MACRONUTRIENT AND MINERAL INTAKE EFFECT ON RACING TIME AND CARDIOVASCULAR HEALTH IN NON-ELITE MARATHON RUNNERS

Running title: ***impact of marathoners' diet on performance and heart***

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ABSTRACT

Objective: The aim of this study was to analyze, in recreational marathon runners, the intake of specific macronutrients and minerals that could influence cardiovascular health.

Methods: 37 males were grouped in two groups according to their 50% percentile race time (3.39 h), dividing into fast (G1: 3.18 ± 0.18 h) and slow runners (G2: 3.84 ± 0.42 h). Anthropometric parameters, macronutrients and mineral records were collected before the race. Minerals (Na^+, K^+ and Mg^{2+}), lipid profile (triglycerides, LDL, HDL and cholesterol), muscle damage (creatine kinase), inflammation (C-reactive protein), and cardiovascular health (high-sensitive troponin-T, ST2 and N-terminal pro-B-type natriuretic peptide) were analyzed in blood 24 h before, immediately after, and 48 h post-race.

Results: Weight (G1: 74.70 ± 7.76 kg, G2: 79.58 ± 6.72 kg; $p < 0.05$) and body mass index (G1: 23.01 ± 1.81 kg/m^2, G2: 25.30 ± 2.02 kg/m^2; $p < 0.01$) were significantly different between the groups. Moreover, G1 consumed significantly ($p < 0.01$) more mono- and poly-unsaturated fatty acids than G2, and presented significantly higher iron, potassium, and magnesium intake. Regarding blood lipid profile, G2 presented significantly higher triglyceride values and lower levels of high-density lipoprotein ($p < 0.01$). The Hs-TnT marker of cardiac myocyte stress/injury was significantly higher ($p < 0.05$) in G2 reaching values above 250 ng/L, and 81% of the runners (30 from 37) presented higher post-race values.

Conclusions: Marathon runners consuming adequate amounts of unsaturated fat, iron, potassium and magnesium, performed better and presented better cardiovascular health.

Keywords: macronutrients; minerals; marathoners; performance; cardiovascular health.

INTRODUCTION

Recreational marathons have become very popular in recent years. When performed properly, aerobic exercises are an optimal way to improve cardiovascular health, reducing morbidity and mortality [1]. Similarly, it has been shown that low performance can culminate in early fatigue, where nutrition plays a very important role [2,3]. In this sense, what we eat influences our body´s capabilities to adapt to training and post-exercise recovery [4,5]. Several sports medicine- and nutrition-related organizations recommend specific amounts of energy, macro- and micro-nutrients for sustained physical activity events in order to maintain body weight, replenish glycogen stores, and provide sufficient proteins to build and repair working tissues [2,6,7]. Optimal carbohydrates are needed before, during, and after intense and prolonged exercise, both during training and competition, for proper performance [7]. Also, fat is of particular interest among macronutrients for endurance athletes, as it provides energy, fat-soluble vitamins, and essential fatty acids, which are associated with a lower risk of cardiovascular disease and mortality [8,9].

When there is an increase in the duration and intensity of an endurance exercise like a marathon, there is at the same time an inter-individual response that depends on the level of physical training, resting conditions, energy disposal, and psychological status, among other parameters [10,11]. In addition, prolonged strenuous endurance exercise can also alter other physiological processes such as fluid imbalance and electrolyte levels [12]. Proper nutrition can help mitigate the majority of these problems [13].

Recreational runners, which represent the majority of endurance practitioners, generally focus on macronutrient intakes, disregarding the role of micronutrients that are mainly lost through sweat production [14]. Our hypothesis is that improper nutrition before an endurance event such as a marathon can affect the runner's performance and cardiovascular health. Therefore, an adequate diet should be designed considering several components: i.e., water with electrolytes, high vs. low glycemic index carbohydrates, saturated vs. unsaturated fat, animal vs. plant-based protein as well as the timing of nutrient intake.

The aim of this research was to analyze in recreational marathon runners the diet effect (content of macronutrients and minerals such as Na^+, K^+ and Mg^{2+}) over the race performance and the cardiovascular health.

MATERIALS AND METHODS

Participants

Thirty-seven male runners participating in the 2016 Barcelona Marathon were voluntarily recruited through the event's organizing committee. The exclusion criteria included participants under 18 and over 50 years of age, and suffering from any pathology or injury. Ethics approval was obtained from the "Consejo Catalán del Deporte" (Ref: 0099S/2046/2013) according to principles of Helsinki Declaration for experiments with human beings. All participants signed an informed consent.

Data collection

All participants completed a questionnaire including the following items: demographic and health data, height, weight, and training parameters, such as hours/week, intensities, type of exercise, locations selected to exercise, racing records, and main classifications in key challenges (data not shown). Training intensities were established according to race rhythm, based on time taken to run 1 km at maximal intensity. Intensities were adapted during training sessions accordingly (light intensity was performed as warm-up and moderate for recovery periods, and intensive intensities were planned for marathon finishing objectives).

The participants were weighed two hours before the race and immediately afterwards, using the same scale (Jata 565, Barcelona, Spain).

Participants were monitored using a 3-day dietary questionnaire. Individuals were instructed regarding serving sizes, supplements, beverages, food preparation and other variables that could influence estimation of diet composition, which was analyzed using the software DIAL [15].

During the race, the participants were provided with guidelines to maintain adequate levels of hydration. The first liquid intake was programmed at 60 min of the race: 400 ml for lighter/slower runners and 800 ml for heavier/faster runners, drinking 100-150 ml every 15-20 min. Commercialized beverages were provided to participants with an average of 480 mg/L for Na^+, 85 mg/L for K^+ and 45 mg/L for Mg^{2+}.

Blood analysis

Fasting blood samples (3 x 10 ml) were obtained from the antecubital vein in EDTA vacutainers 24h before the race, immediately after the race, and 48h afterwards. Blood samples were centrifuged at 3000 rpm at 4ºC for 10 min in a bench centrifuge. Supernatant (plasma) was aliquoted and stored on dry ice until all samples were frozen at -80ºC in sealed Eppendorf tubes to avoid evaporation.

Serum cholesterol, low-density (LDL) and high-density (HDL) lipoproteins, triglycerides, electrolytes, creatine-kinase (CK) and C-reactive protein (CRP) were determined using the AU-5800 Chemistry Analyzer (Beckman Coulter).

Hs-TnT Assay

Troponin levels were measured by electrochemiluminescence immunoassay using an Hs-TnT assay on a Modular Analytics E 170 (Roche Diagnostics). The Hs-TnT assay had an analytic range from 3 to 10,000 ng/L. At the 99th percentile value of 13 ng/L, the coefficient of variation was 9%. The analytic performance of this assay has been validated and complies with the recommendations of the Task Force for use in the diagnosis of myocardial necrosis. The assays were run with reagents from lot 157123, not affected by the analytical issues emerged with Roche Hs-TnT assays.

ST2 Assay

ST2 was measured from plasma samples using a high-sensitivity sandwich monoclonal immunoassay (Presage® ST2 assay, Critical Diagnostics, San Diego, CA, USA). The antibodies used in the Presage assay were generated from recombinant protein based on the human cDNA clone for the complete soluble ST2 sequence. The ST2 assay had a within-run coefficient of <2.5% and total coefficient of variation of 4%.

NT-proBNP Assay

NT-proBNP levels were determined using an immuno-electrochemiluminescence assay on a Modular Analytics E 170 (Roche Diagnostics). This assay has <0.001% cross-reactivity with bioactive BNP, and in the constituent studies in this report, the assay had inter-run coefficients of variation ranging from 0.9% to 5.5%.

CRP Assay

CRP concentration was measured using a particle-enhanced turbidimetric immunoassay technique (CRPHS, Roche Diagnostics, ref. 04628918 190) on an automatic analyzer, Cobas 6000 (Roche Diagnostics, Switzerland). The method was standardized against BCR470/CRM470 reference material from the IRMM. The linearity of the method was 0.15-20.0 mg/L; the detection limit was 0.15 mg/L, the functional sensitivity was 0.3mg/L; and the interserial coefficient of variation was <8.4%.

CK Assay

CK was measured using the AU-5800 Chemistry Analyzer (Beckman Coulter, ref. OSR6179 4). The method was standardized against controls ODC0003 and ODC0004 or other control materials with quantified values using this Beckman Coulter system. The reference values in males was ≤ 171 U/L (2,85 μkat/L) and the interserial coefficient of variation was <4.55%.

Statistical analysis

For the present study, thirty-seven runners were divided into two groups (G1 and G2) according to the 50^{th} percentile of race time (3.39 h). G1 corresponds to the fastest runners according to the values under the 50th percentile (n=19, 3.18 ± 0.18 h) while G2 corresponds to the slowest runners over the 50^{th} percentile (n=18, 3.84 ± 0.42 h). The race time of each participant was taken from the official race organization.

The variables sample size [16] was estimated according to the anthropometric of 14 runners (7 by group), nutrition of 21 runners (10 by group), circulating blood biomarkers of 35 runners (18 by group), circulating blood electrolytes of 31 runners (15 by group) and blood lipid profile of 39 runners (20 by group) to have a power (β =0.80) to detect an effect size of 0.996 with a 0.05 significance level using MedCalc statistical software version 19.0.3 (MedCalc Software bvba, Ostend, Belgium).

Data was collected 24h before-race, immediately post-race and 48h post-race. The normality of distribution of the variables was checked by the Shapiro-Wilk test and homogeneity of variances by Levene's test.

Repeated measures one-way Anova test was used to determine the effect of the marathon on variables measured 24h before-race, immediately post-race and 48h post-race. The Kruskal-Wallis test was used for repeated measures of data non-normally distributed.

In addition, samples were separated in two groups according to their 50% percentile race time (3.39 h), dividing into fast (G1: 3.18 ± 0.18 h) and slow runners (G2: 3.84 ± 0.42 h). Mann Whitney's U test or Student's t-test was applied to analyze non-parametric and parametric variables respectively.

The variables normally distributed are shown as mean ± SD while that non-normally distributed data are shown as median and interquartile range (IQR). The level of statistical significance was set at $P < 0.05$. The statistical software IBM® SPSS® version 24.0 (Armonk, NY: IBM Corp, USA) was used for data analysis.

RESULTS

Anthropometric, training characteristics and race time

Anthropometric and training characteristics are summarized in Table 1. Significant differences between groups with respect to weight ($p < 0.05$) and body mass index ($p < 0.01$) were observed. The slower runners were significantly heavier than the faster runners, with similar results observed when considering BMI, although both groups were within the healthy range (BMI = 20-25). In addition, G2 reported less training hours per week compared to G1, and also less light, moderate, and intensive training hours per week compared to G1, although in all cases the differences were not significant.

Dietary intakes of participants

The diet analysis recorded from the 3 day-questionnaires is shown in Table 2. The values indicate that all runners participating in this study consumed lower levels of carbohydrates than those recommended for endurance athletes (5-10 g/kg of body weight) [17]. In addition, protein intake in G1 was correct regarding recommendations for endurance runners (1.2-1.4 g/kg of body weight), but was significantly lower in the G2 group ($p < 0.01$). Finally, fat intakes were in the recommended levels for endurance athletes (20-35% kJ of daily diet) in both groups, although G2 consumed significantly less fat than G1 ($p < 0.01$). Regarding total energy consumption, this was significantly lower in G2 ($p < 0.01$). However, the participants in this study seemed to consume approximately 25% less energy than recommended. Energy requirements for men who are slightly-moderately active and between 19-50 years of age is established as 12139.4 kJ/day (2900 kcal/day) [13].

Altogether, G1 presented significantly higher fat intake than G2 ($p < 0.01$) but presented a lower BMI. Therefore, the type of fat consumed by the participants was assessed. Runners in G1 consumed significantly higher amounts of mono- and poly-unsaturated fatty acids compared to G2 ($p < 0.01$), whereas the amount of saturated fatty acids was similar in both groups. Finally, no significant differences were observed in cholesterol and water intakes, although fiber intake was significantly higher in G1 ($p < 0.01$).

According to mineral intake, G1 met the recommended requirements for sodium, potassium, iron and magnesium (1500, 3100, 9 and 350 mg/day respectively), whereas G2 did not reach the recommended amounts for potassium and magnesium, with significant differences compared to G1 ($p < 0.01$). Calcium was also under the recommended requirements (900 mg/day) in both groups, and iron intake was significantly higher in G1 ($p < 0.05$).

Blood markers of muscle damage, inflammation and cardiovascular health

The total serum biomarkers associated to muscle damage, inflammation and cardiovascular health are shown in Table 3. Initial levels of circulating CK in G1 and G2 were significantly higher in G2 before-race ($p < 0.05$) and post-race ($p < 0.01$), reaching the highest values 48h post-race (nearly 2400 U/L). Inflammatory C-reactive protein biomarker in G2 was significantly higher ($p < 0.01$) post-race and 48h post-race, also reaching the highest levels between groups (24 mg/dL).

Regarding cardiovascular parameters-- Hs-TnT, NT-proBNP and ST2, no significant differences were observed in two of the three cardiovascular biomarkers analyzed between groups, but there were values post-race that were over the cut-off point. The ST2 marker of extracellular matrix remodeling, fibrosis, inflammation, and myocardial strain has a cut-off ≥ 35 ng/mL, and 78% of the 37 runners presented higher post-race values. The NT-proBNP marker of myocardial strain has a cut-off ≥ 125 ng/L, and 27% of the runners (10 of 37) presented higher post-race values. The Hs-TnT marker of myocyte stress/injury has a cut-off ≥ 14 ng/L, and 81% of the runners (30 from 37) presented higher posts-race values. In addition, Hs-TnT value post-race was significantly higher ($p < 0.05$) in G2, reaching values above 250 ng/L.

Blood minerals and lipid profile

Total serum micronutrients such as Na^+, K^+ and Mg^{2+}, and lipid profile are shown in Table 4. No significant differences were observed in circulating electrolytes between groups. Triglycerides were significantly higher in G2 before ($p < 0.05$) and 48h post-race ($p < 0.01$), and HDL levels were significantly higher in G1 compared to G2 before, post-race and 48h post-race ($p < 0.01$). No significant differences were observed in LDL and cholesterol levels between groups.

DISCUSSION

The purpose of this study was to analyze macro- and micro-nutrient intakes that are generally considered to be related to cardiovascular health in recreational marathon runners, and report the effect on racing time and on blood cardiac biomarkers. Regarding training, selected runners presented no differences in their training years, but in the total hours/week of training, despite the fact that the values in G1 were higher without presenting significant differences, the increase in intensive training hours/week of this group was significantly higher compared to G2 (Table 1), also justifying better performance in the race. Runners from the slower group (G2) were physically heavier than the faster group (G1), which would require more effort to move their body during the marathon. This difference among the participants was initially considered to be due to differences in nutritional intake.

In this context, we have observed that nutrition varies among participants (Table 2), but those who consumed more unsaturated fatty acids and adequate mineral intakes, especially iron, potassium and magnesium, had faster finishing times and a healthier lipid blood profile (Table 4). Runners in G1 had higher iron intake and this might benefit hemoglobin levels, preserving aerobic performance [2,7].

In addition, the slower runners presented higher circulating amounts of cardiovascular-damage biomarkers, such as high triglycerides and low HDL (Table 4) [18]. When analyzing three well-known cardiovascular biomarkers (Table 3), all increased post-race, most notably Hs-TnT in slower runners (G2), and can confer long-term increased risk in cardiovascular health or can be a cardiac sport-driven adaptation [19].

Altogether, these observations indicate that the slower runners are performing a very demanding aerobic effort with a less optimal profile, regarding circulating cardiovascular biomarkers. In this context, their diet choices, especially regarding fat and mineral intakes, could be the most relevant factors responsible for this outcome, although training also plays a prominent role.

Although the amount of fat taken by both groups was adequate for endurance training [20], the most significant difference between the G1 and G2 groups was the type of fat consumed. Different studies have assessed that the type of fat (saturated *vs.* unsaturated) could be a main contributing factor to increased adiposity and higher triglyceride and LDL levels in blood [21]. Table 4 depicts how G2 presents significantly higher levels of triglycerides compared to G1. At the same time, consuming more saturated fats correlates with higher body weights and BMI, hindering the performance of G2 runners through mechanisms that require further research [22,23]. In addition, HDL (an indicator of arterial protection) was significantly higher in G1 (Table 4), which can increase due to aerobic exercise and higher amounts of monounsaturated fats in diet [24]. Taken together, this could translate to better cardiovascular health status in G1 *vs.* G2 (Table 3).

Analyzing diet questionnaires, faster runners (G1) consumed frequent servings of seeds and nuts, more servings of fruits and vegetables, and adequate servings of whole cereals. Coincidently, many of these foods are sources of unsaturated fatty acids. In addition, G2 finishers presented low amounts of certain minerals in their diet, such as Fe^{2+}, K^+ and Mg^{2+}. Interestingly, the previously mentioned foods provide adequate amounts of these micronutrients. Unsaturated fats, as well as K^+ and Mg^{2+}, play an instrumental role in cardiac function [25], possibly favoring a more adaptive response to exercise [26]. This observation emphasizes the importance of an adequate selection of foods when designing training diets, not only for macronutrients, but for specific micronutrients as well. In this manner, the runners can perform the race in healthier cardiovascular conditions.

When physical activity such as the marathon is performed, there are energy and macronutrient needs, especially carbohydrates and proteins, that must be satisfied to maintain body weight, replenish glycogen stores and provide adequate proteins to build and repair tissue [7]. In addition, fat intake should be sufficient to also provide energy along with essential fatty acids and fat-soluble vitamins [27,28]. Regarding the runners participating in this study, there are some points mentioned that can be improved. Dietary recommendations for endurance runners are 5-10 g of carbohydrates/kg of body weight [2,13], but the amount consumed by the participants in this study was lower, and this deficiency could be related to the lower amounts (25%) of kcal consumed in their diet. Protein intakes were in the recommended range, although slightly lower in G2. However, these deficiencies in particular macronutrients do not seem to have an influence in the cardiovascular health status, since G1 runners did not present noticeable levels of circulating cardiac biomarkers [19]. Nevertheless, a first corrective intervention in the population studied should focus on adding more carbohydrates for optimal performance.

A limitation of the study was the small group sample. Another limitation was to not know if a deficient intake in K^+ and Mg^{2+} can lead to decreased performance of certain body compartments, such as the heart. The body content of the electrolytes studied (Table 4), particularly Mg^{2+}, was unknown, as this requires specific overloading protocols that we have not performed [14,29,30]. In the present study, lower consumption of K^+ and Mg^{2+} in the diet does not result in a hypokalemia or hypomagnesemia, as the circulating electrolyte content was very similar between both groups. Additional studies must be carried out to answer this question. In addition, our future research direction is focused on proving if the above-mentioned diet changes in a population of recreational runners similar to G2 would improve the circulating profile of cardiovascular health biomarkers.

In conclusion, the consumption of mono- and poly-unsaturated fatty acids and a correct intake of K^+ and Mg^{2+}, in non-athlete (recreational) marathon runners, performed better (had shorter race times) without compromising their health status assessed by a correct circulating lipid profile (the present study) and no noticeable circulating cardiovascular risk biomarkers [19]. Nevertheless, the diet of recreational runners needs to be improved in certain macronutrients and the relation to the health status must be assessed in future studies.

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CONFLICTS OF INTEREST

None of the authors have conflicts of interest to disclose.

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Table 1: Anthropometric and training data of the participants in the study.

Parameters	Total	Fast runner group (G1)	Slow runner group (G2)
Age (years)	38.06 ± 6.31	37.50 ± 6.13	38.65 ± 6.62
Weight (kg)	77.08 ± 7.59	74.70 ± 7.76	79.58 ± 6.72*[a]
Height (cm)	178.70 ± 5.72	180.11 ± 6.10	177.22 ± 5.02
BMI (kg/m^2)	24.12 ± 2.22	23.01 ± 1.81	25.30 ± 2.02**[a]
% Weight lost	3.08 ± 1.63	3.50 ± 1.88	2.63 ± 1.52
Training (yrs)	9.64 ± 6.22	8.71 ± 4.94	10.61 ± 7.35
Training (h/week)	6.93 ± 3.01	7.63 ± 3.00	6.19 ± 2.93
light	1.92 ± 1.37	2.24 ± 1.44	1.59 ± 1.25
moderate	2.63 ± 1.41	2.92 ± 1.68	2.32 ± 1.01
intensive	1.87 ± 0.98	2.03 ± 0.85	1.71 ± 1.10
very intensive	0.95 ± 0.63	0.87 ± 0.52	1.03 ± 0.72
Race time (h)	3.50 ± 0.46	3.18 ± 0.18	3.84 ± 0.42**[b]

Values presented as mean ± SD.
*$p < 0.05$; **$p < 0.01$ significant differences when comparing both groups.
Statistical analysis: [a]One-way Anova, [b]Kruskal-Wallis.
Abbreviations used: BMI, body mass index; h, hours.

Table 2: Nutrition intake of the participants in the study.

Parameters	Total	Fast runner group (G1)	Slow runner group (G2)
Daily (kJ)	9170.28 (6898.22-17053.33)	9846.18 (6938.26-17053.33)	8352.32 (6898.22-11023.76)**
(kcal)	2183.40 (1642.43-4060.32)	2344.33 (1651.97-4060.32)	1988.65 (1642.43-2624.70)**
Carbohydrates			
(g/day)	236.87 (136.35-381.05)	260.94 (136.35-361.41)	202.63 (146.52-381.05)
(g/kg/day)	2.93 (1.70-5.64)	3.13 (2.10-4.63)	2.54 (1.70-5.64)
(% of total intake)	56.72 (33.03-73.96)	56.52 (33.03-65.75)	57.64 (40.62-73.96)
Proteins			
(g/day)	83.64 (51.84-202.68)	88.09 (59.64-202.68)	75.18 (51.84-128.24)*
(g/kg/day)	1.04 (0.63-2.26)	1.25 (0.81-2.26)	0.93 (0.63-1.88)**
(% of total intake)	20.94 (11.42-31.29)	20.79 (15.21-31.29)	21.00 (11.42-27.53)
Lipids			
(g/day)	87.09 (60.68-231.75)	92.62 (71.35-231.75)	78.64 (60.68-129.08)**
(g/kg/day)	1.13 (0.74-3.23)	1.21 (0.97-3.23)	0.97 (0.74-1.91)**
(% of total intake)	22.70 (14.47-35.68)	22.89 (16.25-35.68)	21.37 (14.47-31.86)
Fatty acids (g/day)			
saturated	23.37 (12.06-50.10)	23.85 (15.75-50.10)	22.52 (12.06-29.72)
monounsaturated	44.55 (28.42-120.55)	46.43 (33.06-120.55)	40.30 (28.42-64.45)**
polyunsaturated	11.54 (7.29-38.38)	14.62 (9.44-38.38)	10.91 (7.29-29.64)**
Cholesterol (mg)	246.64 (99.16-882.17)	273.46 (141.12-882.17)	197.78 (99.16-381.55)
Dietary fiber (g/day)	25.17 (12.49-50.95)	31.39 (22.93-50.95)	21.35 (12.49-40.99)**
Water (ml)	1096.81 (426.14-1957.36)	1189.79 (590.03-1957.36)	967.14 (426.14-1752.57)
Na (mg/day)	2243.13 (1641.16-3537.06)	2215.13 (1718.26-3537.06)	2269.58 (1641.16-3449.99)
K (mg/day)	3035.68 (1530.55-6246.98)	3367.56 (2257.26-6246.98)	2413.64 (1530.55-4936.00)**
Fe (mg/day)	16.80 (9.45-32.44)	20.16 (11.07-25.30)	12.65 (9.45-32.44)*
Ca (mg/day)	709.02 (263.27-1531.08)	709.51 (504.24-1531.08)	682.92 (263.27-1138.44)
Mg (mg/day)	304.89 (159.08-738.73)	373.15 (243.65-738.73)	264.95 (159.08-541.95)**

Values presented as median (IQR).
*p < 0.05; **p < 0.01 significant differences when comparing both groups.
Statistical analysis: Kruskal-Wallis.
Abbreviations used: Na, sodium; K, potassium; Fe, iron; Ca, calcium; Mg, magnesium.

Table 3: Circulating blood biomarkers of muscle damage, inflammation and cardiovascular health of the participants in the study.

Parameters	Total	Fast runner group (G1)	Slow runner group (G2)
CK (U/L)			
before-race	168 (83-1206)	219 (92-472)	136 (83-1206)*
after-race	561 (271-1666)	426 (271-778)	630 (343-1666)**
48h after-race	676 (188-2354)	645 (214-1763)	737 (188-2354)
CRP (mg/dL)			
before-race	0.6 (0.2-14.6)	0.4 (0.2-14.6)	1.0 (0.2-5.9)
after-race	0.6 (0.0-10.8)	0.3 (0.0-7.0)	0.9 (0.2-10.8)**
48h after-race	6.5 (2.4-24.0)	5.1 (2.4-15.4)	9.3 (4.0-24.0)**
Hs-TnT (ng/L)			
before-race	2.9 (0.4-26.0)	2.8 (1.2-26.0)	3.0 (0.4-12.9)
after-race	36.0 (4.8-251.6)	23.9 (4.8-111.8)	49.9 (8.2-251.6)*
48h after-race	4.1 (0.4-161.1)	2.6 (0.5-29.2)	4.5 (0.4-161.1)
ST2 (ng/L)			
before-race	35.06 (17.22-106.08)	35.5 (17.2-106.1)	34.7 (21.1-67.3)
after-race	55.47 (18.09-128.58)	55.4 (28.3-112.5)	56.3 (18.1-128.6)
48h after-race	36.52 (12.21-78.82)	38.0 (21.0-78.8)	32.9 (12.2-63.6)
NT-proBNP (ng/L)			
before-race	70 (70-109)	70 (70-109)	70 (70-93)
after-race	101 (70-452)	97 (70-311)	104 (70-452)
48h after-race	70 (70-205)	70 (70-101)	70 (70-205)

Values presented as median (IQR).
*p < 0.05; **p < 0.01 significant differences when comparing both groups.
Statistical analysis: Kruskal-Wallis.
Abbreviations used: CK, creatine kinase; CRP, C-reactive protein; Hs-TnT, high-sensitive troponin-T; NT-proBNP, N-terminal pro-B-type natriuretic peptide.

Table 4: Circulating blood electrolytes and lipid profile of the participants in the study.

Parameters	Total	Fast runner group (G1)	Slow runner group (G2)
Na (mEq/l)			
before-race	139.95 ± 1.75	140.00 ± 1.92	139.89 ± 1.61
after-race	142.73 ± 2.74	143.47 ± 2.78	141.94 ± 2.53
48h after-race	141.62± 1.83	141.37 ± 2.14	141.89 ± 1.45
K (mEq/l)			
before-race	4.12 ± 0.33	4.18 ± 0.32	4.05 ± 0.33
after-race	4.2 ± 0.38	4.30 ± 0.29	4.23 ± 0.46
48h after-race	4.17± 0.24	4.13 ± 0.27	4.21 ± 0.20
Mg (mEq/l)			
before-race	2.07 ± 0.13	2.05 ± 0.11	2.08 ± 0.14
after-race	1.76 ± 0.18	1.73 ± 0.15	1.80 ± 0.21
48h after-race	2.17± 0.13	2.20 ± 0.13	2.14 ± 0.12
Triglycerides (mg/dL)			
before-race	117.57 ± 69.09	87.95 ± 39.95	148.83 ± 80.02 *[b]
after-race	99.08 ± 20.12	101.47 ± 25.18	96.56 ± 13.16
48h after-race	120.57 ± 66.16	89.68 ± 40.02	153.17 ± 73.37 **[b]
LDL (mg/dL)			
before-race	99.60 ± 24.69	97.53 ± 23.88	101.28 ± 26.03
after-race	96.46 ± 20.75	91.90 ± 21.12	101.28 ± 19.78
48h after-race	92.19 ± 22.76	93.68 ± 22.78	90.61 ± 23.29
HDL (mg/dL)			
before-race	60.57± 12.50	66.32 ± 9.60	54.50 ± 12.54 **[a]
after-race	59.16 ± 11.36	63.79 ± 10.39	54.28 ± 10.48 **[b]
48h after-race	60.30 ± 12.66	66.79 ± 11.22	53.44 ± 10.46 **[a]

Cholesterol (mg/dL)			
before-race	183.68 ± 24.45	181.37 ± 21.96	186.11 ± 27.26
after-race	175.41 ± 21.02	176.00 ± 21.73	174.78 ± 20.84
48h after-race	176.70 ± 24.17	178.47 ± 25.30	174.83 ± 23.51

Values presented as mean ± SD.
*p < 0.05; **p < 0.01 significant differences when comparing both groups.
Statistical analysis: [a]One-way Anova, [b]Kruskal-Wallis.
Abbreviations used: Na, sodium; K, potassium; Mg, magnesium; LDL, low-density lipoprotein; HDL, high-density lipoprotein.