < 0.01$).

Conclusion: Our study shows that participating in short-distance triathlon competitions can have a positive impact on the blood lipid profile, possibly improving serum lipid metabolism and reducing the risk of cardiovascular diseases. Additional investigation should prioritize the clarification of the physiological mechanisms that explain these alterations in lipid profiles, particularly the process of mobilizing and utilizing lipids as an energy source during prolonged bouts of exercise. Furthermore, performing research on the impact of pre-competition nutrition practices could offer valuable knowledge on how to optimize lipid metabolism and improve athletic performance. These studies may include carefully planned changes to diets to evaluate how they affect the pace at which lipids are broken down and how they subsequently affect the changes in the athletes' lipid profiles.

Keywords: *Exercise, Cholesterol, Triglycerides, Lipoproteins, Health.*

How to cite this article:

Khcharem A, Abroug T. Acute Changes in Plasma Lipid Levels after an Endurance Triathlon Competition in Young Physical Education Students. *Tun J Sport Sci Med*. 2024;2(2):11-16.

1. Introduction

Physical exercise is widely accepted as beneficial for metabolic health, potentially protecting against coronary artery disease (1). Exercise independently influences cardiovascular risk factors by modifying plasma lipid levels (2). Recent studies by Carrillo-Larco et al. (3) and Dong et al. (4) have demonstrated a strong association between reduced mortality from cardiovascular diseases and improved blood lipid metabolism. Physical activity benefits include lowering triglycerides and low-density lipoprotein (LDL), while increasing high-density lipoprotein cholesterol (HDL-C) (5-7). It also induces phenotypic changes in the LDL molecule, reducing smaller, denser particles with greater atherogenic potential (8).

Most research on exercise effects involves long-term activities over weeks or months, showing clear benefits. However, fewer studies have examined the impact of acute exercise, particularly multi-disciplinary events like triathlons (9, 10). Triathlon distances vary significantly, with swim (300–4000 m), cycle (7–180 km), and run (1.6–42.2

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km) segments differing considerably (11). These variations may lead to different physiological outcomes.

Previous investigations suggest that triathlons can potentially improve lipid profiles and lower blood pressure, offering protective effects against cardiovascular diseases and even some cancers (12, 13). However, these benefits may be accompanied by adverse effects such as muscle damage, inflammation, and gut health disturbances, particularly evident in ultra-endurance events (14, 15). The physiological stress induced by such events can lead to oxidative stress and increased inflammatory markers, complicating the overall health outcomes.

Despite the recognized cardiovascular benefits, the specific effects of triathlons on plasma lipid metabolism remain less explored. Existing studies often focus on long-term exercise regimens, leaving a gap in understanding the acute lipid responses to multi-disciplinary exercises like triathlons (13, 16). Additionally, the complex interplay between exercise intensity, duration, and individual metabolic responses makes it challenging to generalize findings. The relative efficacy of short-distance triathlons in promoting overall health through serum lipid metabolism is still not well understood, necessitating further investigation (10).

Given the limited research on acute exercise effects and the specific impact of triathlons on plasma lipid metabolism, this study aimed to determine the effect of an acute short-distance (i.e., sprint) triathlon competition on plasma lipid levels (i.e., triglyceride (TGL), total cholesterol (TC), LDL-C and HDL-C).

2. Materials and Methods

2.1. Participants

Fourteen healthy male recreational triathletes, being physical education students, volunteered to participate in this study. Their mean (± S.D) physical characteristics were as follows: age 21.8 (± 0.9) years, weight 67.1 (± 7.2) kg, height 1.74 (± 0.11) m, BMI 21.9 (±1.6) kg/m2, VO_2max 52.5 (± 6.3) ml/kg/min. All of them had the same academic schedule under the control of the experimental staff. All the participants did not have a clinical history of coronary heart disease or other conditions that could interfere with the lipid profile. They affirmed being non-consumers of alcoholic beverages and non-smokers.

The participants were informed about the experimental process, the possible risks, and the troubles associated with the realization of trials before giving a written agreement to participate. The protocol was approved by the local Institutional Review Board of the Faculty of Medicine's research committee (University of Sfax, Tunisia) (CPP SUD N° 0166/85). The study also complied with the ethical and procedural requirements of the journal for the conduct of sports medicine and exercise science research (17).

2.2. Sample Size Calculation

The software G*Power (v3.0.10) was used to calculate the required sample size using alpha and power levels of 0.05 and 0.8. Based on the results of de Sousa Fernandes et al. (18) and after the authors' discussion, the effect size was fixed at 0.8 (large effect); at minimum thirteen participants are required for the present study to reach the desired power.

2.3. Experimental design

During the month preceding the experiment, the participants visited the university laboratory on different occasions. Firstly, measurements of weight, height, and BMI were taken. Two weeks before the experiments, the incremental running test of VAMEVAL (19) around a calibrated 400 m track was established to estimate individuals' maximal oxygen uptake (VO_2max). After one week, the participants performed one pre-test of a short-distance triathlon to become familiar with the competition. Two days before the competition, the participants were instructed to avoid strenuous physical exercise, to sleep for at least 7 hours, and to abstain from products containing psycho-stimulants. Moreover, they were prescribed to consume standard isocaloric meals with an energy intake of about 2400 kcal per capita/day (calculated using the software NUTRISOFT-BILNUT®, Ver. 4, Paris, France).

On the test day, participants were allowed to drink only water and to fast 6 hours before the start of the competition. The race took place under the conditions: temperature of 25 °C, humidity of 39%, atmospheric pressure of 1022 mbar, and wind of 5 km/h.

One hour before the race, blood samples were taken from an antecubital forearm vein. Just before the competition, a warm-up was performed on the track for 15 min followed by stretching. At 10:00 am, participants started the triathlon competition. Just after the exercise, performance times were recorded, and the same initial blood extraction was repeated for each participant.

2.4. The triathlon competition

The short-distance triathlon competition was conducted during an official outdoor competition (triathlon race of "Kerkennah Mermaid Festival"). It was held in the islands of Kerkennah (Sfax-Tunisia). The short-distance triathlon competition (classified as Sprint Distance Triathlon) consists of three successive events without rest: swimming (750 m), cycling (20 km), and running (5 km). Participants were encouraged to produce their maximal efforts until reaching the finish line.

2.5. Blood parameters

A blood sample was drawn at rest and after the triathlon competition to measure levels of triglyceride (TGL), total cholesterol (TC), low-density lipoprotein cholesterol (LDL-C), and high-density lipoprotein cholesterol (HDL-C). Five milliliters of venous blood were collected in EDTA tubes and were centrifuged at 4000 × g for five minutes at a temperature of 4°C to obtain plasma. Then, plasma was collected and stored in aliquots at -80°C until use. Hematocrit and hemoglobin were determined for estimating plasma volume changes, according to Dill and Costill (20).

- *Lipid profile*

TGL and TC levels were quantified enzymatically by using a Hitachi 911 autoanalyzer (Roche Diagnostics) according to the manufacturer's recommendations. Triglyceride measurement was corrected for endogenous glycerol (21). LDL-C and HDL-C were measured by b-quantification according to Lipid Research Clinics procedures (22). HDL-C levels were quantified after the precipitation of ApoB100-containing particles by dextran sulfate and MgCl2 (23).

2.6. Statistical analysis

SPSS Statistics for Windows (Version 20.0 Armonk, NY: IBM Corp.) was used for statistical analysis. The results were expressed as Means ± SD. The normality of the population was checked by the Shapiro-Wilk test. To evaluate the impact of the triathlon competition on the variables of interest, the Student t-test for paired samples was used. P-values of < 0.05 indicated statistical significance. A 95% confidence interval was used to set confidence margins for the results. Relative differences in percentages between pre-race and post-race conditions were also calculated as follows:

Δ (%) = [(Peak value – Minimum value) / peak value)] × 100

- ✓ Peak value: the greatest value among the pre-race and post-race conditions.
- ✓ Minimum value: the lowest value among the pre-race and post-race conditions.

3. Results

3.1. Triathletes data

Fifteen triathletes being physical education students, showed interest in participating in the current study. Of these, fourteen completed the run and provided blood samples before and after the competition. Participants' performances achieved during the short-distance triathlon, are presented in Table 1.

Table 1. Performances of the participants during the Triathlon

Athlete	Swimming 750m (min)	Cycling 20km (min)	Running 5km (min)	Triathlon time (min)
1	23	43	24	90
2	19	55	20	94
3	21	56	22	99
4	19	61	24	104
5	21	59	26	106
6	16	62	29	107
7	21	58	28	107
8	19	59	29	107
9	22	58	27	107
10	21	63	30	114
11	22	62	31	115
12	22	64	30	116
13	23	64	35	122
14	23	65	35	123
Mean	20.85	59.21	27.86	107.9
SD	1.99	5.59	4.42	9.58

min: minute; **Km:** kilometer; **SD:** standard deviation.

3.2. *Serum lipids*

Table 2 summarizes the mean changes in plasma levels of lipid profile parameters. Statistical analysis showed a significant effect of exercise on TGL, TC, LDL-C, and HDL-C. After exercise, a significant decrease in triglyceride levels by 22.9% (t= 5.058; $p < 0.001$) was reported. Similarly, the plasma TC levels presented a significant decrease of 2.5% (t= 3.644; $p < 0.01$). In addition, a significant decrease was reported in the levels of LDL-C by 3.3% (t= 2.371; $p < 0.05$). On the other hand, the plasma HDL-C levels presented a significant increase by 8% (t = 3.37; $p < 0.01$) between the pre- and post-triathlon competition measurements respectively.

Table 2. Plasma lipid and lipoprotein measurements before and after the triathlon competition.

	Before race	After race	Δ %	P value*
TGL (mg/dL)	55.6 ± 37.84	42.86 ± 33.59$^{\#\#\#}$	-22.9 %$^{\#\#\#}$	0.0002
TC (mg/dL)	138.8 ± 20	135.4 ± 19.6$^{\#\#}$	-2.5 %$^{\#\#}$	0.0030
LDL-C (mg/dL)	47.1 ± 5.4	45.38 ± 5.01$^{\#}$	-3,3 %$^{\#}$	0,0339
HDL-C (mg/dL)	73.36 ± 6.18	79.15 ± 11.2$^{\#\#}$	8 %$^{\#\#}$	0,0050

HDL-C: high-density lipoprotein cholesterol**; LDL-C:** low-density lipoprotein cholesterol**; SD**: standard deviation**; TC:** total cholesterol**; TGL:** triglyceride**.**

Values are mean ± **SD** (n = 13).

#: p <.05; ##: p <.01; ###: p <.001: Significant difference between before and after the race.

4. Discussion

The present study investigated the effects of a short-distance triathlon—750 m swimming, 20 km cycling, and 5 km running—on plasma lipid levels in young physical education students. The main findings suggested improvements in serum lipid metabolism, with decreased levels of triglycerides, total cholesterol, and LDL-C, and increased HDL-C levels.

These findings align with previous literature, indicating that triathlon competitions may enhance serum lipid profiles by increasing HDL-C and decreasing LDL-C levels (9, 13, 16). Such results provide valuable information for both athletes and sedentary individuals about the potential benefits of multidisciplinary exercise. It is important to note that while these changes suggest possible protective effects against coronary heart disease, the direct impact on cardiovascular health should be interpreted cautiously. The changes observed may be associated with lipid utilization as an energy source during exercise.

Regarding triglyceride levels, the study showed a significant decrease of 22.9% ($p < 0.001$) between pre- and post-race measurements. Similarly, Lamon-Fava et al. (16) reported a 66% reduction in triglycerides after a long triathlon. This reduction can be attributed to the substantial role of lipids in energy metabolism during endurance activities. There is evidence supporting that prolonged exercise is linked to decreased serum triglyceride levels (24).

For total cholesterol, results indicated a 2.5% decrease ($p < 0.01$) after the race. Yu et al. (13) also found a 7.3% reduction in total cholesterol following a long triathlon. These findings suggest that triathlons could lead to modest but significant improvements in total cholesterol for both trained and recreational triathletes. It is acknowledged that cholesterol metabolism is likely to be modified if exercise meets specific duration and intensity criteria (6).

Concerning lipoprotein variations, the study found a 3.3% decrease in LDL-C and an 8% increase in HDL-C after the triathlon competition. These findings align with studies reporting significant increases in HDL-C and decreases in LDL-C post-triathlon (9, 13, 16). Pilardeau (25) noted that endurance exercise at 60% of maximal oxygen uptake (VO2 max) is sufficient to significantly raise HDL-C levels. The prolonged and intense effort of the triathlon, averaging one hour and 48 minutes at approximately 67% of VO2 max, likely contributed to the observed increase in HDL-C.

It is known that LDL oxidation is a key step in atherosclerosis, but this process can be inhibited by HDL. The functionality of HDL, reflected in its cholesterol efflux activity, as well as its antioxidant, anti-inflammatory, and antithrombotic properties, suggests beneficial metabolic modifications that may protect against vascular diseases (7). Therefore, the increase in HDL following endurance exercise is associated with these positive metabolic changes.

In summary, the triathlon appeared to improve lipid profiles, with potential cardiovascular benefits. However, these findings should be interpreted as associations rather than direct impacts. Future research could explore pre-competition nutrition strategies and assess the applicability of blood volume corrections, as used in hematology, to lipid profile studies. Further investigation is necessary to fully understand the complex effects of triathlon participation on cardiovascular health.

5. Limitations

There are several limitations to consider in the current study. Firstly, only male participants were included, excluding females and limiting the generalizability of the findings across genders. Additionally, important measures such as protein fractions and inflammation biomarkers were not assessed, which could have helped consolidate the study's conclusions. The sample size was limited to 14 male triathletes, making it challenging to generalize the findings to a broader population of physically active individuals. Furthermore, the study included only two assessment points, pre- and post-competition. Having multiple post-competition measures could have provided valuable insights into the kinetics of the impacts over time, leading to a more comprehensive understanding. Lastly, only four blood parameters were assessed, and expanding the range of parameters could offer a more detailed picture of the physiological changes and responses related to exercise and recovery.

6. Conclusion

Our study indicates that participating in short-distance triathlon competitions is associated with positive changes in the blood lipid profile, including reduced triglycerides, total cholesterol, and LDL-C, alongside increased HDL-C levels. These associations suggest a potential role for multi-disciplinary sports in promoting general health and reducing cardiovascular risks. While these findings highlight the benefits of incorporating triathlon training into regular exercise routines, further research is needed to explore the underlying physiological mechanisms. Future studies should focus on how endurance exercise influences lipid metabolism and examine the impact of pre-competition nutrition practices. Such research could inform the development of targeted exercise and dietary programs for diverse populations, enhancing overall health and well-being.

Acknowledgments

The authors wish to express their sincere gratitude to all the participants for their maximal effort and cooperation.

Ethical Approval and Consent to Participate

This study was approved by the local Institutional Review Board of the Faculty of Medicine’s research committee (University of Sfax, Tunisia) (CPP SUD N° 0166/85).

Informed consent was obtained from all individual participants included in the study.

Availability of Data and Materials

The datasets generated during and/or analyzed during the current study are available from the corresponding author upon reasonable request.

Consent for Publication

Not applicable.

Competing Interests

The authors declare that they have no conflict of interest to disclose.

Funding

This research received no specific grant from any funding agency in the public, commercial or not-for-profit sectors.

Authors’ Contributions

A. Khcharem developed the original idea and the protocol, abstracted and analyzed the data, and wrote the manuscript. T. Abroug contributed to the development of the protocol and the final preparation of the manuscript.

Declaration

None.

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