<u>Title</u>: INFLAMMATION, MUSCLE DAMAGE AND POST-RACE PHYSICAL ACTIVITY FOLLOWING A MOUNTAIN ULTRAMARATHON

<u>Heading title</u>: Determinants of ultramarathon recovery

Martínez-Navarro Ignacio[1,2*], Collado Eladio[3], Hernando Carla[4], Hernando Barbara[5], Hernando Carlos[6,7]

[1] *Physical Education and Sports Department, University of Valencia, Valencia, Spain.*

[2] *Sports Health Unit, 9 de Octubre Hospital, Valencia, Spain*

[3] *Faculty of Health Sciences, Jaume I University, Castellon, Spain*

[4] *Department of Mathematics, Carlos III University of Madrid (Spain)*

[5] *Department of Medicine, Jaume I University, Castellon, Spain*

[6] *Sport Service, Jaume I University, Castellon, Spain.*

[7] *Department of Education and Specific Didactics, Jaume I University, Castellon, Spain*

Correspondence to:

Ignacio Martínez-Navarro

Department of Physical Education and Sports

University of Valencia.

C/Gascó Oliag, 3 - 46010 - Valencia (Spain).

email: Ignacio.Martinez-Navarro@uv.es

phone number: +34 667331613

Abstract

Background. The study aimed at exploring whether muscle membrane disruption, as a surrogate for muscle damage, and inflammation recovery following a mountain ultramarathon (MUM) was related with race performance and post-race physical activity. **Methods.** Blood samples were obtained from thirty-four athletes (29 men and 5 women) before a 118-km MUM, immediately after and three and seven days post-race. Creatine kinase (CK), lactate dehydrogenase (LDH) and C-reactive protein (CRP) were compared between faster (FR) and slower (SR) runners. Physical activity performed during the week following the MUM was objectively analyzed using accelerometers and compared between FR and SR. **Results**. CK was significantly higher in FR at 3 days post-race ($p<0.012$, $d=1.17$) and LDH was significantly higher in FR at 3 and 7 days post-race ($p=0.005$, $d=1.01$; $p<0.015$, $d=1.05$ respectively), as compared to SR. No significant differences were identified in post-race physical activity levels between FR and SR. Significant relationships were found between race time and CK and LDH concentrations at 3 days post-race ($r_s=-0.41$, $p=0.017$; $r_s=-0.52$, $p=0.002$ respectively) and 7 days post-race ($r_s=-0.36$, $p=0.039$; $r_s=-0.46$, $p=0.007$ respectively). However, post-race physical activity was not associated with muscle damage and inflammation recovery, except for light intensity and CRP at 3 days post-race ($r_s=-0.40$, $p=0.025$). **Conclusions.** Race time appeared to have a higher influence on muscle damage recovery than the intensity of physical activities performed in the week after running a MUM. Inflammatory activity takes longer to normalize than muscle damage following a MUM, it is not related with race time and lightly related with post-race physical activity.

Keywords: accelerometry, creatine kinase, lactate dehydrogenase, c-reactive protein, recovery

1. Introduction

The popularity of mountain ultramarathons (MUM) has grown exponentially during the last few years (1, 2), and a large number of studies has documented the acute physiological side effects of performing such exhaustive physical efforts (3). Indeed, a very pronounced increase in inflammation and muscle membrane disruption markers, as a surrogate for muscle damage, has been reported following MUMs (4, 5). The succession of prolonged eccentric actions that occur in the downhill sections of these races has been pointed as the main trigger of such inflammatory and muscle damage response (6, 7). For instance, while 1,350 U/l of circulating levels of creatine kinase (CK) were observed following a protocol of 2 sets of 50 bicep curls with 12 maximal eccentric contractions (8), CK concentrations of over 15,000 U/l have been reported after MUMs (i.e., Ultra Trail du Mont-Blanc or Western States Endurance Run) (4, 5).

However, the evolution and recovery from muscle damage and inflammatory response over the subsequent days following a MUM has been considerably less investigated (5, 9). Moreover, previous studies did not assess possible factors that may influence this time course of the restoration of muscle damage and inflammatory response. The knowledge of these key factors may be essential for supporting both athletes and coaches in the design of post-competition return-to-training schedules (10). The attention on post-competition recovery processes and its optimization in sport has increased enormously (11). Different early post-exercise interventions such as cooling, massage, compression garments, electrostimulation, stretching, cold water immersion or cryotherapy have been previously assessed (12). However, there is a lack of scientific literature about athletes' physical activity in the days following a main competition and its possible repercussion on recovery (13).

Therefore, the purposes of our study were three-fold. First, we focused on analyzing the recovery timeline of muscle membrane disruption and inflammatory biomarkers following a MUM. Secondly, we wanted to describe the physical activity performed by recreational athletes during the week after the race (recovery week). Lastly, we aimed at exploring whether competition and training background, race performance, age, sex and post-race physical activity were associated to the recovery rate of muscle membrane disruption biomarkers and inflammatory response.

According to previous literature, we hypothesized that: muscle membrane disruption biomarkers may return to baseline values within 7 days post-race, while inflammatory response may still remain significantly increased at this time point (5); athletes may progressively spend greater time at moderate and vigorous intensity levels from the second day after the race onwards; faster runners possibly will recover quicker from muscle membrane disruption and inflammation response than slower runners due to their superior performance level; performing more activities at light and moderate intensity levels during the post-race week will accelerate the recovery from muscle membrane disruption and inflammatory response.

2. Materials and methods

2.1. Experimental design

This research was developed at the Penyagolosa Trails CSP race. The track consisted of 118 km, starting at an altitude of 40 m and finishing at 1280 m above the sea level, with a total positive and negative elevation of 5439 and 4227 m respectively. Four blood samples were collected per runner at different time-points: the day before the race, within 30 min after crossing the finishing line, 3 days post-race and 7 days post-race. Concomitantly, after crossing the finish line, we gave a GENEActiv accelerometer (Activinsights, Ltd., Kimbolton, Cambridgeshire, United Kingdom) to all finishers, who should wear it for the following seven days after the race in order to objectively quantify their physical activity. Finishers were divided into two groups as faster runners (FR; those with a finishing time below the mean value of our sample, n=15) and slower runners (SR; those with a finishing time above the mean value of our sample, n=19) and post-race physical activity and blood variables were compared between groups. Data about hydration status, executive function and response to orthostatism from this study were already published (14).

2.2. Participants

Fifty recreational ultraendurance athletes (44 men and 6 women) were recruited to participate in the study. Selected athletes were required to: have previously completed at least one ultramarathon (>42 km) and be free from cardiac or renal disease and from taking any medication on a regular basis. All subjects were fully informed of the procedure and gave their written informed consent to participate. They were also allowed to withdraw from the study at will. A questionnaire was used to collect demographic information as well as training and competition history. All athletes considered the Penyagolosa Trails CSP115 as their main competitive goal of the season. The investigation was conducted according to the Declaration of Helsinki, and it was approved by the Research Ethics Committee of the University Jaume I of Castellon.

2.3. Procedures

Blood samples were collected from an antecubital vein by venipuncture using BD Vacutainer PST II tubes. Samples were centrifuged on site at 3500 rpm for ten minutes and kept at 4°C during transport to Vithas Rey Don Jaime Hospital (Castellon), where they were processed using the modular platform Roche / Hitachi clinical chemistry analyzer Cobas c311 (Roche Diagnostics, Penzberg, Germany), following previous studies (15, 16). CK and Lactate dehydrogenase (LDH) were used to assess muscle membrane disruption, as a surrogate for muscle damage. C-reactive protein (CRP) was used as an indicator of acute inflammatory reaction. Biochemical results obtained in the sample collected immediately post-race were adjusted following Dill and Costill method (17), using hematocrit and hemoglobin to determine the magnitude of plasma volume changes after the race in each participant (17, 18).

The time spent by the participants at each one of the six-relative intensity levels of physical activity was determined by applying the GENEActiv's cut-off points established by Hernando et al. (19, 20). Then, the following composite variables were created for the correlational analysis: LIGHT_3d, total time spent at light intensity level during the first 3 days following the race; MOD_3d, total time spent at moderate intensity level during the first 3 days following the race; VIG_3d, total time spent at the highest three intensity levels of physical activity (vigorous, very vigorous and extremely vigorous) during the first 3 days following the race; LIGHT_7d, total time spent at light intensity level from the 3rd day to the 7th day following the race; MOD_7d, total time spent at moderate intensity level from the 3rd day to the 7th day following the race; VIG_7d, total time spent at the highest three levels of physical activity (vigorous, very vigorous and extremely vigorous) from the 3rd day to the 7th day following the race.

2.4. Statistical analysis

Statistical analyses were carried out using the Statistical Package for the Social Sciences software (IBM SPSS Statistics for Windows, version 22.0, IBM Corp., Armonk, NY). Normal distribution of the variables was verified through the Shapiro-Wilks test, obtaining values of $p<0.05$ for all variables, except for age, body mass index (BMI), training and competition history. This result motivated the usage of nonparametric tests for the analysis of blood and accelerometry-derived data. Friedman and Wilcoxon tests were conducted to appraise the evolution of CK, LDH and CRP from pre-race to 7 days post-race per runner's group (FR and SR). The same procedure was applied to assess the evolution in the time spent at light, moderate and vigorous intensity levels of physical activity across the recovery week per runner's group. Comparisons of quantitative variables between groups at each specific time-point were performed using Mann-Whitney U tests.

Additionally, we performed univariate Spearman correlations between each primary outcome (CK, LDH and CRP at all time points) and each independent variable explored (sex, age, BMI, training-related variables, race time and variables related to post-race physical activity). The meaningfulness of the significant outcomes was estimated through Cohen's *d* effect size: a $d<0.5$ was considered small; between 0.5-0.8, moderate; and greater than 0.8, large (21). Likewise, correlations >0.5 were considered strong, 0.3-0.5, moderate and <0.3, small. The significance level was set at $p<0.05$ and data are presented as means and standard deviations (±SD). Additionally, ranges are shown in those variables that did not follow a normal distribution.

3. Results

Thirty four athletes (29 men and 5 women) successfully completed the race. The finishers/starters ratio for the subjects of the present study (i.e. 68%) was similar to the ratio when all race participants were considered (63.5%). Male athletes' average finish time was 22 h 31 min ± 3 h 50 min, 168% of winning time (13 h 26 min); while females athletes' average finish time was 22 h 16 min ± 2 h 55 min, 137% of winning time. Average finish times of FR and SR were 19 h 01 min ± 2 h 25 min and 25 h 14 min ± 1 h 46 min respectively. The characteristics of the final sample, as divided into FR and SR, are presented in **Table 1**.

***** Insert Table 1 near here *****

The total time spent at each physical activity intensity level during the recovery week following the race by FR and SR is presented in **Table 2**. Friedman analysis revealed significant differences both in FR and SR in the evolution of light (FR: $\chi^{2(6)}$=16.095, p=0.013; SR: $\chi^{2(6)}$=19.035, p=0.004), moderate (FR: $\chi^{2(6)}$=24.891, p<0.001; SR: $\chi^{2(6)}$=24.891, p<0.001) and vigorous intensity (FR: $\chi^{2(6)}$=12.973, p=0.043; SR: $\chi^{2(6)}$=13.167, p=0.040) physical activity levels during the week post-race. However, no significant inter-group differences were identified. The second day following the race, both runner groups significantly increased the time spent at light intensity (FR: p=0.022, *d*=0.75; SR: p=0.001, *d*=0.37) and moderate intensity (FR: p=0.007, *d*=0.91; SR: p=0.005, *d*=0.85) compared to the first day post-race, although the magnitude of the observed changes ranged from small to moderate. SR did not evidence any other significant day-to-day change in their physical activity. Meanwhile, FR augmented the time spent at vigorous intensity the 5th day post-race (p=0.046, *d*=0.61), concomitantly reducing the time spent at moderate intensity (p=0.020, *d*=0.20), compared to the 4th day post-race.

***** Insert Table 2 near here *****

Friedman analyses revealed significant differences between FR and SR in CK (FR: $\chi^{2(3)}$=30.496, p<0.001; SR: $\chi^{2(3)}$=41.612, p<0.001), LDH (FR: $\chi^{2(3)}$=29.630, p<0.001; SR: $\chi^{2(3)}$=48.867, p<0.001) and CRP (FR: $\chi^{2(3)}$=30.209, p<0.001; SR: $\chi^{2(3)}$=44.333, p<0.001) during the week post-race. CK remained significantly and largely elevated compared to baseline values at 3 days post-race (FR: p=0.002, *d*=1.26; SR: p<0.001, *d*=1.07 respectively), but not at 7 days post-race (**Figure 1A**). Moreover, CK concentration was largely higher in FR compared to SR at 3 days post-race (p<0.012, *d*=1.17). LDH kept significantly and moderately to largely increased at 7 days post-race (FR: p=0.005, *d*=1.08; SR: p=0.020, *d*=0.63 respectively) (**Figure 1B**). In addition, LDH values were largely higher in FR compared to SR at 3 and 7 days post-race (p=0.005, *d*=1.01; p<0.015, *d*=1.05 respectively). CRP remained significantly and largely increased 7 days post-race (FR: p=0.001, *d*=2.09; SR: p<0.001, *d*=1.01 respectively) (**Figure 1C**). No significant differences were observed in CRP at any time point between FR and SR.

***** Insert Figure 1 near here *****

The results from Spearman correlation analyses are presented in **Table 3.** A negative correlation was observed between the time performing light physical activities and CRP at 3 days post-race (r_s=-0.40, p=0.025). No other significant association was found between the time spent at each intensity level of physical activity and biomarkers concentrations (CK, LDH and CRP) at 3 and 7 days post-race. No significant relationships were identified between biomarkers levels and training-related data, age and body mass index (BMI). Conversely, moderate to large significant associations were found between race time and muscle damage biomarkers at 3 days post-race

(CK: r_s=-0.41, p=0.017; LDH: r_s=-0.52, p=0.002) and at 7 days post-race (CK: r_s=-0.36, p=0.039; LDH: r_s=-0.46, p=0.007). On the other hand, female sex was moderately correlated with lower CK values at 7 days post-race (r_s=0.35; p=0.048).

***** Insert Table 3 near here *****

4. Discussion

The present study was aimed at exploring whether the evolution of muscle damage and inflammatory response biomarkers during the week following a MUM is related with race performance and post-race physical activity. Contrary to our expectations, the results showed that muscle damage recovery is quicker in SR compared to FR, while a lack of relationship was found between post-race physical activity and the recovery rate of muscle damage and inflammatory response.

CK and LDH returned to baseline values within 5 and 9 days following a 166km MUM, whereas CRP remained higher at 9 days post-race (5). Three days after a 111-km MUM, CK, LDH and CRP remained elevated compared to baseline values (9). Our results showed that CK levels returned to baseline between 3 and 7 days after the race, while LDH and CRP kept significantly increased compared to pre-race values 7 days post-race. Following a road marathon, CK and LDH were reported to return to pre-race values 6 and 8 days after the race, respectively; while CRP remained above baseline values the 8th day post-race (15). Following an Ironman triathlon, CRP remained significantly elevated up to 19 days after the competition (22). Hence, in light of previous findings and ours, it seems that inflammatory response takes longer to normalize following ultraendurance competitions, while muscle damage biomarkers return earlier to pre-race values.

On the other hand, a recent scoping review, focused on discussing the relevance of physical activities performed by athletes on their recovery, highlighted the necessity of performing more descriptive researches in different athlete populations (13). The results of the present study showed a very heterogeneous pattern of physical activity (as evidenced by the large variability in the time spent at each intensity level) in recreational runners following a MUM. Nevertheless, we noted a significant and large increase in moderate physical activity intensity from the first to the second day after the race, while from the second day post-race to the seven day post-race the distribution of daily physical activity intensities remained virtually unchanged. Total daily time at vigorous intensity was on average below 10 min until the 4th day post-race and between 10-20 min between the 5th and the 7th day post-race. Therefore, although some runners displayed outlying post-race physical activities in terms of effort intensity, the majority of our runners barely exercised at a vigorous intensity during the week following the race. Moreover, FR and SR showed similar post-race physical activities.

Post-race CK level has been described as the main determinant of the recovery rate in perceived muscle soreness and a 400 m run at maximal speed following a 161-km MUM (23). The authors from this study concluded that the most effective strategies to enhance post-MUM recovery would be the ones focused on attenuating the extent of muscle damage. We hypothesized that more active runners during the week after the race may show an accelerated recovery of muscle damage and inflammatory biomarkers. Our results did not corroborate this assumption. However, they are in accordance with a recent study where no differences were identified regarding muscle damage and inflammatory response restoration during the week after running a road marathon between those participants who performed elliptical training, running or complete resting (24).

On the other hand, FR displayed a more attenuated muscle damage recovery than SR. In fact, finishing time emerged as a more influencing factor than post-race physical activity regarding the recovery rate of muscle damage. Interestingly, a previous study also showed that LDH concentrations from 24 h to 192 h following a road marathon was inversely correlated with finishing time, while the acute inflammatory response was positively correlated with finishing time (15). Our results also showed that post-race CRP was moderately higher in SR compared to FR, although the difference was not statistically significant ($p=0.117$; $d=0.65$; **Figure 1C**). Finally, female sex relationship with lower CK values at 7 days post-race coincides with a previous study performed on Ironman triathletes (25). Notwithstanding, given the low number of women in our sample (n=5), this result should be obviously interpreted with caution. In fact, a recent review concluded that it remained unclear whether recovery from exercise-induced muscle damage differs between males and females (10).

There are some limitations in our study that should be acknowledged. Firstly, we assume that serum CK and LDH assess muscle membrane disruption and do not necessarily correlate well with muscle structural damage. Secondly, the addition of biomarkers of ion metabolism disorders and damage caused by energy loss would have given us a broader view of the acute physiological side effects and the recovery timeline following the race. Thirdly, we acknowledge that CRP is a non-specific indicator of inflammation, so it does not accurately reflect the inflammation of the muscle. Lastly, we assume that finishing time does not equate to physical fitness, but unfortunately we were unable to perform a cardiopulmonary exercise test at baseline.

5. Conclusions

In light of these findings, an appropriate recovery period after MUMs seems prudent and particularly important among faster runners, given that they showed higher levels of muscle damage at 3 and 7 days post-race. Moreover, race time was inversely correlated with muscle damage biomarkers at 3 days and 7 days post-race. Accordingly, exercise that could induce greater muscle damage should be avoided at least during the first 3 days following the competition. At the same time, the augmented inflammatory activity during the week post-race should not be overlooked. Notwithstanding, given that CRP is a non-specific indicator of inflammation, further studies are required to clarify whether this could affect immune competence, performance and fatigue. Neither competition and training background nor age displayed a relationship with muscle damage and inflammatory response restoration following the race. Lastly, our results evidenced a very heterogeneous pattern of physical activity in recreational runners following a MUM, so accelerometry is proposed as a suitable tool to monitor and consequently adjust athletes' physical activities following ultraendurance events.

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Conflicts of interest

The authors certify that there is no conflict of interest with any financial organization regarding the material discussed in the manuscript.

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Authors' contributions

All authors contributed equally to study design and data acquisition. Author A and C analyzed the data. Author A wrote the manuscript. Author B and D and E revised it critically. All authors have read and approved the final version of the manuscript, and agree with the order of presentation of the authors.

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399 **Table 1.** Characteristics of Faster and Slower runners (mean ± SD).

	Whole sample (n = 34)	Faster Runners (n = 15; 3 women)	Slower Runner (n = 19; 2 women)	**Faster vs Slower** **p-value**	**Cohen's D**
Age (years)	39 ± 7	38 ± 6	41 ± 9	0.157	0.41
BMI (kg/m^2)	24 ± 2.4	22.9 ± 1.8	24.8 ± 2.6	0.014	0.86
Number of races >100 km	3 ± 3	2 ± 3	4 ± 4	0.358	0.39
Weekly training days	5 ± 1	5 ± 1	4 ± 1	0.046	0.77
Weekly running volume (km)	66 ± 26	74 ± 19	61 ± 30	0.174	0.51
Weekly positive elevation (m)	1758 ± 844	2079 ± 980	1508 ± 644	0.071	0.73
Strength training (%)	44.1%	57.1%	36.8%	0.247	-

400 **Abbreviations:** BMI, Body Mass Index; Strength training (%), percentage of participants who performed at least one weekly strength-training in

401 the previous 3 months

Table 2. Physical activity during the week following the race (mean ± SD and range).

		Whole sample	Faster Runners	Slower Runners	**Faster vs Slower**	
		(n=34)	(n = 15)	(n = 19)	**p-value**	**Cohen's D**
Light Intensity Physical Activity (min)	**1st day post-race**	165 ± 158 (45 – 972)	150 ± 50 (92 – 256)	177 ± 211 (45 – 972)	0.356	0.19
	2nd day post-race	227 ± 166 (81 – 1029)	196 ± 74 (104 – 344) *	253 ± 214 (81 – 1029) **	0.518	0.39
	3rd day post-race	247 ± 167 (62 – 952)	230 ± 124 (62 – 445)	260 ± 198 (71 – 952)	0.953	0.19
	4th day post-race	262 ± 163 (84 – 897)	264 ± 123 (84 – 478) *	260 ± 194 (97 – 897)	0.597	0.02
	5th day post-race	239 ± 164 (63 – 911)	245 ± 114 (116 – 440)	233 ± 199 (63 – 911)	0.316	0.08
	6th day post-race	251 ± 147 (67 – 868)	252 ± 100 (87 – 418)	251 ± 180 (67 – 868)	0.681	0.01
	7th day post-race	225 ± 152 (3 – 883)	223 ± 98 (92 – 486)	227 ± 188 (3 – 883)	0.625	0.02
Moderate Intensity Physical Activity (min)	**1st day post-race**	12 ± 7 (1 – 25)	12 ± 6 (4 – 24)	11 ± 7 (1 – 25)	0.570	0.16
	2nd day post-race	48 ± 60 (1 – 232)	50 ± 60 (3 – 232) **	47 ± 61 (1 – 232) **	0.830	0.05
	3rd day post-race	46 ± 45 (0 – 156)	51 ± 50 (0 – 156)	42 ± 41 (1 – 156)	0.739	0.18
	4th day post-race	54 ± 43 (3 – 180)	60 ± 48 (3 – 180)	49 ± 39 (7 – 138)	0.468	0.26
	5th day post-race	46 ± 42 (1 – 156)	51 ± 49 (5 – 156) *	42 ± 36 (3 – 144)	0.984	0.20
	6th day post-race	64 ± 54 (4 – 190)	68 ± 59 (9 – 190)	60 ± 52 (4 – 178)	0.830	0.15
	7th day post-race	69 ± 75 (0 – 301)	67 ± 77 (1 – 301)	71 ± 76 (0 – 301)	0.953	0.06
	1st day post-race	2 ± 7 (0 – 41)	1 ± 2 (0 – 9)	2 ± 10 (0 – 41)	0.984	0.27

Vigorous Intensity Physical Activity (min)	**2nd day post-race**	3 ± 8 (0 – 32)	2 ± 6 (0 – 24)	3 ± 9 (0 – 32)	0.830	0.13
	3rd day post-race	4 ± 10 (0 – 40)	3 ± 7 (0 – 22)	5 ± 12 (0 – 40)	0.953	0.25
	4th day post-race	6 ± 13 (0 – 44)	5 ± 12 (0 – 36)	7 ± 15 (0 – 44)	0.653	0.19
	5th day post-race	13 ± 24 (0 – 81)	18 ± 30 (0 – 81) *	8 ± 18 (0 – 62)	0.518	0.41
	6th day post-race	12 ± 24 (0 – 113)	3 ± 7 (0 – 24)	19 ± 30 (0 – 113)	0.138	0.77
	7th day post-race	19 ± 40 (0 – 153)	25 ± 42 (0 – 153)	15 ± 38 (0 – 153)	0.493	0.26

* Significantly different from the preceding day (p<0.05); ** Significantly different from the preceding day (p<0.01)

Table 3. Results from Spearman correlation analyses (r/p)

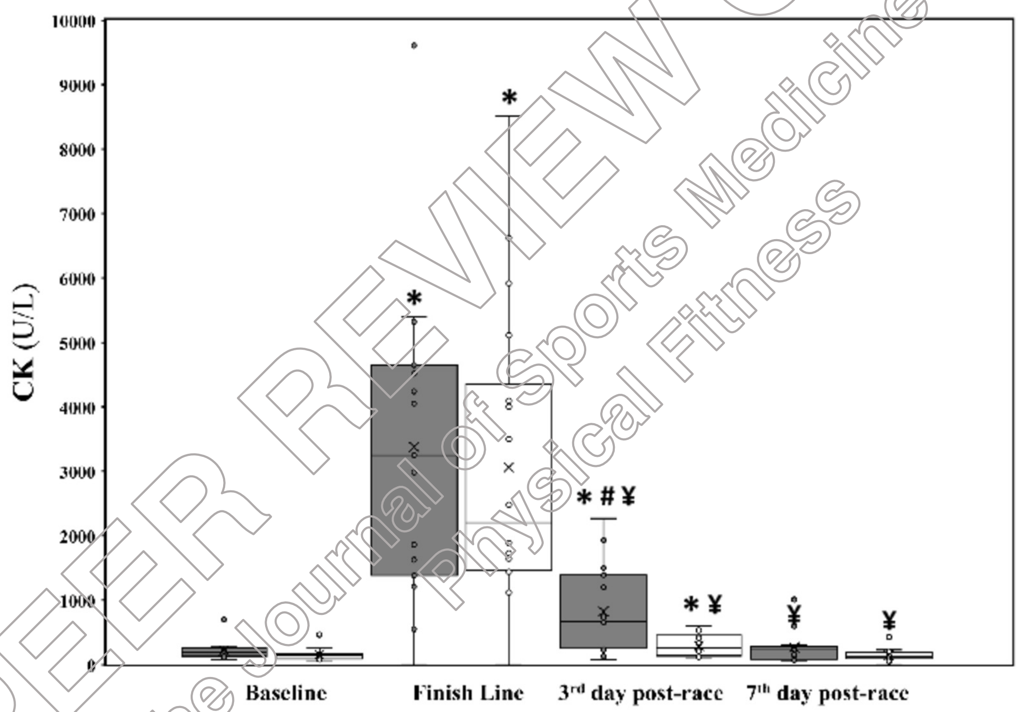
	3rd day post-race			7th day post-race		
	CK	**LDH**	**CRP**	**CK**	**LDH**	**CRP**
Sex	-0.165 / 0.351	0.072 / 0.686	0.220 / 0.211	-0.346 / 0.048 *	-0.009 / 0.961	0.049 / 0.787
Age	0.086 / 0.630	0.071 / 0.689	0.098 / 0.582	-0.057 / 0.753	0.012 / 0.949	0.141 / 0.453
Race time	-0.408 / 0.017 *	-0.519 / 0.002 **	-0.314 / 0.070	-0.361 / 0.039 *	-0.464 / 0.007 **	-0.191 / 0.288
BMI	-0.124 / 0.492	-0.297 / 0.093	-0.071 / 0.696	-0.123 / 0.502	-0.270 / 0.135	0.090 / 0.624
Number of races >100 km	0.129 / 0.473	0.156 / 0.384	0.059 / 0.743	-0.052 / 0.779	0.171 / 0.349	-0.063 / 0.734
Weekly training days	-0.046 / 0.800	0.090 / 0.616	0.182 / 0.311	-0.104 / 0.571	-0.041 / 0.826	0.064 / 0.729
Weekly running volume (km)	0.057 / 0.754	0.128 / 0.477	-0.053 / 0.770	0.052 / 0.779	0.011 / 0.952	-0.067 / 0.715
Weekly positive elevation	0.128 / 0.487	0.214 / 0.240	0.173 / 0.344	0.143 / 0.451	0.235 / 0.203	0.193 / 0.299
Strength training	0.096 / 0.596	-0.118 / 0.512	-0.297 / 0.093	0.302 / 0.093	0.027 / 0.883	-0.204 / 0.263
LIGHT_3d	-0.032 / 0.864	0.227 / 0.220	0.401 / 0.025 *	-	-	-
MOD_3d	-0.051 / 0.785	0.203 / 0.273	0.280 / 0.128	-	-	-
VIG_3d	0.057 / 0.762	0.030 / 0.873	0.016 / 0.931	-	-	-
LIGHT_7d	-	-	-	0.174 / 0.357	0.204 / 0.279	0.228 / 0.226
MOD_7d	-	-	-	0.154 / 0.417	0.089 / 0.639	0.091 / 0.631
VIG_7d	-	-	-	0.232 / 0.217	0.103 / 0.588	0.141 / 0.458

Abbreviations: CK, Creatine Kinasa; LDH, Lactate dehydrogenase; CRP, C-reactive protein; LIGHT_3d, total time spent at light intensity level during the first 3 days following the race; MOD_3d, total time spent at moderate intensity level during the first 3 days following the race; VIG_3d, total time spent at the highest three intensity levels of physical activity (vigorous, very vigorous and extremely vigorous) during the first 3 days following the race; LIGHT_7d, total time spent at light intensity level from the 3rd day to the 7th day following the race; MOD_7d, total time spent at moderate intensity level from the 3rd day to the 7th day following the race; VIG_7d, total time spent at the highest three levels of physical activity (vigorous, very vigorous and extremely vigorous) from the 3rd day to the 7th day following the race. * $p<0.05$ ** $p<0.01$

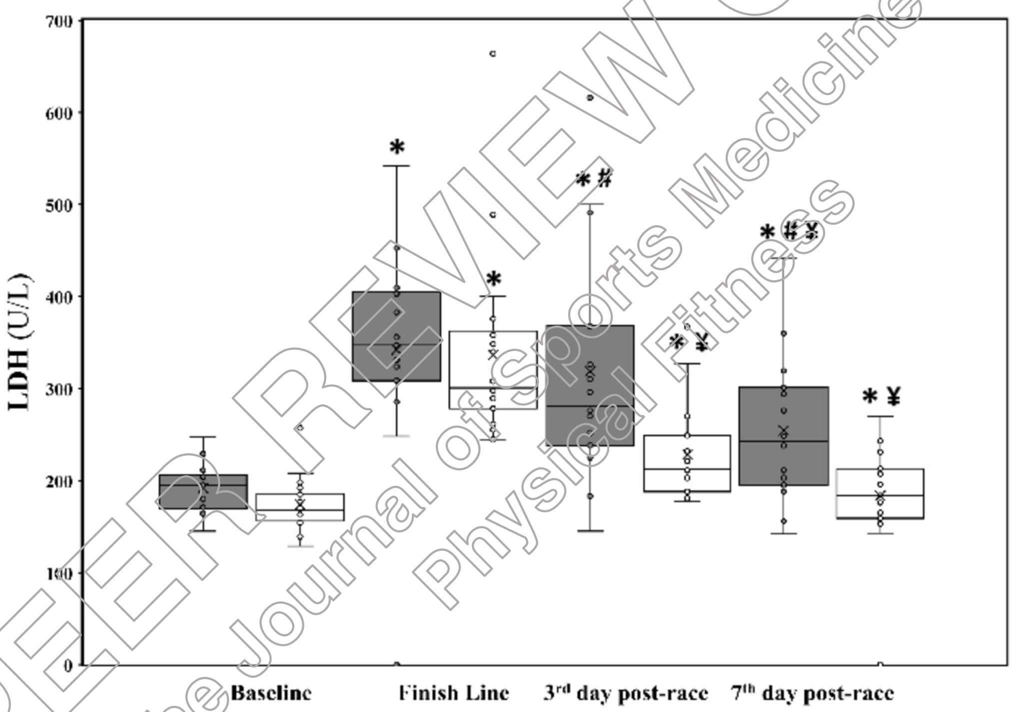
Figure legend

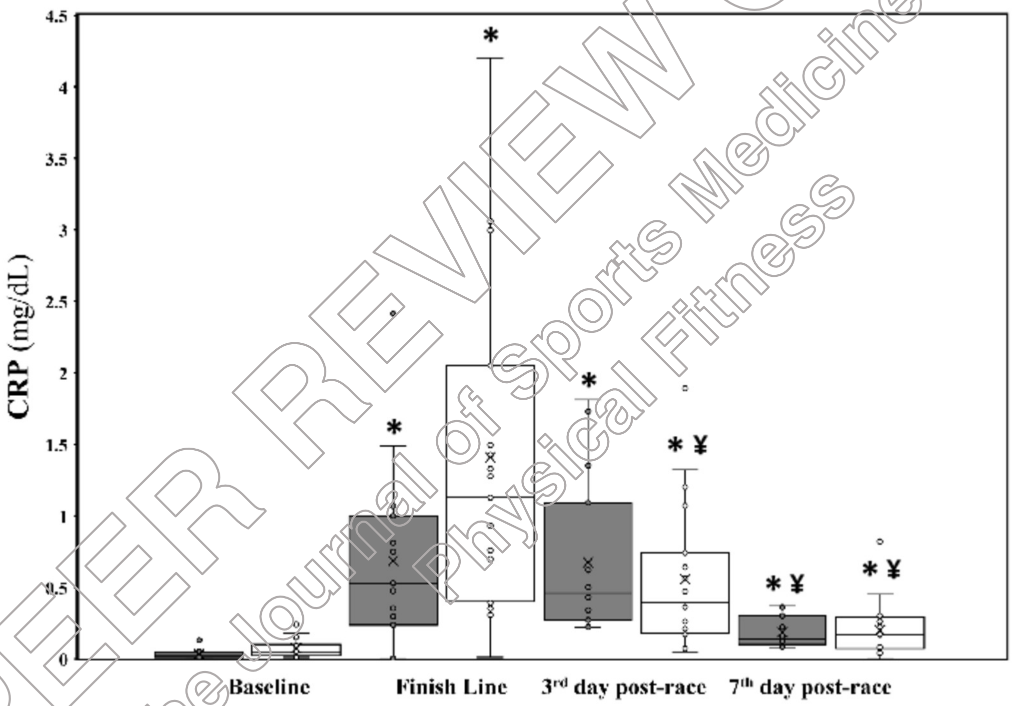
Figure 1. CK (panel A), **LDH** (panel B) **and CRP** (panel C) **evolution from pre-race to 7 days following the MUM in FR** (grey boxes) **and SR** (white boxes)

Abbreviations: CK, Creatine Kinasa; LDH, Lactate dehydrogenase; CRP, C-reactive protein; FR, Faster runner; SR, Slower runners. * Significantly different from baseline ($p<0.05$); # Significantly different from slower runners ($p<0.05$); ¥ Significantly different from the preceding time point ($p<0.05$)



CK (U/L)
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
*
*
* # ¥
* ¥
¥
¥
Baseline
Finish Line
3rd day post-race
7th day post-race


LDH (U/L)
700
600
500
400
300
200
100
0
*
*
* #
* ¥
* # ¥
* ¥
Baseline
Finish Line
3rd day post-race
7th day post-race


CRP (mg/dL)
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
*
*
*
* ¥
* ¥
* ¥
Baseline
Finish Line
3rd day post-race
7th day post-race