Rev Bras Cineantropom Hum

original article

DOI: http://dx.doi.org/10.5007/1980-0037.2016v18n2p127

Somatotype, body composition and performance in ultramarathon

Somatotipo, composição corporal e desempenho em ultramaratona

Taisa Belli[1]
Cláudio Luiz de Souza Meireles[2]
Mônica de Oliveira Costa[3]
Marco Aurélio Ackermann[1]
Claudio Alexandre Gobatto[1]

Abstract – This study aimed to characterize somatotype, analyze anthropometric indicators associated with body composition during the race and verify possible relationships with the performance of athletes in a 217-km ultramarathon. For this, ten male volunteers (42.8 ± 3.5 years; 171.4 ± 1.9 cm height, 70.7 ± 3.1 kg body mass; 15 ± 3 years of running exercise) performed a critical velocity (CV) test one week before the competition and were submitted to anthropometric measurements before, at 84 km of the race and at the end of the race. Volunteers finished the race in 46.8 ± 3.4 h (4.9 ± 0.4 km / h; 33.4 ± 1.8% CV). Mean values equivalent to somatotype components accounted for 3.4 ± 0.4 for endomorphy, 5.2 ± 0.4 for mesomorphy and 1.7 ± 0.3 for ectomorphy. Body mass, body mass index, fat-free mass and chest circumference decreased ($P < 0.05$) after 84 and 217 km compared to baseline. Pre-race values of thigh skinfold thickness ($R = 0.79$) and waist circumference ($R = 0.64$) were significantly correlated ($P < 0.05$) with final race time. Thus, we concluded that ultramarathoners had mean endo-mesomorph somatotype and reductions in both body mass and fat-free mass during and after the race. Furthermore, the results suggest that increased body fat deposits concentrated in the lower limbs and abdominal region may have a negative impact on the performance of the athletes in 217-km ultramarathon.

Key words: Anthropometry; Body composition; Running; Athletic performance.

Resumo – O presente estudo teve como objetivo caracterizar o somatotipo, analisar indicadores antropométricos associados à composição corporal durante a prova e verificar possíveis relações com o desempenho de atletas em uma ultramaratona de 217 km. Para tanto, dez homens (42,8±3,5 anos; 171,4±1,9 cm de estatura; 70,7±3,1 kg de massa corporal; 15±3 anos de treino de corrida) tiveram determinada a velocidade crítica (VC) uma semana antes da competição e foram submetidos às avaliações antropométricas antes, aos 84 km e ao final da prova. Os voluntários completaram a prova em 46,8 ± 3,4h (4,9 ± 0,4 km/h; 33,4 ± 1,8 % VC). Os valores médios equivalentes aos componentes do somatotipo corresponderam a 3,4 ± 0,4 para endomorfia, 5,2 ± 0,4 para mesomorfia e 1,7 ± 0,3 para ectomorfia. Massa corporal, índice de massa corporal, massa magra e circunferência peitoral reduziram ($P < 0,05$) aos 84 e 217-km comparados aos valores iniciais. Espessura da dobra cutânea de coxa ($R= 0,79$) e a circunferência de cintura ($R=0,64$) identificadas antes da prova foram correlacionadas significativamente ($P < 0,05$) com o tempo final de prova. Dessa maneira, nós concluímos que ultracorredores apresentaram somatotipo médio endo-mesomorfo e reduções tanto de massa corporal como de massa magra durante e após a prova. Além disso, os resultados sugerem que maiores depósitos de gordura corporal concentrados nos membros inferiores e na região abdominal podem ter um impacto negativo no desempenho dos atletas em ultramaratona de 217 km.

Palavras-chave: *Antropometria; Composição corporal; Corrida; Desempenho atlético.*

1 University of Campinas. School of Applied Sciences. Laboratory of Applied Sport Physiology. Limeira, SP. Brazil.

2 Federal University of Paraíba. Department of Physical Education. Joao Pessoa, PB. Brazil.

3 "Carlos de Campos" Technical School. Technical Course in Nutrition and Dietetics. São Paulo, SP. Brazil.

Received: 29 September 2015
Accepted: 20 December 2015

INTRODUCTION

The morphological constitution of athletes involved in running depends on the distance to be covered. Thus, larger fat stores can provide an important energy reservoir as well as increased muscle mass can be valuable to move on uneven grounds and surfaces of trails in ultramarathon events, characteristics that are not necessary and could even have a negative impact in running events involving shorter distances[1].

However, although this assumption is relevant, to our knowledge, only one case study involving a participant in a 243 km foot race found that his physical constitution was characterized by a dominant mesomorph somatotype[2]. Somatotype is a parameter that expresses the morphological constitution of the individual in terms of body composition and shape. It consists of three numeral values representative of components: endomorphy or adiposity, mesomorphy or musculoskeletal robustness and ectomorphy or linearity[3].

In addition, an initial overview has been elucidated about the changes associated with body composition over 160-246 km ultramarathons. In this sense, while some studies have found body mass (BM) maintenance in ultramarathoners[4-6], others found reduction in these values [7-9], accompanied by a decrease in fat-free mass (FFM) and fat mass (FM)[9].

Classically, identifying changes in BM provides one of the most simple and accurate indexes to assess hydration status during exercise[10]. However, it seems that when a decrease in BM is observed in ultramarathon races, it probably does not occur only due to dehydration, but also due to the decrease in FFM and FM[11].

It has recently been proposed that while strategies to minimize the energy cost of locomotion are essential for running events up to the distance of a marathon, minimizing tissue damage of the lower limbs is one of the crucial factors of performance in ultramarathon[12], in addition to others such as physical, environmental, psychological, motivational and tactical factors[12-14].

In this regard, while for an elite marathon athlete to have large thighs dramatically increases internal work, for ultramarathoners, who exercise at a much lower running speeds, this anthropometric characteristic does not appear to be detrimental and may even be advantageous in terms of resistance to muscle damage[12].

However, the results found in the current scientific literature are still scarce and sometimes conflicting to support the premise that the specific body composition profile of ultramarathoners may be associated with their performance in 160-350 km ultramarathon events[15-17].

This study aimed to characterize somatotype, analyze anthropometric indicators associated with body composition during the race and verify possible relationships with the performance of athletes in a 217-km ultramarathon.

METHODOLOGICAL PROCEDURES

Volunteers and race description

Ten men were volunteers in this study, among the 42 finalists of the "Brazil

135 Ultramarathon – 2009". The characteristics of volunteers are shown in Table 1. This study was approved by the Ethics Research Committee of the São Paulo State University (UNESP) (in 037/2008) and the informed consent form was signed by each athlete before participation in the study.

Table 1. Characteristics of volunteers (n = 10)

Age (years)	42.8 ± 3.5
Height (cm)	171.4 ± 1.9
Training history (years)	15 ± 3
Training volume (km/week)	118 ± 20
Participation in ultramarathons (n)	12 ± 6
Critical velocity (km/h)	13.5 ± 0.7

'Brazil 135 Ultramarathon' is a 217-km international ultramarathon (135 miles) held annually at *Serra da Mantiqueira*, southern state of Minas Gerais / Brazil. This race takes place on dirt roads in the heavier segment of the Brazilian pilgrimage trail called *Caminho da Fé*, and the total uphill and downhill segments during the race has been estimated at 9.6 km and 10 km, respectively. Thus, it is considered one of the toughest ultramarathon events held in Brazil and athletes who are able to complete this competition achieve qualification to perform ultramarathons renowned around the world. In that edition, the start took place in Poços de Caldas (1304 m altitude) at 08: 00 am and arrival in Paraisópolis (927m altitude) and runners who reached the finish line within 60 hours were considered finishers. The ambient temperature ranged from 08 to 30°C.

Experimental design

The critical velocity (CV) of athletes was determined one week before the competition. Then, in the afternoon before the start of the race, the volunteers at five hours postprandial condition underwent initial evaluation, which consisted of anthropometric measurements and completing a demographic and training history questionnaire. Furthermore, anthropometric measurements were also performed in Serra dos Limas (84 km), an intermediate support point, and immediately after the race (217 km). These were referred to as intermediate and final evaluation, respectively. Race time was obtained from the official race reports. Volunteers were able to eat and drink *ad libitum* during the race.

Critical velocity

One week before the competition and in the following days, athletes individually performed four maximum races at different distances (800, 1200, 1600, 2000m) in a track, performed in random order. Thus, the critical velocity was determined by the angular coefficient of the linear fit of distance vs. running time[18].

Anthropometric measurements

During the initial evaluation, with volunteers barefooted and wearing light clothing, body mass (kg) and height (cm) measurements were performed using a platform scale (Welmy®), with an accuracy of 0.1kg and 0.5cm, respectively. Skinfold thickness (chest, abdominal, thigh, suprailiac, subscapularis, triceps and calf) were measured using a caliper (Sanny®) with an accuracy of 1mm and the value recorded was the average of three consecutive measurements of each body region. Circumferences measures (cm) (chest, relaxed arm, flexed arm, umbilical waist, thigh and medial calf) were performed with flexible inextensible metal tape, with an accuracy of 0.1cm (Sanny®) and bone diameters (mm) (humeral biepicondyle and femoral bicondyle) were measured with the elbow and knee joints flexed to 90° and the caliper rods (Sanny®) at 45° in relation to them.

In intermediate (84 km) and final evaluations (217 km), replicas were made of body mass, skinfold thickness (chest, abdominal and thigh) and girth (chest, relaxed arm, umbilical waist and legs) measurements.

A single experienced evaluator performed all anthropometric measurements on the right side of the body according to conventional techniques[19].

Body mass index [$kg.(m^2)^{-1}$] (BMI) was calculated as body mass divided by the squared height. Fat mass was estimated according to the equation of Stewart and Hannan[20] for male athletes:

FM (g) = (331.5 x abdominal skinfold thickness (mm)) + (356.5 x thigh skinfold thickness (mm)) + (111.9 x body mass (kg)) - 9108

Fat percentage was then calculated as % BF = (FMx100) / BM and fat-free mass was calculated by subtracting fat mass from body mass. Somatotype was calculated from the initial assessment of body mass, height, skinfold thickness (suprailiac, subscapularis, triceps and calf), girth (flexed arm and medial calf) and diameters (humeral biepicondyle and femoral bicondyle)[21] and somatochart was plotted using the somatotype 1.1 software (Sweat Technologies® Australia).

Statistical analysis

Mean and standard error of the mean were calculated for all studied variables. The normal distribution and homogeneity of the data were verified by the Shapiro-Wilk and Levene´s tests, respectively. Analysis of variance for repeated measures (ANOVA) was used to comparisons among assessment times, and the Greenhouse-Geisser correction was applied if sphericity violation has been appointed by the Mauchly test. Scheffe post hoc was used when appropriate. Pearson correlation was used to test the relationship among variables. For all tests, significance level adopted was $P < 0.05$ and the Statistic 7.0 software was used (STATSOFT, Tulsa, USA).

RESULTS

The volunteers' race time corresponded to 14.4 ± 1.2h and 46.8 ± 3.4h and the average speed was 6.2 ± 0.5 km / h (43.2 ± 3.0% CV) and 4.9 ± 0.4 km / h (33.4 ± 1.8% CV) in 84 and 217 km, respectively.

The average values of the three somatotype components accounted for

3.4 ± 0.4 for endomorphy, 5.2 ± 0.4 for mesomorphy and 1.7 ± 0.3 for ectomorphy and its graphic representation, somatochart, is presented in Figure 1.

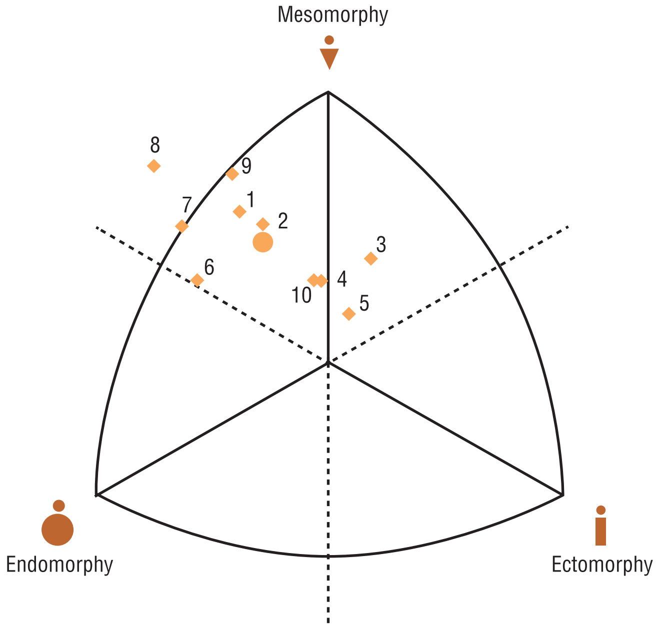

Figure 1. Graphical representation of the somatotype (somatochart). The numerical sequence of points (diamonds) denotes the order of arrival of the volunteers in the race. Circle corresponds to the average Somatotype.

Anthropometric measurements at initial, intermediate and final assessments are shown in Table 2. Significant differences (ANOVA, P <0.05) were found for BM, BMI, FFM and chest circumference, with post hoc showing significant reductions (p <0.05) during and at the end of the race compared with initial values. Furthermore, significant decrease (P <0.05) in arm circumference was observed at the end of the race compared to values obtained in initial and intermediate evaluations. %BF, FM, waist and thigh circumference values, as well as chest, abdominal and thigh skinfold thickness measurements have not changed significantly over the race (P> 0.05).

Thigh skinfold thickness and waist circumference identified before the race were positively correlated with the 217-km ultramarathon race time (P <0.05) (Figure 2).

Table 2. Anthropometric measurements at initial, intermediate and final assessments (n = 10)

	0 km	84 km	217 km	ANOVA
Body mass (kg)	72.3 ± 3.1	69.8 ± 3.1[a]	69.5 ± 3.0[a]	$F_{(2, 18)}$ = 48.391, P<0.0001
BMI (kg(m²)⁻¹)	24.5 ± 0.7	23.7 ± 0.7[a]	23.6 ± 0.7[a]	$F_{(2, 18)}$ = 48.171, P<0.0001
Fat mass (kg)	9.9 ± 1.5	9.2 ± 1.6	8.9 ± 1.5	$F_{(2, 18)}$ = 2.1582, P=0.15
Body fat (%)	13.2 ± 1.8	12.6 ± 1.9	12.3 ± 1.8	$F_{(2, 18)}$ = 1.0200, P=0.38
Fat-free mass (kg)	62.4 ± 2.2	60.6 ± 2.0[c]	60.5 ± 1.8[c]	$F_{(2, 18)}$ = 5.0737, P=0.02
Circumferences (cm)				
Chest	97.7 ± 1.8	95.7 ± 1.8[c]	95.3 ± 1.7[b]	$F_{(2, 18)}$ = 9.9044, P=0.001
Arm	29.9 ± 1.2	29.7 ± 1.4	28.9 ± 1.2[b,d]	$F_{(2, 18)}$ = 12.056, P=0.0006

Continue...

... continue

	0 km	84 km	217 km	ANOVA
Waist	86.0 ± 2.5	83.6 ± 2.2	84.2 ± 2.7	$F_{(1,253, 11,279)}$ = 2.4045, P=0.12*
Thigh	53.5 ± 1.0	52.6 ± 1.2	52.5 ± 0.9	$F_{(2, 18)}$ = 1.1975, P=0.32
Skinfold thickness (mm)				
Chest	9.4 ± 1.3	10.4 ± 1.3	9.4 ± 1.0	$F_{(2, 18)}$ = 2.0714, P=0.15
Abdominal	19.1 ± 2.7	17.7 ± 2.4	17.3 ± 2.3	$F_{(2, 18)}$ = 2.5585, P=0.10
Thigh	12.8 ± 1.3	12.9 ± 1.9	12.7 ± 1.7	$F_{(2, 18)}$ = 0.03203, P=0.96

Post hoc: a: P< 0.00001, b: P<0.005, c: P<0.05 compared at 0 km; d:P<0.005 compared at 84 km
* Greenhouse-Geisser correction applied if the sphericity violation was appointed by the Mauchly test. BMI= Body mass index

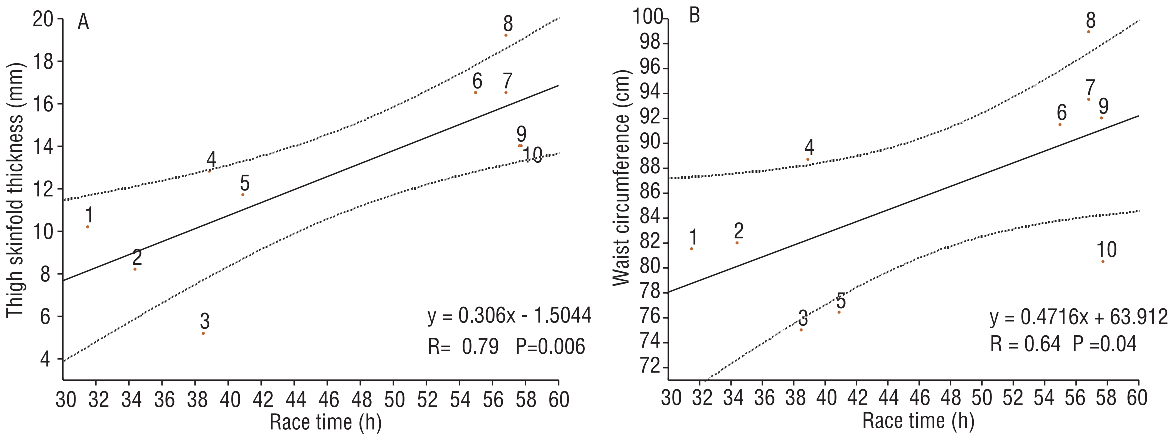

Figure 2. Correlation between race time and A) thigh skinfold thickness; B) waist circumference measured at baseline. Linear fit (solid line) and 95% confidence intervals (dotted line). The numerical sequence of points denotes the order of arrival of the volunteers in the race.

DISCUSSION

The main findings of this study were that athletes have in general somatotype classified as endo-mesomorph and that body mass, body mass index, fat-free mass and chest and arm girth values were reduced during the race. Moreover, pre-race thigh skinfold thickness and waist circumference measurements were positively correlated with total race time.

To our knowledge, this is the first study that evaluated somatotype in a sample of ultramarathon runners and the results presented here of dominant mesomorphy corroborate previous findings observed in a 243-km ultramarathoner[2] and in triathletes[22, 23].

In addition to a dominant musculoskeletal component, the present investigation also showed higher adiposity than linearity in these athletes, since the endomorphic component was larger than the ectomorphic component. When considering these results together, they suggest that the morphological constitution of ultramarathoners may differ from that observed in marathon runners, that these body characteristics can be valuable for ultramarathon athletes moving over rough terrain, such as dirt roads, as well as for provide them an important energy substrate for longer running events[1].

In relation to body composition identified during the race, this study found that significant reductions in BM, BMI, FFM and chest circumference occurred in the first 84 km of the race and kept up to 217 km while the decrease in arm circumference was checked only at the end of the race. Moreover, although it has not reached statistical significance, reduced FM values were found at 84 km (- 7.0%) and at the end (- 9.7%) of the race.

Significant reduction in BM values has been previously observed in athletes after 'Spartathlon' (246 km)[8], 24-h ultramarathon (~ 199km of distance covered)[7] and 'Marathon des Sables' (243 km)[9]. However, similar results were found in participants of the 'Western States Endurance Run' (*WSER*) evaluated at 90 and 160 km[4-6].

Establishing the possible reasons for these differences in BM responses has not been possible to date because many factors can influence the results such as volunteers of different age groups (40.3 ± 1.7 to 46.8 ± 2, than 1 year), initial BM (60.1 ± 8.3 to 72.3 ± 3.1 kg), sex (men only, or both), and different race times (24 to 46.8 ± 3.4 h), intensities (4.9 ± 0.4 to 8.3 ± 0.3 km/h) and hydration regimen (restricted or unrestricted) in these various competitions.

The results of this study corroborate the findings of Zouhal et al.[9], in which reduced BM was accompanied by reduced FFM and FM at 93 km and at the end of the 'Marathon des Sables', emphasizing that when reduced BM is observed in these races, it possibly does not occur solely due to dehydration[11].

In this sense, we also observed that the percentage change in BM represented on average -3.5% (-1.5 to -6.4%) in 84 km and -3.9% (-2.0 to -6.4 %) in 217 km, and the volunteer with the greatest reduction was the third fastest among those evaluated and ranked among the top 10 in the race.

The average reduction of 6.1% in BM values was observed after the 'Marathon des Sables', and the volunteer with the greatest reduction (-9.0%) was the fastest to finish the race (6th place) [9], and positive relationship between BM reduction (-5.1 ± 2.6%) and performance was observed in 24-hour ultramarathon[7]. Furthermore, triathletes that exhibited dramatic BM decrease (-10.7 to +3.7 %) during the 'South African Ironman' (224 km) were among the fastest to finish the race and this reduction was not associated with increased medical complications and rectal temperature[24].

Thus, reinforcing this set of previous results, our results also suggest that the classical assumptions to prevent dehydration during exercise based on BM reductions (i.e., to prevent dehydration, BM reductions must be less than 2% and discontinue exercise in case of BM reductions over 7%)[25, 26] need to be properly reassessed in ultraendurance events[9, 24].

The correlations observed in this study suggest that increased body fat deposits concentrated in the lower limbs and abdominal region, predicted by waist circumference[27], may have a negative impact on ultramarathon performance.

Interestingly, although Knetchle et al.[16] did not observe a relationship between anthropometric measurements and race time of athletes participating in the 'Swiss Jura Marathon' (350 km), our findings add to those observed in most previous studies in which BM, BMI, %BF and arm circumference were positively related with time or negatively related with speed in races such as *WSER* (160 km)[1, 17], '*Marathon Des Sables*' (243 km)[9] and '*Isar Run*' (338 km)[15].

CONCLUSION

We concluded that the average somatotype of ultramarathon runners was endo-mesomorph and BM, BMI, FFM and chest perimeter reductions have been observed in the first 84 km of the race. Furthermore, we found that anthropometric characteristics associated with body composition such as higher thigh skinfold thickness and waist circumference values were associated with lower performance of the athletes in 217-km ultramarathon in the mountains.

Acknowledgments

We would like to thank the volunteers, organizers and staff of the "Brazil 135 Ultramarathon". We also would like to acknowledge Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES), Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) (Proc. 305650/2009-2) and Fundação de Amparo à Pesquisa do Estado de São Paulo (FAPESP) (Proc. 2009/08535-5) for financial support.

REFERENCES

1. Hoffman MD. Anthropometric characteristics of ultramarathoners. Int J Sports Med 2008; 29(10): 808-11.
2. Ryder JJ, Grantham NJ, Kellett DW, Mcnaughton L, Lovell R, Jones GE. Marathon Des Sables: A Scientific Case Study. Res Sports Med 2004; 12(1): 33-44.
3. Carter JE, Ackland TR, Kerr DA, Stapff A. Somatotype and size of elite female basketball players. J Sports Sci 2005; 23(10):1057-63.
4. Nieman DC, Dumke CI, Henson DA, McAnulty SR, McAnulty LS, Lind RH, et al. Immune and oxidative changes during and following the Western States Endurance Run. Int J Sports Med 2003; 24(7): 541-7.
5. Nieman DC, Dumke CL, Henson DA, McAnulty SR, Gross SJ, Lind RH. Muscle damage is linked to cytokine changes following a 160-km race. Brain Behav Immun 2005; 19(5): 398-403.
6. Nieman DC, Henson DA, Dumke CL, Oley K, McAnulty SR, Davis JM, et al. Ibuprofen use, endotoxemia, inflammation, and plasma cytokines during ultramarathon competition. Brain Behav Immun 2006; 20(6): 578-84.
7. Kao WF, Shyu CL, Yang XW, Hsu TF, Chen JJ, Kao WC, et al. Athletic performance and serial weight changes during 12- and 24-hour ultra-marathons. Clin J Sport Med 2008; 18(2): 155-8.
8. Skenderi KP, Kavouras SA, Anastasiou CA, Yiannakouris N, Matalas AL. Exertional Rhabdomyolysis during a 246-km continuous running race. Med Sci Sports Exerc 2006; 38(6): 1054-7.
9. Zouhal H, Groussard C, Vincent S, Jacob C, Abderrahman AB, Delamarche P, et al. Athletic performance and weight changes during the "Marathon of Sands" in athletes well-trained in endurance. Int J Sports Med 2009; 30(7): 516-21.
10. Armstrong LE. Assessing hydration status: the elusive gold standard. J Am Coll Nutr 2007; 26(5 Suppl): 575S-84S.

11. Knechtle B, Knechtle P, Wirth A, Alexander Rust C, Rosemann T. A faster running speed is associated with a greater body weight loss in 100-km ultra-marathoners. J Sports Sci 2012; 30(11):1131-40.
12. Millet GY, Hoffman MD, Morin JB. Sacrificing economy to improve running performance--a reality in the ultramarathon? J Appl Physiol 2012; 113(3): 507-9.
13. Hoffman MD. Performance trends in 161-km ultramarathons. Int J Sports Med 2010; 31(1):31-7.
14. Wegelin JA, Hoffman MD. Variables associated with odds of finishing and finish time in a 161-km ultramarathon. Eur J Appl Physiol 2011; 111(1): 145-53.
15. Knechtle B, Duff B, Welzel U, Kohler G. Body mass and circumference of upper arm are associated with race performance in ultraendurance runners in a multistage race--the Isarrun 2006. Res Q Exerc Sport 2009; 80(2):262-8.
16. Knechtle B, Knechtle P, Rosemann, T. Race performance in male mountain ultra-marathoners: anthropometry or training? Percept Mot Skills 2010; 110(3 Pt 1): 721-35.
17. Hoffman MD, Lebus DK, Ganong AC, Casazza GA, Van Loan M. Body composition of 161-km ultramarathoners. Int J Sports Med 2010; 31(2):106-9.
18. Kranenburg KJ, Smith DJ. Comparison of critical speed determined from track running and treadmill tests in elite runners. Med Sci Sports Exerc 1996; 28(5): 614-8.
19. Guedes DP, Guedes JERP, Manual prático para avaliação em educação física. Barueri: Manole; 2006.
20. Stewart DA, Hannan WJ. Prediction of fat and fat-free mass in male athletes using dual X-ray absorptiometry as the reference method. J Sports Sci 2000; 18(4): 263-74.
21. Heath BH, Carter, JE. A modified somatotype method. Am J Phys Anthropol 1967; 27(1):57-74.
22. Anjos MAB, Fernandes Filho J, Novaes J.S. Características somatotípicas, dermatoglíficas e fisiológicas do atleta de triatlo. Fitness Perform J 2003; 2(1):49-57.
23. Leake CN, Carter JE. Comparison of body composition and somatotype of trained female triathletes. J Sports Sci 1991; 9(2):125-35.
24. Sharwood KA, Collins M, Goedecke JH, Wilson G and Noakes, TD. Weight changes, medical complications, and performance during an Ironman triathlon. Br J Sports Med 2004; 38(6):718-24.
25. Adolph, E.F.; Brown, A.H.; Goddard, D.R. Physiology of man in the desert. New York: Interscience; 1947. p. 16–33, 226–241, 326–42.
26. Convertino VA, Armstrong LE, Coyle EF, Mack GW, Sawka MN, Senay LC Jr., et al. American College of Sports Medicine position stand. Exercise and fluid replacement. Med Sci Sports Exerc 1996; 28(1): i-vii.
27. Pouliot MC, Despres JP, Lemieux S, Moorjani S, Bouchard C, Tremblay A, et al. Waist circumference and abdominal sagittal diameter: best simple anthropometric indexes of abdominal visceral adipose tissue accumulation and related cardiovascular risk in men and women. Am J Cardiol 1994; 73(7):460-8.

CORRESPONDING AUTHOR

Claudio Alexandre Gobatto
Universidade Estadual de Campinas.
Faculdade de Ciências Aplicadas.
Laboratório de Fisiologia Aplicada ao Esporte. Limeira, SP. Brasil.
Rua Pedro Zaccaria, 1300 - Caixa Postal 1068, CEP 13484-350
Limeira, São Paulo, Brasil.
E-mail: claudio.gobatto@fca.unicamp.br