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ULTRA TRAIL PERFORMANCE IS DIFFERENTLY PREDICTED BY ENDURANCE VARIABLES IN MEN AND WOMEN

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Keywords: sex, ultraendurance, maximal oxygen uptake, ventilatory thresholds, maximal fat oxidation

1. Introduction

Ultra trail races (UT) have become extremely popular in recent years and the physiological and health consequences of performing such demanding efforts have increasingly awaken the interest of the scientific community [1, 2]. Additionally, trail running has recently been recognized by the World Athletics as a new running discipline hosting its own Trail World Championships [2]. It is therefore of interest for athletes and coaches to identify those factors that play a critical role in performance in order to improve training strategies and competition results. Previous studies have explored possible factors related with race time in trail running races ranging from 21 km to 75 km [3-8]. It remains unclear, however, whether the classical physiological variables of endurance running performance (i.e., maximal oxygen uptake, ventilatory thresholds) [9] hold for longer trail running races (i.e., >100 km). Moreover, the abovementioned studies were conducted in male samples and there is lack of investigations comparing performance factors in male and female athletes competing in ultramarathon races [10].

Indeed, controversy remains regarding the importance of running economy (i.e., energy demand for a given velocity of submaximal running) upon trail running performance [11, 12], with some authors reporting a correlation to race time [8, 13] while others do not [4-6]. In addition, the importance of substrate utilization is being increasingly emphasized to predict endurance performance [14, 15]. It is well known that human carbohydrate stores are limited and exogenous carbohydrate uptake cannot match utilization rates during prolonged endurance exercise, leading in turn to muscle and liver glycogen depletion and thus fatigue and decreased performance [16]. This has sparked interest into strategies to augment fat oxidation during endurance exercise to preserve endogenous carbohydrate stores [15, 17]. Yet, no previous research regarding trail running performance factors have examined whether fat metabolism keeps a significant relationship with race time, as it has been demonstrated for Ironman triathlon [16, 18].

The main aim of the present study was therefore to investigate whether the classical physiological variables of endurance running performance, as well as maximal fat oxidation capacity, were linked to performance in an UT race. Secondly, we wanted to assess whether the abovementioned relationships varied between male and female participants. Lastly, we were interested in exploring possible associations between body composition and race time. Our hypothesis were: (1) peak oxygen uptake, peak speed and speed at first and second ventilatory thresholds would be related with performance; (2) maximal fat oxidation capacity would be independently associated with performance in male but not in female athletes [16, 18].

2. Material and methods

2.1. Participants

Forty seven ultra-endurance athletes (29 men and 18 women) were recruited to participate in the study. This research was developed at the Penyagolosa Trails CSP race in 2019. The track consisted of 107.4 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 5604 and 4356 m respectively (**Figure 1**). Temperature at the start was 17.2°C and it ranged between 18 and 10.6°C at mid-race (km 66), and between 20.1 and 1.5°C at the finish line. All subjects were fully informed of the procedure and gave their written 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. The investigation was conducted according to the Declaration of Helsinki, it obtained the approval from the research Ethics Committee of the XXX (Expedient Number XXX) to be conducted and it met the ethical standards of the International Journal of Sports Medicine [19]. This study is enrolled in the ClinicalTrails.gov database, with the code number XXX (www.clinicaltrials.gov).

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

2.2. Body composition

Body Mass Index (BMI), percentage of fat mass (%FM) and percentage of lean body mass (%LBM) were evaluated using a bioelectrical impedance weight scale (Tanita BC-780MA, Tanita Corp., Tokyo, Japan). Measurements were performed in a fasted state (>6 h) with minimal clothing (i.e., running shorts and t-shirt), following the manufacturer's guidelines. The skin and the electrodes were cleaned and dried before testing.

2.3. Cardiopulmonary exercise test

Cardiopulmonary exercise tests (CPET) were performed on a treadmill (H/P/cosmos pulsar, H/P/cosmos sports & medical GmbH, Nussdorf-Traunstein, Germany) between 2 to 4 weeks prior to the race. Participants were asked to attend the laboratory in a fasted state (>6 h) and maintain their habitual mixed macronutrient diet the day before the test. Vigorous exercise was not allowed for 48 h before and no training was permitted for 24 h before. All these pre-trial standardisation measures were verbally checked with each participant at his/her arrival to the laboratory. Tests were performed in standard environmental conditions (room temperature between 20°C and 22°C) within the same time frame (between 16 PM and 18 PM). Pulmonary VO_2 and VCO_2 were measured breath-by-breath using an automated online system (Oxycon Pro system, Jaeger, Würzburg, Germany). Gas analysis system was calibrated for ambient temperature and humidity, air flow and VO_2 and VCO_2 concentrations (with a 4.96% CO_2 – 12.10% O_2 gas mixture) before each testing session according to manufacturer instructions [20]. After a 4 min warm up at 6 $km{\cdot}h^{-1}$, CPET protocol started at 8 $km{\cdot}h^{-1}$ and speed was increased 1 $km{\cdot}h^{-1}$ every 2 min. When subjects reached a respiratory exchange ratio (RER) > 1.0 increments of 1 $km{\cdot}h^{-1}$ were induced every minute until voluntary exhaustion. VO_2max values were accepted when a plateau (an increase of <2ml/kg/min) or a decline in VO_2 was reached despite increasing workloads and an RER above 1.15 was achieved. If this criteria was not met, a VO_2peak value was taken, defined as the highest VO_2 measured over a 30 seconds period. First and second ventilatory thresholds (VT_1 and VT_2) were determined using Skinner and McLellan [21] guidelines by two independent researchers. Peak speed (V_{peak}) Speed and percentage of VO_2peak at VT_1 and VT_2 (V_{VT1}, V_{VT2}, $\%VT_1$ and $\%VT_2$) were retained for statistical analysis. Subsequently, VO_2, VCO_2 and ventilation data were averaged over the last 60 s of each 2-min stages and stoichiometric equations described by Frayn [22] were used to calculate fat oxidation rates with the assumption that urinary nitrogen excretion was negligible. Fat oxidation rates were then plotted against the relative exercise intensity ($\%VO_2peak$) and a third-degree polynomial regression was used to determine maximal fat oxidation (MFO) and the exercise intensity eliciting MFO (FAT_{max}) for each participant [23].

MFO was normalized to lean body mass (mg/min/kg LBM). Finishing times were obtained from the official timer of the race (LiveTrail®, LiveTrail SARL, France).

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). Normality was checked using the Shapiro-Wilk test and all variables met normality assumptions. Possible sex differences in FAT_{max} and MFO were assessed using an independent samples Student's t-test. Pearson product-moment correlations were computed to assess whether the primary outcome, race time, was associated with body composition variables (BMI, %FM and %LBM) and CPET-derived variables (VO_2peak, V_{peak}, V_{VT1}, V_{VT2}, $\%VT_1$, $\%VT_2$, FAT_{max} and MFO). This analysis was carried out for the whole sample and for the men and women sample sets. The following criteria were adopted to interpret the magnitude of the correlations: $r \leq 0.1$, trivial; $0.1 < r \leq 0.3$, small; $0.3 < r \leq 0.5$, moderate; $0.5 < r \leq 0.7$, large; $0.7 < r \leq 0.9$, very large; and $r > 0.9$, almost perfect [24]. Afterwards, body composition and CPET-derived variables were entered as independent variables into a stepwise multiple regression analysis with race time as the dependent variable. This analysis was conducted on both the whole sample and the men and women sample sets. Additionally, using the percentage of winning time as a splitting variable, we divided the sample into faster and slower runners (i.e., below and above the mean value for our sample) and we also conducted the abovementioned analysis on those sample sets. Assumptions of linearity, normality, independence (Durbin-Watson statistic values were between 1.5 and 2.5), homoscedasticity and absence of collinearity (all VIF values were below 1.3) were checked in all the multiple regression analyses performed. The significance level was set at $p<0.05$ and data are presented as means and standard deviations (±SD).

3. Results

From the initial sample (47 athletes), 4 participants did not start the race due to injury and 32 athletes (19 men and 13 women) successfully completed the race. The finishers/starters ratio for the subjects of the present study (i.e. 74.4%) was similar to the ratio when all race participants were considered (73.8%). Male athletes' average finish time was 20 h 43 min ± 3 h 58 min, 174% of winning time; while females athletes' average finish time was 22 h 20 min ± 2 h 24 min, 157% of winning time. All levels of performance were represented in our sample, as shown by their rank ranging from 13th to 395th place (of 397 finishers) in male category, and from 7th to 32th place (of 47 finishers) in female category. Participant characteristics, including demographic information, training and competition history and data from the cardiopulmonary exercise test, are presented in **Table 1**.

**** Insert Table 1 and 2 near here ****

No significant sex differences were noted in MFO and FAT_{max}. Results from correlational analysis are depicted in **Table 2**. Both among men and women, %FM and %LBM were significantly and largely associated with race time. V_{VT1} was significantly correlated with performance in men and women, although the magnitude of the correlation was greater for the women sample set (very large vs moderate). V_{VT2} was significantly and very largely correlated with race time in both sexes. Conversely, neither in women nor in men %VT1 was associated with performance; whereas %VT2 was linked with race time only in the women sample set. VO_2peak was significantly correlated with performance in men and women, although the magnitude of the correlation was greater for the women sample set (very large vs large) (**Figure 2**). V_{peak} was significantly correlated with race time in both sexes, but the magnitude of the correlation was greater for the men sample set (very large vs large). Lastly, neither in women nor in men FAT_{max} was associated with performance, while MFO was largely correlated with race time in both sexes (**Figure 3**).

**** Insert Figure 2 and 3 near here ****

Results from multiple regression analysis are reported in **Table 3**. Considering the whole sample, V_{VT2} and MFO together explained 55% of the variation observed in race time (adj $R^2 = 0.549$; $F_{2,29} = 19.89$; $p<0.001$). For the men sample set, V_{peak} and MFO together explained 66% of the variation observed in race time (adj $R^2 = 0.658$; $F_{2,16} = 18.32$; $p<0.001$). Meanwhile, for the women sample set, VO_2peak was the only statistically significant variable explaining 69% of the variation in race time (adj $R^2 = 0.693$; $F_{1,11} = 28.14$; $p<0.001$). Lastly, when splitting the sample by relative race time, for the faster runners sample set, V_{peak} was the only statistically significant variable explaining 75% of the variation in race time (adj $R^2 = 0.748$; $F_{1,16} = 47.46$; $p<0.001$); while for the slower runners sample set, VO_2peak was the only statistically significant variable explaining 33% of the variation in race time (adj $R^2 = 0.326$; $F_{1,12} = 5.77$; $p=0.033$).

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

4. Discussion

The main finding of this study was that UT performance, both in men and women, was correlated with classical physiological variables of endurance running performance (V_{VT1}, V_{VT2}, V_{peak} and VO_2peak), as well as with MFO and body composition factors (%FM and %LBM). However, multiple regression analysis indicated that V_{VT2} and MFO explained 55% of the variation observed in all participants' race times. Regarding possible sex differences, men performance was independently predicted by V_{peak} and MFO; while VO_2peak was the only statistically significant variable explaining the variation in women's race times. The abovementioned regression models were able to explain 66% of the variation in men performance and 69% of the variation in women performance. Lastly, the magnitude of the correlation with performance of V_{VT1} and VO_2peak was larger among women; whereas the magnitude of the correlation with performance of V_{peak} was larger among men.

The significant association found between VO_2peak and performance coincides with most of previous research in the field [3, 5-7], although not all [8]. Besides, our results highlight a large association between race time and V_{VT1} and V_{VT2}. This relationship contrasts with two recent studies undertook in shorter trail races (i.e., 27 and 31 km), where authors found no correlation between race time and those two variables [3, 8]. However, it is in agreement with Fornasiero et al. [7], who showed that power output at VT_1 and VT_2 (in W/kg) was associated with performance in a 65-km trail race. Despite keeping in mind that correlation does not imply causation, our results suggest that the importance of submaximal parameters associated with exercise thresholds increases as competition length does, even though peak speed and oxygen uptake remain associated with performance in UT races.

On the other hand, in Ironman triathletes it has been shown that the relationship between MFO and performance is slightly stronger among women, as compared to men [16, 18]. However, when VO_2peak was integrated in the analysis, the abovementioned association in women disappeared, unlike the association in men. Authors showed that VO2peak was the only independent variable that predicted women performance. Our results matches with those previously published and extend it to the UT field. Moreover, as far as we are concerned, no study had previously compared the association of V_{VT1} with ultraendurance performance between men and women. The stronger relationship we found between race time and V_{VT1} in women, as compared with men, suggest it could be related with the lower absolute speed at which they performed the race. Notwithstanding, further studies in the field are required to clarify this assumption.

MFO values in our sample were largely higher than previously reported in male ultramarathon runners (12.85 ± 2.64 vs 7.3 ± 2.5 mg/min/kg LBM) [25]; and compared to previous studies in Ironman athletes [16, 18], values for male runners were also higher (12.85 ± 2.64 vs 9.05 ± 0.27 mg/min/kg LBM), whereas values for female runners were slightly lower (11.74 ± 3.58 vs 12.9 ± 0.5 mg/min/kg LBM). Interestingly, contrary to prior investigation [15, 16, 18], our results failed to show a higher MFO for female participants compared to male participants. Overall, our UT runners seem to possess a high fat oxidative capacity. Notwithstanding, differences in CPET protocol (cycling vs running; 2-min vs 3-min stages) and time frame of testing (morning vs afternoon) are known to affect MFO [23, 26].

On the other hand, as far as we are concerned, no previous studies have assessed the possible relationship between fat metabolism and performance in UT. Investigations conducted on Ironman triathlon have showed that MFO is associated with finishing time [16, 18], whereas Lima-Silva et al. [27] reported no relationship between 10-km running performance and fat oxidation parameters. Our results thus contribute to propose a greater relevance of fat metabolism in long-lasting endurance events (i.e., Ironman triathlon and UT races) compared to shorter competitions (10-km running). Moreover, the fact that MFO appeared an independent performance predictor in the multiple regression analysis when considering the whole sample and the male sample set highlights the important role of fat metabolism in UT events. Considering that these races are performed at a HR around 90% of VT_1 [7], thus a moderate intensity where fat metabolism could supply a large percentage of the required energy, faster UT runners may elicit higher rates of fat oxidation and/or have a greater reliance upon fat as a fuel source during UT races [15, 28]. However, a recent study has failed to show an improvement in fat metabolism among recreational ultramarathon runners following either a polarized or a threshold 12-week training program [25]. Therefore, further research is advocated to aid in establishing training recommendations to increase fat use during UT races and thus preserve carbohydrate stores. Additionally, further studies are needed to confirm whether possessing a high MFO during fasted conditions translates to high rates of fat oxidation during prolonged exercise in a fed state.

Previous research has consistently demonstrated the importance of body composition upon trail running performance [3, 5, 7, 29]. Some studies reported an inverse relationship between %FM and race time [3, 7, 29] whereas others found a positive association between %LBM and performance [5]. In our study both %FM and %LBM appeared correlated to race time. Although these relationships with performance were not independent from the other variables assessed in the study and the usage of bioelectrical impedance analysis leads us to be cautious, current results seem to reinforce previous assumptions regarding the important of body composition in trail running performance, both in male and female athletes.

The predictive strength of our performance model (55% for the whole sample, 66% for the men sample set and 69% for the women sample set) matches Fornasiero et al. [7] results in a 65-km trail race, but it is lower than those previously reported in shorter trail running races (between 27 and 31 km) [3, 6, 8]. Consequently, it could be argued that finishing times are less predictable from laboratory variables in UT races as compared with shorter trail running races. Nevertheless, although our study was performed on a larger sample (even when considering men and women sample sets) than most of previous studies in the field, the sample was not yet large enough to draw robust conclusions and further studies are required to confirm our results. In addition, we acknowledge that additional neuromuscular factors (isometric strength, local endurance strength or downhill running ability) could improve the predictive strength of the proposed UT performance model [4, 6, 30]. Even more, as previously suggested, in UT races factors difficult to objectively measure such as mental toughness or avoidance of gastrointestinal symptoms probably play a relevant role in determining the final result [11].

There are some limitations in our study that should be acknowledged. Although participants were asked to attend the laboratory for the cardiopulmonary exercise test with at least 6 h of fasting, we do not record fasting times of each participant and we recognize that differences in the length of fast may have impacted estimates of MFO and $FAT_{max.}$ It is also acknowledged that testing in a fasted state may entail a limitation to the study design as UT races are performed in fed state. Notwithstanding, as it is known that exogenous carbohydrate uptake cannot match utilization rates during prolonged endurance exercise, running with low carbohydrate availability is not an uncommon situation in the final stages of UT races. Lastly, we must recognize that the results are based on a single race with its own characteristics (race profile, terrain, etc.) and cannot be generalized to any UT race. This fact jointly with sample size prevent us from establishing a robust UT performance model (especially when considering sex specific models).

5. Conclusions

Although the nature of the study and the sample size lead us to be cautious in reaching definitive conclusions, maximal fat oxidation appears to be an important determinant of final race time in UT competitions. At the same time, peak speed and submaximal speeds associated with exercise thresholds, maximal aerobic capacity (VO_2peak), and body composition (percentage of fat mass and lean body mass) are also linked to performance in those races. Moreover, in male athletes, maximal fat oxidation is associated with race time independently of the classical physiological variables of endurance running performance; while maximal aerobic capacity and V_{VT1} seem to be stronger performance predictors among female athletes.

Therefore, current results support that UT coaches should undertake training strategies to upregulate fat oxidation during submaximal exercise and include workouts aimed both at improving submaximal (V_{VT1} and V_{VT2}) and maximal (V_{peak} and VO_2peak) capacities. In a similar way, clinicians are encouraged to assess fat metabolism, as well as VO_2peak and ventilatory thresholds, when performing CPET in ultraendurance athletes. Further research is needed in order to establish the mechanisms responsible for training-induced changes in MFO. Future studies should also look into additional variables that could have an impact on UT performance, and investigate whether the application of the abovementioned training strategies improve athletes' performance in UT races.

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Figure legend

Figure 1. Altitude profile of the race including aid stations (reproduced with permission from race organization)

Figure 2. Relationship between race time and peak oxygen uptake (VO_2peak). Men results are depicted in full circles and women results in empty circles

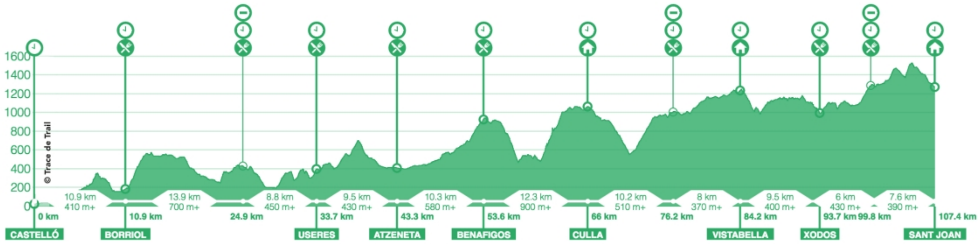
Figure 3. Relationship between race time and maximal fat oxidation (MFO). Men results are depicted in full circles and women results in empty circles

Table legend

Table 1. Sample main characteristics (mean ± SD)

Table 2. Results from correlational analysis

Table 3. Model summary resulting from stepwise multiple regression analyses



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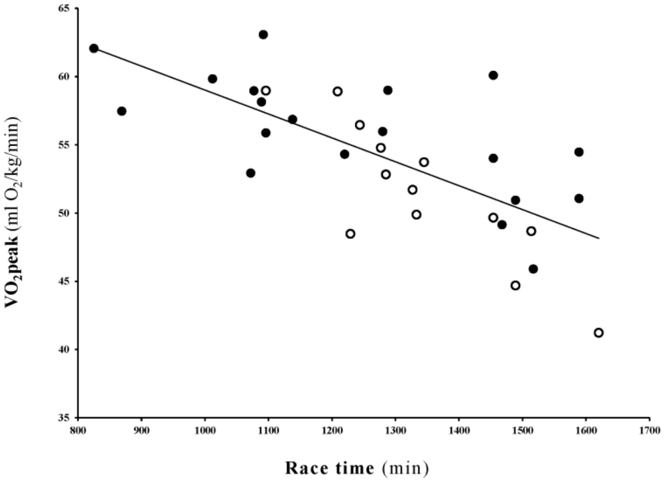

Figure 2. Relationship between race time and peak oxygen uptake (VO2peak). Men results are depicted in full circles and women results in empty circles

221x312mm (300 x 300 DPI)

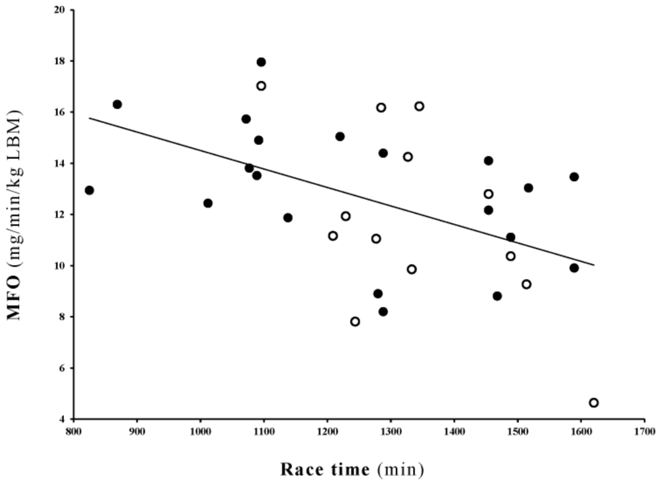

Figure 3. Relationship between race time and maximal fat oxidation (MFO).
Men results are depicted in full circles and women results in empty circles

221x312mm (300 x 300 DPI)

Table 1. Sample main characteristics (mean ± SD)

	All sample (n = 32)	Males (n = 19)	Females (n = 13)
Age (years)	41 ± 6	40 ± 5	42 ± 6
Number of years running	8 ± 3	8 ± 2	8 ± 3
Number of races >100 km	2 ± 3	2 ± 3	2 ± 4
Weekly training days	5 ± 1	5 ± 1	5 ± 1
Weekly running volume (km)	70 ± 22	76 ± 25	61 ± 13
Weekly positive elevation (m)	1772 ± 691	1868 ± 765	1631 ± 565
Weekly training hours	10 ± 4	10 ± 4	9 ± 5
Strength training (%)	81.3%	73.7%	92.3%
BMI (kg/m^2)	22.8 ± 2	23.6 ± 1.6	21.7 ± 2
FM (%)	15.4 ± 4.9	12.9 ± 3.5	19.1 ± 4.5
LBM (%)	80.3 ± 4.7	82.7 ± 3.4	76.8 ± 4.4
V_{VT1} (km/h)	10.8 ± 1.2	11.2 ± 1.1	10.1 ± 0.9
%VT_1 (% VO_2peak)	71.9 ± 5.4	71.8 ± 6.1	72.1 ± 4.4
V_{VT2} (km/h)	13.3 ± 1.4	13.8 ± 1.2	12.5 ± 1.3
%VT_2 (% VO_2peak)	85.6 ± 5.3	85.3 ± 4.7	86.1 ± 6.2
VO_2peak (ml O_2/kg/min)	54.1 ± 5.2	55.8 ± 4.5	51.5 ± 5.2
V_{peak} (km/h)	15.9 ± 1.9	16.9 ± 1.5	14.4 ± 1.4
FAT_{max} (%VO_2peak)	64.3 ± 9.4	64.9 ± 10.7	63.4 ± 7.3
MFO (mg/min/kg LBM)	12.4 ± 3.1	12.9 ± 2.6	11.7 ± 3.6

Abbreviations: Strength training (%), percentage of participants who performed at least one weekly lower-limb strength training in the previous 3 months; BMI, Body mass index; FM, fat mass; LBM, lean body mass; V_{VT1}, speed at the first ventilatory threshold; %VT_1, percentage of VO_2peak at the first ventilatory threshold; V_{VT2}, speed at the second ventilatory threshold; %VT_2, percentage of VO_2peak at the second ventilatory threshold;VO_2peak, peak oxygen uptake; V_{peak}, peak speed reached at the CPET; FAT_{max}, exercise intensity eliciting MFO; MFO, maximal fat oxidation.

Table 2. Results from correlational analysis

	Correlation with race time (r / *p*)		
	All sample (n=32)	Men (n=19)	Women (n=13)
BMI (kg/m^2)	0.253 / 0.163	**0.482 / 0.037**	0.523 / 0.066
FM (%)	**0.575 / 0.001**	**0.577 / 0.010**	**0.618 / 0.024**
LBM (%)	**-0.586 / <0.001**	**-0.608 /0.006**	**-0.612 / 0.026**
V$_{VT1}$ (km/h)	**-0.579 / 0.001**	**-0.486 / 0.035**	**-0.757 / 0.003**
%VT$_1$ (% VO$_2$peak)	-0.199 / 0.275	-0.148 / 0.547	-0.526 / 0.065
V$_{VT2}$ (km/h)	**-0.717 / <0.001**	**-0.730 / <0.001**	**-0.755 / 0.003**
%VT$_2$ (% VO$_2$peak)	**-0.393 / 0.026**	-0.408 / 0.083	**- 0.652 / 0.016**
VO$_2$peak (ml O$_2$/kg/min)	**-0.670 / <0.001**	**-0.629 / 0.004**	**-0.848 / <0.001**
V$_{peak}$ (km/h)	**-0.693 / <0.001**	**-0.743 / <0.001**	**- 0.692 / 0.009**
FAT$_{max}$ (%VO$_2$peak)	0.195 / 0.285	0.353 / 0.138	0.344 / 0.250
MFO (mg/min/kg LBM)	**-0.538 / 0.001**	**-0.530 / 0.019**	**-0.592 / 0.033**

Abbreviations: BMI, Body mass index; FM, fat mass; LBM, lean body mass; V$_{VT1}$, speed at the first ventilatory threshold; %VT$_1$, percentage of VO$_2$peak at the first ventilatory threshold; V$_{VT2}$, speed at the second ventilatory threshold; %VT$_2$, percentage of VO$_2$peak at the second ventilatory threshold;VO$_2$peak, peak oxygen uptake; V$_{peak}$, peak speed reached at the CPET; FAT$_{max}$, exercise intensity eliciting MFO; MFO, maximal fat oxidation.

Table 3. Model summary resulting from stepwise multiple regression analyses

Analysis 1: All sample (n=32)

	Model	Coefficients B	95% CI for B Lower	95% CI for B Upper	Standardized Coefficient	p-value	Partial R	R^2	R^2 Change
1	(Constant)	-1.894	-5.441	1.653		0.284		0.514	
	V_{VT2}	0.734	0.468	1.001	0.717	<0.001	0.717		
2	(Constant)	-1.720	-5.091	1.651		0.305		0.578	0.064
	V_{VT2}	0.610	0.330	0.890	0.596	<0.001	0.637		
	MFO	0.147	0.004	0.291	0.280	0.045	0.538		

Analysis 2: Men sample set (n=19)

	Model	Coefficients B	95% CI for B Lower	95% CI for B Upper	Standardized Coefficient	p-value	Partial R	R^2	R^2 Change
1	(Constant)	-5.995	-12.539	0.548		0.070		0.553	
	V_{peak}	0.839	0.453	1.225	0.743	<0.001	0.743		
2	(Constant)	-7.299	-12.975	-1.626		0.015		0.696	0.143
	V_{peak}	0.744	0.406	1.082	0.660	<0.001	0.760		
	MFO	0.272	0.062	0.482	0.388	0.014	0.566		

Analysis 3: Women sample set (n=13)

	Model	Coefficients B	95% CI for B Lower	95% CI for B Upper	Standardized Coefficient	p-value	Partial R	R^2	R^2 Change
1	(Constant)	0.836	-1.891	3.562		0.514		0.719	
	VO_2peak	0.127	0.074	0.180	0.848	<0.001	0.848		

Analysis 4: Faster runners sample set (n=18)

	Model	Coefficients B	95% CI for B Lower	95% CI for B Upper	Standardized Coefficient	p-value	Partial R	R^2	R^2 Change
1	(Constant)	-2.493	-5.952	0.966		0.146		0.748	
	V_{peak}	0.681	0.471	0.890	0.865	<0.001	0.865		

Analysis 5: Slower runners sample set (n=14)

	Model	Coefficients B	95% CI for B Lower	95% CI for B Upper	Standardized Coefficient	p-value	Partial R	R^2	R^2 Change
1	(Constant)	3.510	0.556	6.464		0.024		0.325	
	VO_2peak	0.063	0.006	0.120	0.570	0.033	0.570		

Abbreviations: V_{VT2}, speed at the second ventilatory threshold; MFO, maximal fat oxidation; V_{peak}, peak speed reached at the CPET; VO_2peak, peak oxygen uptake.