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Ultra Pirineu 2017: Characteristics of elite and non-elite runners and effects on health of a mountain marathon: Serialmed-UP pilot study



Joan Carles Trullàs^{a,b,c,*}, Emma Roca^{c,d}, Albert Guillermo^c, Llorenç Bové^c, Jordi Gibert^{c,e}

^a Servei de Medicina Interna, Hospital d'Olot, Olot, Girona, Spain

^b Departament de Ciències Mèdiques, Universitat de Girona, Girona, Spain

^c Serialmed LAB, S.L., Spain

^d Universitat Politècnica de Catalunya, Barcelona, Spain

^e Unitat de Medicina i Traumatologia de l'Esport, COT CAT, Àptima Centre Clínic, Spain

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Abstract

Introduction: There is an increase in the number of participants in long distance races as well as the interest in knowing their effects on health. Our main objective is to analyse the characteristics of mountain marathon runner, its effects on health and whether there are differences between elite and non-elite runners.

Methods: The Serialmed-UP is a pilot, observational (cohort) prospective study carried out at the Ultra Pirineu Marathon 2017. A survey of health, nutrition and training habits was carried out among non-élite runners. Clinical and analytical variables were measured before and after the race. A descriptive and comparative study was performed between results before and after the race and among élite and non-élite runners.

Results: 29 runners participated in the study, 22 non-élite and 7 élite. The non-élite were mostly men with a median age of 39 years-old, with good cardiovascular health (90.9% with recent medical check-ups), with a high load of training (professional counselling in 72.7%) and good eating habits (counselling in 54.5%). Before the race, there were no clinical or analytical alterations but 33.3% had alterations in the ECG. The most notable findings after the race were weight loss (3% of body weight), acute renal failure (66.7%) and alterations in sodium (44%), being these alterations more significant in non-élite runners.

Conclusions: Long distance races have an impact on runners' health, especially among non-élite runners. We need more research in order to offer personalised recommendations based on scientific evidence.

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* Corresponding author.

E-mail address: jctv5153@comg.cat (J.C. Trullàs).

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PALABRAS CLAVE

Correr;
Resistencia física;
Ejercicio

Ultra Pirineu 2017: características de los corredores de élite y de no élite y efectos sobre la salud de una maratón de montaña: estudio piloto Serialmed-UP**Resumen**

Introducción: Incremento del número de participantes en carreras de larga distancia, así como el interés por conocer sus efectos sobre la salud. El objetivo principal es analizar las características de los corredores de una maratón de montaña, sus efectos sobre la salud y si existen diferencias entre los corredores de élite y de no élite.

Métodos: El estudio Serialmed-UP es un estudio piloto, observacional, de cohortes prospectivo que se realizó en la Maratón Ultra Pirineu 2017. Se realizó una encuesta sobre hábitos de salud, alimentarios y de entrenamiento a los corredores de no élite. Se midieron las variables clínicas y analíticas antes y después de la carrera. Se realizó un estudio descriptivo y comparativo entre resultados antes y después de la carrera entre corredores de élite y de no élite.

Resultados: Participaron 29 corredores, 22 de no élite y 7 de élite. Los de no élite son principalmente varones de mediana edad de 39 años, con buena salud cardiovascular (el 90,9% con revisiones médicas recientes), con alta carga de entrenamientos (asesoramiento profesional en el 72,7%) y buenos hábitos alimentarios (asesoramiento en el 54,5%). Antes de la carrera no había alteraciones clínicas ni analíticas, pero el 33,3% presentaban alteraciones en el ECG. Los hallazgos más destacables post-carrera fueron pérdida de peso (3% del peso corporal), insuficiencia renal aguda (66,7%) y alteraciones en el sodio (44%), fueron más significativos en los corredores de no élite.

Conclusiones: Las carreras de larga distancia tienen repercusión en la salud de los corredores, sobre todo en los de no élite. Es necesario realizar más investigaciones para poder aportar recomendaciones personalizadas basadas en la evidencia científica.

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Introduction

The prescription of physical exercise to prevent cardiovascular and non-cardiovascular mortality has been proven to be useful. Moderate aerobic exercise for a minimum of 30 min, 5 days a week, or vigorous exercise for 20 min, 3 days a week, is recommended to achieve these benefits. Physical exercise can also entail injury and risk but, overall, the benefits outweigh the risks.¹

Recent years have seen an increase in the number of people who run, and they are currently undertaking long distances such as marathons and ultramarathons. In many cases, the amount and intensity of training and competitions far outweigh the recommendations for maintaining good health.² In parallel, there is some concern as to the constraints that exercising entail and whether they are the same for everyone.³ Therefore there is increased interest in exploring the effects of high duration and intensity exercise on health, and whether there is an upper limit at which the harmful effects of physical exercise might outweigh its benefits.

Serialmed-UP is a pilot study with the principal aim of analysing the characteristics of a group of mountain marathon runners, the immediate effects of the race on their health and whether there are differences between elite and non-elite runners. The secondary aim is to explore whether implementing ongoing health measures is helpful in improving runners' awareness and preparedness in order to prevent risks to their health in the future.

Material and methods**Design and scope of the study**

Serialmed-UP is an observational cohort prospective study. The main objectives of the company Serialmed LAB S.L. are to research the effects of sport on health and promote healthy lifestyle habits.⁴ The scope of the study was the Ultra Pirineu (UP) mountain marathon that took place in the municipality of Bellver de Cerdanya on 23 September 2017. The marathon comprised a mountain run of 45 km with a positive vertical drop of 2400 m.⁵

Selection of participants and data compilation

To select participants, runners were sent an email (*via* the organiser), explaining the pilot study and encouraging them to take part voluntarily. The data compilation for the study was divided into two parts. First, a few weeks before the race, a survey on health, dietary and training habits was sent by email. The second part entailed clinical and analytical measurements the evening before the race (pre-race) and immediately after the finish line (post-race) within a maximum interval of 15 min. The order of systematic data collection order was as follows: first, the runner was weighed on a calibrated scale (with shorts and socks and before any fluid intake), then their blood pressure (BP), heart rate and oxygen saturation seated in an armchair

were taken, and finally an electrocardiogram (ECG) at rest was performed and venous blood taken with the runner lying down on a stretcher.

Study variables

The survey sent by email in the first part of the study included the following variables: demographic, anthropometric, medical history and cardiovascular risk factors, training and dietary habits. The degree of adherence to a Mediterranean diet was assessed within the dietary habits, since it is currently considered the diet with the greatest benefits in terms of primary cardiovascular disease prevention. The Predimed test was used. This is a validated instrument comprising a set of 14 short questions scored between 0 and 14 points and classifying the degree of adherence as low (<7 points), intermediate (7–10 points) or high (10–14 points).⁶

The variables collected in the second part of the study (before and after the race) were as follows: clinical variables (weight, BP, heart rate and oxygen saturation), ECG at rest and blood test variables (haemoglobin, haematocrit, venous blood gas, blood sugar, creatinine, lactate, sodium, potassium, ionic calcium and chloride). The "epoc Host2®" system from Alere™ was used for the blood analyses, which enables immediate results without the need to process and transport blood samples.⁷ Any increase in serum creatinine of 0.3 mg/dl or above (or an increase of 50% or above of baseline) between the level before and after the race was considered acute kidney failure.⁸

All the volunteers who participated in the study read and signed their informed consent before any tests were performed.

Statistical methodology

The Shapiro–Wilks test was used to determine whether the quantitative variables followed a normal distribution. The quantitative variables were expressed in medians and interquartile range, and the qualitative variables as numbers and percentages. Pearson's χ^2 test was used to compare the qualitative variables. The Student's *t*-test was used to compare the quantitative variables for independent samples, and the Student's *t*-test for paired samples to compare the quantitative variables before and after the race. Non-parametric tests were used such as the Mann–Whitney *U* test to perform these comparisons in the event of distribution that was not normal. A *p* value below .05 was considered statistically significant.

Results

A total of 29 runners took part in the Serialmed-UP study, 22 non-elite and 7 elite. Twenty-two non-elite runners took part in the first part of the study (survey), and 18 non-elite runners and 7 elite runners took part in the second part of the study (measurements before and after the race). It was possible to obtain blood samples from 9 runners, 6 non-elite and 3 elite.

Table 1 Descriptive results of the survey conducted on non-elite runners.

<i>Variable^a</i>	
Number of participants	22
<i>Demographic data</i>	
Males	18 (81.8%)
Age (years)	39.2 (7.9)
Height (m)	1.7 (0.1)
<i>Smoking</i>	
Active smoker	1 (4.5%)
Ex-smoker	8 (36.4%)
Never smoked	13 (59.1%)
<i>Cardiovascular risk factors</i>	
High blood pressure	1 (4.5%)
Diabetes mellitus	0 (0%)
Hypercholesterolaemia	1 (4.5%)
Family history of cardiovascular disease	7 (31.8%)
<i>Medical check</i>	
In the past two years	20 (90.9%)
Electrocardiogram	19 (86.4%)
Stress test	19 (86.4%)
Echocardiogram	9 (40.9%)
Spirometry	9 (40.9%)
Blood test	13 (59.1%)
<i>Training</i>	
Exercising for more than 10 years	13 (59.1%)
Exercising for between 2 and 10 years	9 (40.9%)
Exercising for days each week	5.5 (1.0)
Exercising for hours each week	12.0 (7.2)
Professional advice	16 (72.7%)
<i>Sports</i>	
Swimming	5 (22.7%)
Running	20 (90.9%)
Cycling	12 (54.5%)
Triathlon	2 (9.1%)
Gym	9 (40.9%)
Football, handball or basketball	3 (13.6%)
Tennis or paddle tennis	3 (13.6%)
<i>Diet</i>	
Dietary advice	12 (54.5%)
Dietary supplements	14 (63.6%)
Fluid intake during training (water/isotonic drinks)	9 (40.9%)/13 (59.1%)
Adherence to Mediterranean diet (score) ^b	9.0 (2.0)
Adherence: low/intermediate/high ^b	1 (4.5%)/18 (81.8%)/3 (13.6%)

^a The quantitative variables are presented as medians and interquartile range and the qualitative variables as numbers and percentages.

^b The Predimed questionnaire consists of 14 short questions scored between 0 and 14 points, classifying the level of adherence as low (<7 points), intermediate (7–10 points) or high (10–14 points).

Table 1 shows the results of the first part of the study in detail with the characteristics of the non-elite runners. In summary, more males participated in the study, with a mean age of almost 40 and in good cardiovascular health, of whom 4.5% were active smokers and 36.4% ex-smokers. Most of the participants had undergone a medical check and complementary examinations within the two previous years. With regard to training, most had exercised for years, trained for many days each week and frequently had professional counselling. The training disciplines were varied, running being the most common. Finally, with regard to dietary habits, more than 50% had professional counselling and adherence to a Mediterranean diet was intermediate or high in a high proportion of the runners.

Table 2 describes the results of the measurements before and after the race, and the comparison between the elite and the non-elite runners. Overall, we can see that there were no significant alterations in the clinical variables and analyses before the race. The most relevant alterations were as follows: a third of the participants had some alteration on the ECG before the race (in particular incomplete right branch block (IRBB) of the bundle of His, 4 cases (44%) had sodium alterations after the race (particularly hypernatraemia) and almost two thirds had signs of acute kidney failure. Furthermore, it was observed that most of the runners lost weight during the race - close to 3% of their body weight. We found some differences when we compared these results between the elite and the non-elite runners (not all of them statistically significant): the elite runners were younger, finished the race in a faster time, weighed less and lost less weight during the race. In terms of vital signs, the elite runners had higher levels of saturation and lower BP and heart rate compared to the non-elite runners, and the elite runners had a higher proportion of IRBB on the ECG. Some differences were found on the blood analyses as well (not all statistically significant): the elite runners had higher baseline lactate levels, and lower ionic calcium, haemoglobin, haematocrit and blood sugar levels.

When we compared the results before and after the race (**Table 3**), we observed that all the runners had significant weight loss, decreased oxygen saturation and increased heart rate. We also observed some essential changes in the blood analyses; the most significant were increases in potassium, lactate and creatinine. There were also increases in haemoglobin and haematocrit, which were not statistically significant. When the differences before and after the race were analysed stratifying the result into elite and non-elite runners, some relevant differences were also observed. Thus, the weight loss and rise in lactate and creatinine were only statistically significant in the non-elite runners. In contrast, the increased potassium after the race was only significant in the elite runners.

Discussion

Serialmed-UP is a pilot study that included 29 mountain marathon runners, which enabled us to study, on the one hand, their health, training and nutrition habits and, on the other, any immediate alterations to their health, and finally we were able to examine whether there were any differences between the elite and the non-elite athletes.

The non-elite runners were around 40 years of age, and overall, had better health, and good dietary and training habits. They showed no alterations in the baseline variables analysed on the day before the race. This is positive and should be maintained for all non-elite runners wishing to take part in a mountain marathon. It is likely that these results cannot be applied to other non-elite runners. It is possible that the fact that participation in the study was voluntary enabled the selection of individuals who were more concerned about their health and consequently had better habits. It would be useful to analyse a greater number of non-elite runners (chosen randomly and not on a voluntary basis) to determine whether the same results are reproduced.

The fact that the great majority of the participants had undergone a medical check-up within the previous two years⁹ highlights their awareness of sports safety and might encourage sports' test organisers to recommend or even demand certificates of fitness in order to participate in competitive events.

A high proportion (near 30%) of the sportspeople showed IRBB on their ECG in the baseline tests before the race, and was more common in the elite runners than the non-elite runners. Complete right branch block is an electrocardiographic alteration that presents above all in older individuals (over 50 years of age) and is rare in those aged under 30 (estimated prevalence of 0.2%).¹⁰ By contrast, IRBB is a more frequent finding in healthy and younger individuals, with estimations of prevalence of up to 13.5% in some studies.¹¹ IRBB in athletes has been described frequently (between 9% and 24% according to the series) and together with early repolarisation and sinus bradycardia, is considered a benign disorder and a marker of physiological and structural adaptation to intense physical exercise.¹²⁻¹⁴

With regard to weight, almost 90% of the participants had lost some weight after the race, this was more frequent in the non-elite runners, even when this difference was not statistically significant. Almost 3% of body weight was lost and was also more frequent in the non-elite runners. Dehydration (loss greater than 2% of body weight as water) might degrade the performance of aerobic exercise, especially in hot environments. The greater the dehydration, the higher the physiological effort and the poorer the performance during aerobic exercise. A reduction in total available body water results in a reduction of total volume, systolic volume and cardiac output.¹⁵ Dehydration (whether hypo, hyper or isotonic) can entail symptoms after a 1% loss of body weight (malaise, muscle weakness, etc.) and can even result in death if it increases to around 8%-10%. Thirst is not a completely reliable indicator of dehydration, since it occurs when weight loss has reached 1%-3%, therefore runners should be aware of this fact and drink even if they are not thirsty during the race.¹⁶

A large proportion of runners showed altered kidney function and electrolytes after the race, two thirds showed elevation of creatinine with signs of acute kidney failure and 44% altered sodium, particularly hypernatraemia. These alterations are common and well described in the literature; it has been suggested that they are occasionally present before starting the competition.¹⁷ None of the participants in this study had altered renal function or natraemia the day before the race, which indicates that these alterations

Table 2 Descriptive results of the measurements before and after the race and comparative results between the elite and the non-elite runners.

Variables ^a	Total	Élite	No élite	<i>p</i>
Number	25	7 (28%)	18 (72%)	
<i>Demographic data</i>				
Males	21 (84%)	5 (71.4%)	16 (88.9%)	0.29
Age (years)	37.3 (12.2)	30.8 (15.2)	37.5 (9.6)	0.23
<i>Race times</i>				
Finisher	23 (92%)	6 (85.4%)	17 (94.4%)	0.47
Race time (hours)	6.2 (2.1)	4.6 (1.5)	6.3 (1.3)	<0.001
Speed (km/h)	7.3 (2.5)	10.9 (2.8)	7.1 (1.5)	<0.001
<i>Weight N = 19</i>				
Weight before the race (kg)	69.4 (14.2)	60.0 (16.0)	72.0 (12.7)	0.001
Weight after the race (kg)	66.9 (12.8)	56.7 (12.6)	71.7 (8.7)	0.001
Difference in weight (kg)	-1.9 (1.4)	-1.5 (1.8)	-2.1 (1.5)	0.32
Weight loss	17 (89%)	5 (83.3%)	12 (92.3%)	0.55
% of weight loss	-2.8 (1.9)	-2.7 (3.3)	-3.0 (1.9)	0.78
<i>Vital signs</i>				
Oxygen saturation (%) before the race	98 (2)	99 (1)	98 (1)	0.003
Oxygen saturation (%) after the race	96 (4)	95 (5)	96 (4)	0.37
Heartbeat (bpm) before the race	64 (16)	58 (10)	72 (16)	0.05
Heartbeat (bpm) after the race	97 (19)	93 (8)	103 (21)	0.25
Systolic BP (mmHg) before the race	128 (10)	122 (17)	128 (14)	0.02
Systolic BP (mmHg) after the race	110 (15)	116 (16)	110 (22)	1.00
Diastolic BP (mmHg) before the race	79 (13)	74 (12)	81 (17)	0.44
Diastolic BP (mmHg) after the race	75 (12)	76 (14)	75 (14)	0.64
<i>Electrocardiogram N = 21</i>				
Normal	14 (66.7%)	3 (42.9%)	11 (78.6%)	0.11
Incomplete right branch block	6 (28.6%)	4 (57.1%)	2 (14.3%)	
Ventricular overload	1 (4.8%)	0 (0%)	1 (7.1%)	
<i>Blood test N = 9</i>				
pH before the race	7.36 (0.02)	7.36 (0.03)	7.36 (0.03)	1.00
pH after the race	7.38 (0.03)	7.38 (0.03)	7.38 (0.03)	0.50
pCO ₂ before the race (mmHg)	51.7 (5.1)	51.6 (2.5)	52.4 (6.3)	0.79
pCO ₂ after the race (mmHg)	40.6 (7.1)	44.2 (5.1)	40.4 (5.6)	0.74
pO ₂ before the race (mmHg)	25.6 (6.1)	22.7 (1.6)	27.5 (6.8)	0.18
pO ₂ after the race (mmHg)	25.4 (14.3)	25.2 (16.9)	25.8 (9.7)	0.61
HCO ₃ before the race (mmol/L)	29.4 (1.0)	29.2 (1.2)	29.6 (1.6)	0.13
HCO ₃ after the race (mmol/L)	25.3 (2.9)	26.5 (1.5)	24.8 (6.5)	0.55
Na ⁺ before the race (mmol/L)	141 (2)	141 (0)	141 (4)	0.41
Na ⁺ after the race (mmol/L)	142 (6)	142 (4.5)	142 (7)	0.75
Hyponatraemia after the race	1 (11%)	0 (0%)	1 (16.7%)	0.45
Hypernatraemia after the race	3 (33%)	1 (33.3%)	2 (33.3%)	1.00
K ⁺ before the race (mmol/L)	3.9 (0.6)	3.8 (0.2)	4.1 (0.7)	0.51
K ⁺ after the race (mmol/L)	4.7 (0.4)	4.6 (0.2)	4.7 (0.6)	0.95
Ca ⁺ before the race (mmol/L)	1.1 (0.07)	1.1 (0.03)	1.2 (0.05)	0.005
Ca ⁺ after the race (mmol/L)	1.2 (0.06)	1.1 (0.02)	1.2 (0.07)	0.035
Chlorine before the race (mmol/L)	103 (4)	105 (1.5)	102 (4)	0.15
Chlorine after the race (mmol/L)	106 (4)	105 (1.5)	106 (5)	0.81
Haematocrit before the race	44 (6)	41 (4)	44 (5)	0.36
Haematocrit after the race	46 (8)	40 (6.5)	47 (5)	0.38
Haemoglobin before the race	14.9 (2.0)	13.8 (1.4)	15.2 (1.6)	0.27
Haemoglobin after the race	15.6 (2.8)	13.7 (2.1)	16.0 (1.9)	0.39

Table 2 (Continued)

Variables ^a	Total	Élite	No élite	<i>p</i>
Blood sugar before the race (mg/dl)	95 (14)	85 (16.5)	96 (13)	0.06
Blood sugar after the race (mg/dl)	90 (49)	90 (13)	89 (75)	0.63
Lactate before the race (mg/dl)	0.9 (0.6)	1.4 (0.28)	0.9 (0.3)	0.04
Lactate after the race (mg/dl)	2.6 (0.7)	2.3 (0.72)	2.7 (1.0)	0.22
Creatinine before the race (mg/dl)	0.9 (0.3)	0.8 (0.1)	0.9 (0.3)	0.13
Creatinine after the race (mg/dl)	1.5 (0.6)	1.2 (0.6)	1.6 (0.8)	0.39
Acute renal failure ^b	6 (66.7%)	2 (66.7%)	4 (66.7%)	1.00

^a The quantitative variables are presented as medians and interquartile range and the qualitative variables as numbers and percentages.

^b Acute renal failure is defined as an increase in serum creatinine of 0.3 mg/dl or more (or an increase of 50% or more of its baseline level) between the level before and after the race.

Abbreviations: BP: blood pressure; $p\text{CO}_2$: partial pressure of carbon dioxide; $p\text{O}_2$: partial pressure of oxygen; HCO_3^- : bicarbonate; Na^+ : sodium; K^+ : potassium; Ca^{2+} : calcium

directly relate to physical exercise. Normally this renal dysfunction is pre-renal in nature and secondary to volume depletion due to suboptimal hydration. The increased haemoglobin levels after the race (although not statistically significant) as a measure of haemoconcentration would confirm this hypothesis. Even so, the possibility of kidney failure in the absence of volume depletion has been described, and it has been posited that strenuous physical exercise may result in systemic disorders, including an inflammatory condition that *per se* might cause damage to the nephrons.¹⁸ Many of the biochemical alterations that have been described in relation to physical exercise are asymptomatic and transitory, but it is not known whether they might have a harmful effect on health in the long term.^{19–22} It would be desirable to know the recovery time of post-race alterations and be able to make recommendations as to when training and/or competing can be resumed.

It is important to observe how most of the differences between the levels before and after the race were only statistically significant in the non-elite runners, the weight loss, increased creatinine and increased lactate being noteworthy even when the baseline lactate levels (before the race) were higher in the elite runners. Blood lactate levels are a marker of the intensity of exercise,²³ and it is possible that the musculature of elite runners is better adapted to running and that they have far more developed lactate clearance, which might explain why their lactate increase after the race was lower than that of the non-elite runners.

We also observed a drop in blood sugar and haemoconcentration (increased haemoglobin and haematocrit) in the non-elite runners, although neither finding was statistically significant. Thus, the non-elite runners, despite apparently retaining their baseline characteristics (health status, training and diet), had more alterations after the race than the elite runners. It is likely that their level of training, diet and rest, and the fact that they required far longer to complete the race than the elite runners contributed, in part, to these findings.

The results of the Serialmed-UP study enable us to examine the practical applicability of a work model that combines assistance and research. Assistance would imply an analysis of the health and training habits of the athlete, with the potential to make immediate recommendations. Research through obtaining, accumulating and analysing data on the effects of endurance training on health, would enable us to make recommendations to athletes (both elite and non-elite) based on scientific evidence. A subjective yet positive perception of this study (by runners and researchers alike) was that the results were available immediately, which in turn enabled immediate recommendations. Significant alterations in the clinical and/or analytical parameters detected before the race would make it necessary to advise against taking part in the competition. Detecting alterations in the evaluations made after the race (as occurred in the study) enabled us to make recommendations *in situ* to be implemented over the following days (rest, hydration, repeat the tests in a few days, improved diet or training, etc.) and for future competitions (improving hydration while racing, for example).

We are aware that the Serialmed-UP study has limitations. Firstly, the size of the sample studied was small and does not enable the findings to be generalised. It is also likely that it did not enable more statistically significant differences to be demonstrated when comparing some variables, when in reality this should be the case. Furthermore, the participants were selected on a voluntary not a random basis from all the runners in the race, and this probably led to some selection bias. It is likely that those who decided to participate voluntarily in the study had different characteristics (motivation and habits) to those who did not wish to take part.

In conclusion, given the increased number of non-elite participants in long distance and endurance races, knowledge of the potential effects on health must be advanced, in order to offer recommendations based on scientific evidence.

Table 3 Comparative results of measurements before and after the race.

Variable ^a		Overall	<i>p</i>	Elite	<i>p</i>	Non-elite	<i>p</i>
Weight (kg)	Before	69.4 (13.2)	<0.001	58.3 (12.5)	0.056	72.5 (10.2)	<0.001
	After	66.9 (12.8)		56.7 (12.6)		71.7 (8.7)	
Oxygen saturation (%)	Before	98 (2)	0.001	99 (1)	0.02	98 (1)	0.02
	After	96 (4)		95 (5)		96 (4)	
Heartbeat (bpm)	Before	64 (16)	<0.001	58 (10)	<0.001	72 (16)	<0.001
	After	97 (19)		93 (8)		103 (21)	
Systolic BP (mmHg)	Before	128 (10)	0.48	122 (17)	0.15	128 (14)	0.46
	After	110 (15)		116 (16)		110 (22)	
Diastolic BP (mmHg)	Before	79 (13)	0.05	74 (12)	0.79	81 (17)	0.03
	After	75 (12)		76 (14)		75 (14)	
pH	Before	7.36 (0.02)	0.06	7.36 (0)	0.21	7.35 (0.03)	0.25
	After	7.38 (0.03)		7.38 (0.03)		7.38 (0.03)	
pCO ₂ (mmHg)	Before	51.7 (5.1)	0.001	51.6 (2.5)	0.043	52.4 (6.3)	0.008
	After	40.6 (7.1)		44.2 (5.1)		40.4 (5.6)	
pO ₂ (mmHg)	Before	25.6 (6.1)	0.001	22.7 (1.6)	0.02	27.5 (6.8)	0.02
	After	25.4 (14.3)		25.2 (16.9)		25.8 (9.7)	
HCO ₃ (mmol/L)	Before	29.4 (1.0)	0.17	29.2 (1.2)	0.03	29.6 (1.6)	0.38
	After	25.3 (2.9)		26.5 (1.4)		24.8 (6.5)	
Na ⁺ (mmol/L)	Before	141 (2)	0.50	141 (0)	0.43	141 (4)	0.84
	After	142 (6)		142 (4.5)		142 (7)	
K ⁺ (mmol/L)	Before	3.9 (0.6)	0.006	3.8 (0.2)	0.04	4.1 (0.7)	0.07
	After	4.7 (0.4)		4.6 (0.2)		4.7 (0.6)	
Ionic Ca ⁺ (mmol/L)	Before	1.1 (0.07)	0.36	1.1 (0.03)	0.59	1.2 (0.05)	0.56
	After	1.2 (0.06)		1.1 (0.03)		1.2 (0.07)	
Chlor (mmol/L)	Before	103 (4)	0.13	105 (1.4)	0.53	102 (4)	0.17
	After	106 (4)		105 (1.5)		106 (5)	
Haematocrit	Before	44 (6)	0.18	41 (4)	0.73	44 (5)	0.21
	After	46 (8)		40 (6.5)		47 (5)	
Haemoglobin	Before	14.9 (2)	0.14	13.8 (1.4)	0.51	15.2 (1.6)	0.23
	After	15.6 (2.8)		13.7 (2.1)		16.0 (1.9)	
Blood sugar (mg/dl)	Before	95 (14)	0.55	85 (16.5)	0.41	96 (13)	0.75
	After	90 (49)		90 (13)		89 (75)	
Lactate (mg/dl)	Before	0.96 (0.6)	0.006	1.41 (0.28)	0.40	0.90 (0.3)	0.007
	After	2.58 (0.7)		2.27 (0.72)		2.69 (0.9)	
Creatinine (mg/dl)	Before	0.97 (0.3)	0.013	0.83 (0.09)	0.20	0.98 (0.3)	0.05
	After	1.49 (0.7)		1.23 (0.57)		1.58 (0.7)	

^a The quantitative variables are presented as medians and interquartile range

Abbreviations: BP: blood pressure; pCO₂: partial pressure of carbon dioxide; pO₂: partial pressure of oxygen; HCO₃: bicarbonate; Na⁺: sodium; K⁺: potassium; Ca⁺: calcium.

Conflict of interests

Authors declare that they don't have any conflict of interests.

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References

- Subirats Bayego E, Subirats Vila G, Soteras Martínez I. Exercise prescription: indications, dosage and side effects. *Med Clin (Barc)*. 2012;138:18–24.
- Schmied C. Paracelsus'' rediscovered: searching for the right dose of physical training. *Open Heart*. 2014;1:e000027.
- Parker-Pope T. Are marathons safe? *The New York Times*. Available from: <http://well.blogs.nytimes.com/2009/10/20/are-marathons-safe> [accessed 20.10.09].
- Serialmed LAB, S.L. Amb acces a: <http://serialmed.com>.
- Ultra Pirineu 2017. Amb acces a: <https://livettrail.net/histo/ultrapirineu.2017>.
- Estruch R, Ros E, Salas-Salvadó J, Covas MI, Corella D, Arós F, et al. Primary prevention of cardiovascular disease with a Mediterranean diet. *N Engl J Med*. 2013;368:1279–90.
- AlereTM. Amb acces a: <https://www.alere.com/es/home/area-of-interest/cardiovascular/blood-gases.html>.
- Kidney Disease: Improving Global Outcomes (KDIGO) Acute Kidney Injury Work Group. KDIGO clinical practice guidelines for acute kidney injury. *Kidney Int Suppl*. 2012;2:1–138.
- Consideracions per als professionals de la salut sobre l'avaluació del risc cardiovascular prèviament a la pràctica esportiva.

- Document de consens. Novembre de 2014. Generalitat de Catalunya. Departament de Salut.
10. Rotman M, Triebwasser JH. A clinical and follow-up study of right and left bundle branch block. *Circulation*. 1975;51:477.
 11. Kobza R, Cuculi F, Abächerli R, Toggweiler S, Suter Y, Frey F, et al. Twelve-lead electrocardiography in the young: physiologic and pathologic abnormalities. *Heart Rhythm*. 2012;9:2018.
 12. Kim JH, Noseworthy PA, McCarty D, Yared K, Weiner R, Wang F, et al. Significance of electrocardiographic right bundle branch block in trained athletes. *Am J Cardiol*. 2011;107:9–1083.
 13. Malhotra VK, Singh N, Bishnoi RS, Chadha DS, Bhardwaj P, Madan H, et al. The prevalence of abnormal ECG in trained sportsmen. *Med J Armed Forces India*. 2015;71:324–9.
 14. Drezner JA, Ackerman MJ, Anderson J, Ashley E, Asplund CA, Baggish AL, et al. Electrocardiographic interpretation in athletes: the 'Seattle Criteria'. *Br J Sports Med*. 2013;47:122–4.
 15. Wall BA, Watson G, Peiffer JJ, Abbiss CR, Siegel R, Laursen PB. Current hydration guidelines are erroneous: dehydration does not impair exercise performance in the heat. *Br J Sports Med*. 2013;0:1–8.
 16. Nutrición. En: Enric Subirats Bayego, director. *Manual de Medicina de Montaña y del Medio Natural basado en la evidencia*. Sección I. Capítulo 2. Páginas 15-37. Editorial Médica Panamericana, Madrid; 2017.
 17. Mohseni M, Silvers S, McNeil R, Diehl N, Vadeboncoeur T, Taylor W, et al. Prevalence of hyponatremia, renal dysfunction, and other electrolyte abnormalities among runners before and after completing a marathon or half marathon. *Sports Health*. 2011;3:145–51.
 18. McCullough PA, Chinnaiyan KM, Gallagher MJ, Colar JM, Geddes T, Gold JM, et al. Changes in renal markers and acute kidney injury after marathon running. *Nephrology (Carlton)*. 2011;16:194–9.
 19. Lippi G, Banfi G, Montagnana M, Salvagno GL, Schena F, Guidi GC. Acute variation of leucocytes counts following a half-marathon run. *Int J Lab Hematol*. 2010;32:117–21.
 20. Lippi G, Schena F, Dipalo M, Montagnana M, Salvagno GL, Aloe R, et al. Troponin I measured with a high sensitivity immunoassay is significantly increased after a half marathon run. *Scand J Clin Lab Invest*. 2012;72:467–70.
 21. Lippi G, Schena F, Montagnana M, Salvagno GL, Banfi G, Guidi GC. Significant variation of traditional markers of liver injury after a half-marathon run. *Eur J Intern Med*. 2011;22:e36–8.
 22. Kupchak BR, Volk BM, Kunces LJ, Kraemer WJ, Hoffman MD, Phinney SD, et al. Alterations in coagulatory and fibrinolytic systems following an ultra-marathon. *Eur J Appl Physiol*. 2013;113:12–2705.
 23. Cairns SP. Lactic acid and exercise performance: culprit or friend? *Sports Med*. 2006;36:279–91.