Original Article

Effects of nutritional intake on performance in master athletes during an extreme ultra-trail

FELICINA BIORCI[1], GIOVANNI CUGLIARI[2] ✉, MARCELLO LUCCHESE[3], MARCO IVALDI[4]

[1]*Center for Preventive and Sport Medicine, SUISM, University of Turin, Italy*
[2]*Department of Medical Sciences, University of Turin, Italy*
[3]*SUISM, University School of Hygiene and Sport Sciences, University of Turin, Italy*
[4]*Department of Life Sciences and Systems Biology, University of Turin, Italy*

ABSTRACT

The purpose of our study was to monitor a well-trained master athlete who competed in the race, keeping under review his performance outcomes. TransPyrenea (La Grande Traversée des Pyrénées) is an Ultra Trail 13-16-d race, 866 km long, 53200 meters of elevation gain, performed for the first time in 2016, becoming the longest race in the world. At every checkpoint, a member of the team ascertained total macronutrients intake and body composition. A wearable device was used to monitor glycemia during all the race. The athlete completed the race with an average speed of 2.6 km/h, including 26 hours and 30 minutes of sleeping. Multiple regression analysis showed that the increase of the speed (β: 0.5 km/h, 95% CI: 0.07 | 1.02 km/h, p-value: .035 and β: 1.32 km/h, 95% CI: 0.53 | 2.11 km/h, p-value: .004) was related to the increase of one hour of sleep and one kg of weight respectively. This evidence could induce the use of specific nutritional supplements and the analysis of body composition on the management strategies of the race, with eventually the planning of a greater number of hours of sleep to acquire greater speed.
Keywords: Nutrient intake; Body composition; Blood glucose; Sleep; Master athlete; Ultra-trail.

Cite this article as:
Biorci, F., Cugliari, G., Lucchese, M., & Ivaldi, M. (2020). Effects of nutritional intake on performance in master athletes during an extreme ultra-trail. *Journal of Human Sport and Exercise*, *15*(4), 794-801. doi:https://doi.org/10.14198/jhse.2020.154.07

✉ **Corresponding author.** *Department of Medical Sciences, University of Turin, C.so Dogliotti 14, 10126 Turin. Italy.*
E-mail: cugliarigiovanni@gmail.com
Submitted for publication July 2019
Accepted for publication September 2019
Published *in press December 2020 (*October 2019)
JOURNAL OF HUMAN SPORT & EXERCISE ISSN 1988-5202

doi:10.14198/jhse.2020.154.07

INTRODUCTION

An ultra-endurance race may refer to running, cycling, swimming, cross-country skiing or a multi-sport event such as triathlon. The criterion to define these modes of exercise as ultra-endurance is to last at least six hours (Zaryski et al., 2005). Considering the long duration of these races, an ultra-endurance athlete faces sport-specific nutritional issues and successful performance is characterized by the ability to sustain a higher absolute speed for a given distance than other competitors. This can be achieved through a periodized training plan and following appropriate nutritional practices, to address the specific limiting factors that would otherwise cause fatigue or a decrement in performance (Burke, 2007).

Glycogen and glucose are the fundamental energy sources for muscle during races (Chiampas et al., 2015). Current practices suggest that carbohydrate intakes during exercise longer than 2 h, will prevent hypoglycemia, will maintain high rates of carbohydrate oxidation, and increase endurance capacity compared with placebo ingestion. Carbohydrate intake recommendations for ultra-endurance events are higher of approximately 90 g/h (Jeukendrup, 2014). In real life, athletes undertake training sessions and competitions with varying carbohydrate availability (Burke, 2011), with intake often significantly below the requisite nutritional recommendations (Kruseman et al., 2005; Martinez et al., 2017).

Another important factor involved in ultra-endurance performance is sleep deprivation. Athletes hypothesize ultra-endurance race management strategies trying to sleep as little as possible, despite the scientific studies describe a reduction in performance according to the reduced sleep hours (Oliver et al., 2009). Short-term sleep restriction (4 h/night for 1 week in a laboratory setting) impaired glucose tolerance during a frequently sampled intravenous glucose tolerance test in healthy subjects: decreases in insulin secretion have been implicated, and sleep restriction increases cortisol levels, which could influence glucose tolerance (Buxton et al., 2010; Punjabi et al., 2004).

Moreover, over the past three decades, there has been a continual increase in the number of master athletes (i.e. > 40 years old) in endurance and ultra-endurance (> 6 h) events (Zaryski et al., 2005). Generally, finishers are older than 40 years in endurance and ultra-endurance events, e.g., 47 years for 100-km running (Knechtle et al., 2012), 43–44 years for 161-km running (Hoffman et al., 2010), or 43 years for ultra-cycling such as Race Across America (Shoak et al., 2013). These findings indicate the difficulty that ultra-endurance athletes experience in meeting standard recommendations (Costa et al., 2013; Costa et al., 2016) either on food requirement or in hours slept. Finally, we lack information regarding nutrition habits of master endurance athletes (Louis et al., 2014; Brisswalter et al., 2014; Borges et al., 2016; Piacentini et al., 2017).

The purpose of this study was to monitor a well-trained master athlete involved in the competition, keeping under review his macronutrients intake, glycaemia, sleep deprivation, cognitive test and speed during the longest competitive race in the world.

MATERIALS AND METHODS

The athlete is a 48-year old male ultra-runner athlete (BMI 21.5), having competed in long distance events around the world, with a training load of average 100 km/week.

The study was conducted during the 2016 Transpyrenea race, held during the first weeks of August, from the Mediterranean Sea to the Atlantic Ocean, 4 checkpoints (at the beginning, at the 165th km, 418th km, 678th km) and a positive drop of 53200 meters. The race was conducted over thirteen days totalling a distance of 868 km, which was performed on a variety of terrains, predominantly off-road trails and paths, but also included steep and narrow mountain passes, and occasional road.

Preliminary measures were taken to determine athlete characteristics. Height was measured by a wall-mounted stadiometer. Body composition was measured by Bio-Impedance Analysis (Tanita SC-331S Body Composition Analyzer; Tanita Inc., Arlington Heights, IL, USA), at the beginning of the race and at check points. Sleeping arrangements included a combination of outdoor tent and check point accommodation. Hours of sleeping were monitored by self-reporting of the athlete.

Food was limited to how much each athlete was able to bring. The midway check- point provided an excellent opportunity where athletes could resupply their backpack and refuel. Each athlete was responsible for their own food selections and energy intake targets throughout each racing day.

At every checkpoint, a member of the team ascertained total macronutrients intake. The athlete was not instructed to adhere to certain dietary guidelines or practices in order to assess natural behaviours in an applied setting. For the entire race, the athlete wore on the back of left upper arm a FreeStyle®Libre™ Flash glucose monitoring system sensor (Abbott Diabetes Care, Alameda, CA) for interstitial glucose, highly correlated to capillary blood glycaemia (Bailey et al., 2015). The system sensor provides measurements every 60 seconds, giving trend and fluctuation of interstitial glucose levels over time.

All procedures performed in this study involving human participants were in accordance with the ethical standards of the institutional research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. Informed consent was obtained from all individual participants included in the study.

Statistical analysis

The normality assumption of the data was evaluated with the Shapiro-Wilk test; homoscedasticity and autocorrelation of the variables were assessed using the Breusch-Pagan and Durbin-Watson tests. Each value was expressed as mean (SD).

Multiple regression analysis was performed to estimate the association between dependent variable (speed and race time) and independent variables (protein, carbohydrates, fat, weight, fat mass, hours of sleep and slope). For multiple comparisons, the Tukey test was used. The level of significance was set at $p < .05$. Statistical analyses were conducted using the R statistical package (version 3.0.3, R Core Team, Foundation for Statistical Computing, Vienna, Austria).

RESULTS

The athlete completed the distance of 866 km (53200 D+, 53200 D-) in 334 hours 9 minutes and 7 seconds at a mean speed of 2.6 Km/h (23 min/km); this means that, on average, the athlete has completed 62,2 km every 24 hours and, on average, each sector was completed in 14,5 hours. The highest average speed recorded in a single sector - between two check points - was 7.43 km/h.

Over the race the runner consumed a total amount 7722.6 g of carbohydrate, 2000.9 g fat and 1536.5 g of protein.

The percentage contribution of macronutrients was CHO = 56.1%, fat = 32.7% and protein = 11.2%.

The average amount was 23,1 g/h of carbohydrate, 6 g/h of fat and 4,6 g/h of protein.

Over the 13 competition days, the amount of sleep the athlete got was 26 hours and 30 minutes, from 1 hours to 5 hours each period. The weight of the athlete has varied from a maximum of 75.10 kg to a minimum of 70.20 kg. The fat mass, excluding the essential fat, has varied from a maximum of 1.9% to a minimum of 0.7 % of body mass. The athlete weight loss was 4.9 kg from the started weight of 75.10 kg (- 6.5%). Concerning glycaemia, an average of 125 mg/dL was recorded during the race ranging from minimum value of 40 mg/dL to a maximum of 217 mg/dL, with three blood glucose events below 70 mg/dL, for an average duration of 85 minutes of low glucose levels.

The analysis carried out with the multiple regression model showed statistically significant association relating to the speed (km/h) and i) hours of sleep, ii) kg of weight and iii) percentage of fat mass. Multiple regression analysis showed the increase of the speed (β: 0.5 km/h, 95% CI: 0.07 | 1.02 km/h, p-value: .035) and (β: 1.32 km/h, 95% CI: 0.53 | 2.11 km/h, p-value: .004) related to the increase of one hour of sleep and one kg of weight respectively. The decrease of the speed (β: -3.87 km/h, 95% CI: -6.82 | -0.91 km/h, p-value: .019) was related to the increase of one percentage point of fat mass of weight. Food intake related variables (carbohydrates, protein and fat) and slope were used to adjust the association estimates in statistical model (Table 1).

Table 1. Multiple regression analysis to estimate the association between speed (Y) and covariates (Xi).

Variable	β	Std. Error	p value	95% CI (low)	95% CI (high)
Protein	-0.013	0.011	.238	-0.034	0.008
Carbohydrates	0.044	0.032	.188	-0.019	0.108
Fat	0.007	0.008	.446	-0.011	0.025
Weight	1.319	0.403	.004**	0.529	2.109
Fat mass	-3.866	1.506	.019 *	-6.818	-0.913
Slope	-0.001	0.001	.507	-0.001	0.001
Hours of sleep	0.546	0.241	.035 *	0.074	1.018

*The β regression coefficient obtained from a multiple regression analysis describes how the outcome variable Y changes with a 1 unit increase in the explanatory variable X. *: p < .05.*

A statistical significance association has also been found between the athlete's weight and the race time: a kg of weight reduction of the athlete produces an increase in the travel time between two check points of about 4 hours (p: .0408).

DISCUSSION

The long duration of an ultra-endurance race implies increased exercise-induced energy expenditure. To balance the increased energy expenditure, an optimal nutrition should ensure adequate energy intake (Nikolaidis et al., 2018).

The scientific literature has consistently demonstrated that daily carbohydrate intake (30-110g/h) during ultra-endurance events can enhance performance at individually tolerable intake rates (Costa et al., 2018; Learsi et al., 2019). In fact, many studies have demonstrated that increases in the hourly rate of CHO and overall energy intake are correlated with faster race times in ultra-endurance events (Paulin et al., 2015), suggesting that carbohydrate intake was higher in faster finishers group compared to the slower finishers (Rae et al., 2017).

The amount of carbohydrates 23 g/h assumed by the athlete is much lower than the consumption advised by the guidelines in the ultra-endurance sport performance diet (90 g of carbo/h). This intake supported an average glycemic value of 125 mg/dl, and the amounts of carbohydrates assumed (in any food form) do not significantly affect the average speed kept in the race and therefore the kilometres travelled in a given time or in the partial or in the total duration of the performance. It seems therefore that the very high efficiency achieved in the biomechanics related to the motion allows to greatly decrease the energy consumption and therefore the request of carbohydrate intake in the elite athletes of ultra-resistance. A consideration can be made considering that the assumptions dictated by the guidelines are set on the running dynamic, while the ultra-strength athletes have extremely low race speeds, which are more similar to the energy consumption of the walking than of the running. It is also known that consumption of O2 in running, especially in UM running could be overestimated (Learsi et al., 2019).

In our study, the athlete experienced a body mass loss of 6.5% of starting body weight occurring throughout the event, according to an average loss of 5% in most ultra-endurance races (Nikolaidis et al., 2018). The large amount of body mass lost is typically a combined result of limited food availability, increased energy expenditure, sleep deprivation and dehydration.

In contrast with previous study, in which no relationships were reported between changes in absolute body weight, lean mass and race performance times (Paulin et al., 2015), we found that fat mass loss has a positive impact with the average travel speed and therefore with the kilometres travelled in a given time and with the final time of completion of the race.

The importance of sleep for athletic performance and recovery is widely acknowledged (Rae et al., 2017). Studies on partial and total sleep deprivation have highlighted the adverse effects of sleep loss on athletic performance (Fullagar et al., 2015), while other studies show that sleep extension may benefit performance (Schwartz et al., 2015). Yet, the minimal quantity of sleep deprivation or extension required to impact athletic performance is unknown (Knufinke et al., 2018). A recent work - conducted in the same race - highlighted no significant correlations between sensory or cognitive scores with body weight, emphasizing instead the correlation with sleep restriction (Tonacci et al., 2017).

An interesting frontier, in this regard, could be linked to the analysis with quantitative EEG of the moments of rest, to optimize the phases of deep sleep, allowing on the one hand to reduce the time necessary for rest, but at the same time maintaining the possibility of recovery from the fatigue of the athlete's central nervous system.

Some studies have been done on athletes, in particular related to motion imagery (Ivaldi et al., 2017; Gennaro et al., 2018) and central activation after stimulation of the stretch reflex (Ivaldi et al., 2018) that could provide a central fatigue index to optimize the athlete's rest, in addition to studies during sleep, to define the timing of most important and essential phases of sleep for recovery.

Furthermore, the use of functional training can be very useful in endurance to reduce injuries, especially with extended performance times (Cugliari et al., 2017). In our study, the speed of the race correlates positively with the hours slept during the race itself, according with previous studies, observing a reduction in endurance performance following sleep deprivation (Oliver et al., 2009). Sleep-related strategies may actually allow a significant improvement in performance, especially considering that natural supplementation with supposed ergogenic effects has not yielded the desired results (Cugliari et al., 2018).

CONCLUSIONS

The aim of the present study was to investigate whether a well-trained ultramarathon runner was able through the 866 km race to: 1) maintain correct intakes of carbohydrates to meet recommendations; 2) maintain adequate blood glucose; 3) well manage the amount of sleep.

Even though the athlete experienced a low intake of carbohydrate per hour, that amount guaranteed a relatively stable blood glucose during all the event, with no effect on the average speed in the race. The lower amount of carbohydrate consumed still allows him to finish the race, even in thirteenth position ranking.

Evidently, the food provided during the race lacked his energy requirements, inducing him a body weight loss. Whereas the athlete started the race with a fat percentage of 1.9%, weight loss was probably attributable to loss of lean mass, fluids and mineral density. That could explain the positive relationship between race time and body weight. The athlete speed was higher in higher body weight.

About the hours slept, the athlete experienced an important sleep deprivation. And the statistical analysis highlighted the correlation between speed and hours slept: more the athlete slept, faster he ran.

This data confirms the importance to instruct ultra-endurance athlete to meet the literature suggested carbohydrate recommendation, and to improve knowledge and guidelines regarding sleep recommendation too.

CONFLICT OF INTEREST

All authors declare no conflicts of interest.

FUNDING

The authors have no funding to declare.

REFERENCES

Bailey T, Bode WB, Christiansen MP, Klaff LJ, Alva S. The Performance and Usability of a Factory-Calibrated Flash Glucose Monitoring System. Diabetes Technol Ther 2015; 17(11):787-794. https://doi.org/10.1089/dia.2014.0378

Best R, Barwick B, Best A, Berger N, Harrison C, Wright M, & Sparrow J. Changes in Pain and Nutritional Intake Modulate Ultra-Running Performance: A Case Report. Sports 2018; 6(4):111. https://doi.org/10.3390/sports6040111

Borges N, Reaburn P, Driller M, Argus C. Age-related changes in performance and recovery kinetics in masters athletes: a narrative review. Journal of aging and physical activity 2016; 24(1):149-157. https://doi.org/10.1123/japa.2015-0021

Brisswalter J, Louis J. Vitamin supplementation benefits in master athletes. Sports Medicine 2014;44(3):311-318. https://doi.org/10.1007/s40279-013-0126-x

Burke L. Training and competition nutrition. Practical Sports Nutrition 2007; 1-26.

Burke LM, Hawley JA, Wong SH, Jeukendrup AE. Carbohydrates for training and competition. Journal of sports sciences 2011; 29(suppl 1):17-27.

Buxton OM, Pavlova M, Reid EW, Wang W, Simonson DC, Adler GK. Sleep Restriction for 1 Week Reduces Insulin Sensitivity in Healthy Men. Diabetes 2010; 59. https://doi.org/10.2337/db09-0699

Chiampas GT, Goyal AV. Innovative Operations Measures and Nutritional Support for Mass Endurance Events. Sports Medicine 2015; 45(1):61-69. https://doi.org/10.1007/s40279-015-0396-6

Costa RJ, Teixeira A, Rama L, Swancott AJ, Hardy LD, Lee B, Barrett E. Water and sodium intake habits and status of ultra-endurance runners during a multi-stage ultra-marathon conducted in a hot ambient environment: an observational field based study. Nutrition journal 2013; 12(1):13. https://doi.org/10.1186/1475-2891-12-13

Costa RJ, Snipe R, Camões-Costa V, Scheer V, Murray A. The impact of gastrointestinal symptoms and dermatological injuries on nutritional intake and hydration status during ultramarathon events. Sports medicine-open 2016; 2(1): 16. https://doi.org/10.1186/s40798-015-0041-9

Costa RJS, Hoffman MD, Stellingwerff T. Considerations for ultra-endurance activities: part 1-nutrition.Res Sports Med 2018; 28:1-16.

Cugliari G, Boccia G. Core muscle activation in suspension training exercises. Journal of human kinetics 2017; 56(1):61-71. https://doi.org/10.1515/hukin-2017-0023

Cugliari G, Messina F, Canavero V, Biorci F, Ivaldi M. Relationship of chlorophyll supplement and platelet-related measures in endurance athletes: a randomized, double-blind, placebo-controlled study. Sport Sciences for Health 2018; 1-6.

Fullagar HHK, Skorski S, Duffield R, Hammes D, Coutts AJ, Meyer T. Sleep and athletic performance: the effects of sleep loss on exercise performance, and physiological and cognitive responses to exercise. Sports Medicine 2015; 45: 161-186. https://doi.org/10.1007/s40279-014-0260-0

Gennaro F, De Bruin ED. Assessing Brain–Muscle Connectivity in Human Locomotion through Mobile Brain/Body Imaging: Opportunities, Pitfalls, and Future Directions. Frontiers in public health 2018; 26:6-39. https://doi.org/10.3389/fpubh.2018.00039

Hoffman MD, Ong JC, Wang G. Historical analysis of participation in 161 km ultramarathons in North America. The International journal of the history of sport 2010; 27(11):1877-1891. https://doi.org/10.1080/09523367.2010.494385

Ivaldi M, Cugliari G, Peracchione S, Rainoldi A. Familiarity affects electrocortical power spectra during dance imagery, listening to different music genres: independent component analysis of Alpha and Beta rhythms. Sport Sciences for Health. 2017; 13(3):535-48. https://doi.org/10.1007/s11332-017-0379-0

Ivaldi M, Pretari F, Cugliari G. Electrocortical activity during stretch reflex in athletes. Sport Sciences for Health 2018; 14(3):625-631. https://doi.org/10.1007/s11332-018-0471-0

Jeukendrup A. A Step Towards Personalized Sports Nutrition: Carbohydrate Intake During Exercise. Sports Med 2014; 44(Suppl 1):25. https://doi.org/10.1007/s40279-014-0148-z

Knechtle B, Rüst CA, Rosemann T, Lepers R. Age-related changes in 100-km ultra-marathon running performance. Age 2012; 34(4):1033-1045. https://doi.org/10.1007/s11357-011-9290-9

Knufinke M, Nieuwenhuys A, Maase K, Moen HM, Geurts AES, Coenen AML, Kompier AJM. Effects of Natural Between-Days Variation in Sleep on Elite Athletes' Psychomotor Vigilance and Sport-Specific Measures of Performance. Journal of Sports Science and Medicine 2018; 17:515-524.

Kruseman M, Bucher S, Bovard M, Kayser B, Bovier PA. Nutrient intake and performance during a mountain marathon: an observational study. European journal of applied physiology 2005; 94(1-2):151-157. https://doi.org/10.1007/s00421-004-1234-y

Learsi SK, Ghiarone T, Silva-Cavalcante MD, Andrade-Souza VA, Ataide-Silva T, Bertuzzi R, de Araujo GG, McConell G, Lima-Silva AE. Cycling TT performance is improved by carbohydrate ingestion during exercise regardless of a fed or fasted state. Scand J Med Sci Sports 2019; 23. https://doi.org/10.1111/sms.13393

Louis J, Hausswirth C, Bieuzen F, Brisswalter J. Vitamin and mineral supplementation effect on muscular activity and cycling efficiency in master athletes. Applied Physiology, Nutrition, and Metabolism 2010; 35(3):251-260. https://doi.org/10.1139/h10-014

Martinez S, Aguilo A, Rodas L, Lozano L, Moreno C, Tauler P. Energy, macronutrient and water intake during a mountain ultramarathon event: The influence of distance. Journal of Sports Sciences 2017; 1-7. https://doi.org/10.1080/02640414.2017.1306092

Nikolaidis PT, Veniamakis E, Rosemann T, Knechtle B. Review. Nutrition in Ultra-Endurance: State of the Art. Nutrients 2018; 10:1995. https://doi.org/10.3390/nu10121995

Oliver SJ, Costa RJ, Laing SJ, Bilzon JL, Walsh NP. One night of sleep deprivation decreases treadmill endurance performance. Eur J Appl Physiol. Sep 2009; 107(2):155-61. https://doi.org/10.1007/s00421-009-1103-9

Paulin S, Roberts J, Roberts Mand Davis I. A case study evaluation of competitors undertaking an antarctic ultra-endurance event: nutrition, hydration and body composition variables. Extreme Physiology & Medicine 2015; 4:3. https://doi.org/10.1186/s13728-015-0022-0

Piacentini MF, De Ioannon G, Cibelli G, Mignardi S, Antonelli A, Capranica L. Training for a 78-km solo open water swim. The Journal of sports medicine and physical fitness 2017; 57(6):790-793.

Punjabi NM, Shahar E, Redline S, Gottlieb DJ, Givelber R, Resnick HE. Sleep Heart Health Study Investigators. Sleep-disordered breathing, glucose intolerance, and insulin resistance: the Sleep Heart Health Study. Am J Epidemiol 2004; 160(6):521-30. https://doi.org/10.1093/aje/kwh261

Rae DE, Chin T, Dikgomo K, Hill L, McKune AJ, Kohn TA, Roden LC. One night of partial sleep deprivation impairs recovery from a single exercise training session.European Journal of Applied Physiology 2017; 117:699-712. https://doi.org/10.1007/s00421-017-3565-5

Schwartz J, Simon RD. Sleep extension improves serving accuracy: A study with college varsity tennis players. Physiology & Behavior 2015; 151:541-544. https://doi.org/10.1016/j.physbeh.2015.08.035

Shoak MA, Knechtle B, Knechtle P, Rüst CA, Rosemann T, Lepers R. Participation and performance trends in ultracycling. Open access journal of sports medicine 2013; 4:41. https://doi.org/10.2147/oajsm.s40142

Tonacci A, Mrakic-Sposta S, Ujka K, Sansone F, Ferrisi A, Giardini G, Conte R, Pratali L. Neurosensory and Cognitive Modifications in Europe's Toughest RandoRaid Competition: the Transpyrénéa Extreme Study. Frontiers in physiology 2017; 8:201. https://doi.org/10.3389/fphys.2017.00201

Zaryski C, Smith DJ. Training principles and issues for ultra-endurance athletes. Curr. Sports Med 2005; 4(1):65-170. https://doi.org/10.1097/01.csmr.0000306201.49315.73

Zaryski C, Smith DJ. Training principles and issues for ultra-endurance athletes. Current sports medicine reports 2005; 4(3):165-170. https://doi.org/10.1097/01.csmr.0000306201.49315.73