Impact of body composition and physiological responses at half race to predict 10.000 m recreational road race

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Abstract:

The present study aims to investigate the association between the half 10.000 m race time, body composition characteristics and physiological responses at half race (i.e., 5.000 m); and to determine the predictor variables of 10.000 m road race time, in recreational female runners. Observational field study of a '10.000 m road race' in Brazil. A sample of 11 recreational runners (age, 45.1 ± 6.9 years), participated in the study. Before road race, body mass and stature were measured, body composition was determined by multi-frequency bioelectrical impedance analysis and blood lactate concentration ([Lac]) was collected. After the first 5.000 m (half road race distance), the rate of perceived exertion (RPE) and [Lac] were collected. The race time, in both tests race were also collected. In the bivariate analysis, absolute values of protein ($r = -0.63$), soft lean mass ($r = -0.61$) and fat free mass ($r = -0.61$), correlated to half race time (all, $p < 0.05$). Stepwise multiple regressions revealed that absolute fat free mass ($r^2 = 0.981$, $p < 0.001$) and rate of perceived exertion in half race ($r^2 = 0.973$, $p < 0.001$) were the best variables to predict 10.000 m road race time for recreational female runners. It seems that recreational female endurance performance is negatively related to absolute fat free mass, and the 10.000 m road race time might be predicted by the following equation ($r^2 = 0.983$, $p < 0.001$): Total race time (10.000 m; minutes) = $0.742 \times (\text{fat free mass, kg}) + 1.805 \times (\text{half race RPE; Borg6-20})$.

Key words: Body composition; recreational runner; rate of perceived exertion; endurance.

Introduction

Nowadays, running is the most popular sport and can be performed over several different distance ^{1,2}, and common long distance running events, such as 10.000 meters road race, is a popular distance among recreational runners. The greatest women's 10 kilometers runs in road history showed that at least 30 minutes are necessary to complete the test (e.g., women's world senior outdoor record is 30:21 set by Paula RADCLIFFE (GBR) on February 23, 2003).

Body composition can be affected by age, gender, race, genes, and numerous environmental and behavioral (e.g., years of training) factors. The association among a variety of morphologic characteristics and endurance running performance has been reported in literature ³⁻⁴. In fact, stature ⁵⁻⁶, body mass ⁷, body mass index ⁸⁻⁹, and body fat ¹⁰ have been investigated in several studies that aim to estimate the morphologic effect on endurance running performance, having particular importance those studies that emphasized the thickness of skinfolds as a 10.000 m running time predictor in male and female athletes. Also, it was supported that reduced thickness of the lower limb skinfolds were a result of high intensity running training ¹⁰⁻¹¹.

It is understandable that recreational long distance runners train less total kilometers per week and at a lower velocity than runners at a higher level ¹². However, it seems that peak running velocity during training is highly related to 5.000 m run times in female athletes ¹³. Although these results show that the relationship among morphologic characteristics, of elite athletes, and running performance have already been investigated it is still lacking accurate measures and prediction values of recreational female runners. In accordance, and apart from morphologic characteristics, the 10.000 m running speed is regulated by aerobic metabolism and demands a huge aerobic capacity ¹⁴, that's why a set of physiological parameters (objective and subjective measured) have been also related to endurance running performance in long distance races ³⁻¹⁵⁻¹⁶.

Although there are few studies with women ^{3,4}, the possible role of the subject's gender in mediating the intensity of RPE has been evaluated in previous research ¹⁷. However, considering body composition and physiological responses at half race to predict 10.000 m recreational road race, gender specific validation of RPE

for women has not been undertaken. In Addition, comparisons with male subjects of trials at RPE 11 (light exertion), followed by an RPE (somewhat hard) trial, and an RPE 15 (hard) trial outcome of running exercise on a treadmill (laboratory) and outdoor track (field) demonstrated that RPE is able to be used as a physiologically valid tool for outdoor track exercise prescriptions, particularly when blood lactate is used as the intensity criterion¹⁸.

There seems to be a lack of studies focused on the association among morphologic and physiological profile⁷⁻¹³, with the peak running velocity moment and the 10.000 m of road race time of female recreational runners. So, the current study hypothesized that significant relationship would be found among morphologic characteristics and half 10.000 m race time of female recreation runners, and that these morphologic characteristics and physiological parameters allows to predict a 10.000 m road race time. In other words, this study aims to investigate the association among the half 10.000 m race time, body composition characteristics and physiological responses measured at half race (i.e., 5.000 m); and to determine the predictor variables of 10.000 m road race time, of recreational female runners.

Method

Sample

A group of 11 recreational female 10.000 m road runners (age: 45.1 ± 6.9 years), participated in the study. The investigation was done in accordance with resolution 196/96 of the national health council and was approved by the Local Ethics Committee (Brazil) and the athletes were informed of the experimental procedures, and after being briefed on the procedures and purpose of the study, the participants signed a written and informed term of consent to participate. The data collection was done in July 2012.

Morphologic profile

One day before the race, were realized the procedure of body mass and stature measurements. The athletes were submitted to measurements of body mass and stature on a scale (Welmy scale[®], Santa Barbara do Oeste, São Paulo, Brazil), coupled with a stadiometer, both estimated to 0.1 kg and 0.1 cm, respectively. With this data we calculated body mass index (kg/m^2).

Body composition analysis was evaluated with multi-frequency bioelectrical impedance analysis (BIA), which has been demonstrated to be an alternate method to measure body composition¹⁹⁻²⁰. The Inbody 520 (Biospace Co., Beverly Hills, CA) body fat analyzer was used to measure Total Body Water (L), Protein (kg), Mineral (kg), Body Fat Mass (kg), Soft Fat Mass (kg), Fat Free Mass (kg) and to estimate Bone Mineral Content (kg).

Physiological profiling

The '10.000 m road race' took place in the City of Maringá, Brazil. The athletes started at 9:00 a.m. and had to run one flat lap on road (asphalt). The weather was fine and dry. The temperature was 17 ° Celsius at the start and the relative humidity was at 65%. The organizer provided nutrition and drinks at eight aid stations. Blood lactate concentrations ([Lac]) were collected immediately before race and at 5.000 m distance (i.e., half race distance). The [Lac], expressed in mmol.L^{-1} , was determined by analysis of 25 μL blood samples collected from digital pulp, with the use of portable strip analysers (Accutrend[®], Germany). Variation (Δ) in [Lac] ($\Delta[\text{Lac}]$) was also calculated having as reference the data collected in start line and 5.000 m distance

The rate of perceived exertion (RPE) was measured at half race distance with the Borg 6-20 scale²¹. The participants were asked to make use of any number on the scale to classify their global effort. Latency or no exertion was associated to a 6 classification, and 20 the classification indicating maximum exertion. All participants were familiar with the scale in use.

Statistical Analysis

Normally distributed data are presented as mean (M) and standard deviation (SD), i.e., $M \pm SD$. The coefficient of variation of performance ($\text{CV}\% = 100 \times \text{SD}/M$) for half race time and 10.000 m were calculated. The bivariate correlation analysis was used to study the association of the morphologic profile, physiological profile and endurance performance variables with 5.000 m race time. In continuation, multiple linear regression analysis with stepwise selection was used to investigate the relationship of morphologic (Model 1) and physiological (Model 2) variables with endurance performance (i.e., 10.000 m race time). A 3th multivariable linear regression (Enter method) was performed (Model 3), accounting for identified influence factors. In addition, bootstrap samples were drawn 5000x, and three linear regressions with the chosen independent variables were performed. Statistical analyses were conducted using PASW Statistics (version 20.0; SPSS Inc., Chicago, IL), and the probability value of less than 0.05 was accepted as significant for the multiple linear regression analysis.

Results

The 11 athletes completed the first 5.000 m within 23.7 ± 2.0 minutes (CV = 8.5%), running at a mean speed of 12.6 ± 1.1 km.h⁻¹ (SI: 3.5 ± 0.30 m.s⁻¹), and finished the 10.000 m within 52.2 ± 4.0 min (CV = 7.6%), running at a mean speed of 11.6 ± 0.9 km.h⁻¹ (SI: 3.2 ± 0.3 m.s⁻¹). Results showed that endurance performance at 5.000 m was significantly associated with 10.000 m road race time ($r = 0.94$, $p < 0.001$)

For the body composition analysis, absolute values of protein ($r = -0.63$, $p = 0.039$), soft lean mass ($r = -0.61$, $p = 0.048$) and fat free mass ($r = -0.61$, $p = 0.048$), were significantly and negatively related to half road race time. Nevertheless, no significant relations were observed among the physiological parameters and endurance performance in half race. Results are presented in Table-1.

Table 1. Association between endurance performance in half road race time (5.000 m) with: the morphological profile, physiological parameters at 5.000 m and endurance performance in 10.000 m, for recreational female runners

Variable	Descriptive statistics			5.000 m race time
	M±SD	Min	Max	r (Sig)
Age (years)	45.1 ± 6.9	31	53	-0.27
Stature (m)	1.62 ± 0.03	1.58	1.68	-0.54
Body mass (kg)	58.2 ± 5.1	47.6	64.4	-0.39
Body Mass Index (kg/m ²)	22.3 ± 1.8	19.1	25.2	-0.16
Body Composition Analysis (MFBIA)				
Total Body Water (L)	32.0 ± 2.8	27.2	37.1	-0.60
Protein (kg)	8.6 ± 0.7	7.3	9.9	-0.63 (*)
Mineral (kg)	3.1 ± 0.2	2.8	3.5	-0.56
Body Fat Mass (kg)	14.5 ± 4.0	7.6	20.0	0.07
Soft Lean Mass (kg)	41.1 ± 3.6	34.9	47.5	-0.61 (*)
Fat Free Mass (kg)	43.7 ± 3.8	37.2	50.4	-0.61 (*)
Osseous (kg)	2.6 ± 0.2	2.3	2.9	-0.57
Physiological parameters				
[Lac] at 5.000 m (mmol.L ⁻¹)	5.1 ± 0.9	4.0	7.0	0.30
Δ[Lac] 0 to 5.000 m (mmol.L ⁻¹)	1.5 ± 1.0	0.2	3.5	0.19
Borg 6-20 (#)	11 ± 2	8	13	0.20
Endurance performance				
Velocity, 0 to 5.000 m (km.h ⁻¹)	12.6 ± 1.1	11.3	14.4	-0.99 (***)
10.000 m race time (minute:seconds)	52.2 ± 4.0	43.6	56.6	0.94 (***)

Sig: NS, not significant; *, p-value < 0.05; ***, p-value < 0.001

The morphologic variables were inserted into a linear regression model (Model 1), and results showed that absolute fat free mass ($t(10) = 23.6$; $p < 0.001$) was related to total race time ($F(1,10) = 554.7$; $p < 0.001$; $R^2_a = 0.981$). When the physiological variables were inserted into a linear regression model (Model 2), the rate of perceived exertion (Borg 6-20; $t(10) = 20.0$; $p < 0.001$) was related to total race time ($F(1,10) = 399.3$; $p < 0.001$; $R^2_a = 0.973$). Nevertheless, when considered the booth profiles (i.e., morphologic and physiological profiles), results of linear regression model (Model 3) showed that the rate of perceived exertion (Borg 6-20) at half road race ($t(10) = 1.6$; $p > 0.05$) and absolute fat free mass ($t(10) = 2.6$; $p < 0.05$) were related to 10.000 m race time ($F(1,10) = 319.4$; $p < 0.001$; $R^2_a = 0.983$). In fact, 10.000 m race time can be predicted by the following equations for recreational female road (asphalt) runners: Total race time (minutes) = $1.805 \times$ (rate of perceived exertion; Borg 6-20) + $0.742 \times$ (fat free mass, kg). Results are presented in Table-2.

Table 2. Variables predicting 10.000 m road race time: results of tree multiple linear regressions

Independent Variables	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval	
	B	Std. Error	Beta			Lower Bound	Upper Bound
Model 1							
Fat Free Mass (kg)	1.182	0.050	0.991	23.553	<0.001	1.071	1.294
Model 2							
RPE at 5.000 m	4.765	0.238	0.988	19.982	<0.001	4.234	5.297
Model 3							
Fat Free Mass (kg)	0.742	0.284	0.622	2.613	0.028	0.100	1.384
RPE at 5.000 m	1.805	1.148	0.374	1.572	0.150	-0.792	4.403

Model 1: $R = 0.991$; $R^2 = 0.982$; $R^2_{\text{adjusted}} = 0.981$.

Model 2: $R = 0.988$; $R^2 = 0.976$; $R^2_{\text{adjusted}} = 0.973$.

Model 3: $R = 0.993$; $R^2 = 0.986$; $R^2_{\text{adjusted}} = 0.983$.

Bootstrap estimates (n=5000) were performed for all measurements and confirmed the high stability of the regression models. Bootstrap mean values for the corresponding coefficients were close to the corresponding regression coefficients of the original models. Results are presented in Table-3.

Table 3. Results of bootstrap for coefficients of multiple linear regression models (Model 1, 2 and 3)

Independent Variables	B	Unstandardized Coefficients		Sig.	95% Confidence Interval	
		Bias	Std. Error		Lower Bound	Upper Bound
Model 1						
Fat Free Mass (kg)	1.182	0.001	0.046	0.001	1.098	1.280
Model 2						
RPE at 5.000 m	4.765	0.016	0.193	0.001	4.456	5.239
Model 3						
Fat Free Mass (kg)	0.742	-0.007	0.289	0.041	0.118	1.299
RPE at 5.000 m	1.805	0.003	1.123	0.112	-0.406	4.091

Model 1: $R = 0.991$; $R^2 = 0.982$; R^2 adjusted = 0.981.

Model 2: $R = 0.988$; $R^2 = 0.976$; R^2 adjusted = 0.973.

Model 3: $R = 0.993$; $R^2 = 0.986$; R^2 adjusted = 0.983.

Discussion

This work aims to study the association between the half 10.000 m race time, body composition characteristics and physiological responses at half race (i.e., 5.000 m); and to determine the predictor variables of 10.000 m road race time, in recreational female runners.

Firstly, it is important to emphasize that the participants in this study are female recreational runners, which take on average more 20 minutes to finish the 10.000 m race than elite athletes. All runners are part of the same race and the same competitive level (veterans). The results revealed that the athletes are faster in the first half race than in the last 5.000 m (~ difference 1Km.h⁻¹). In fact, the literature points that the 5.000 m performance outcome results from athletes' sport preparation process (i.e., effect of the methodology and physiology of training periodization). However, this study has a special focus on fundamental aspects of training biology and sports performance, i.e., kinantropometry.

It is known that body composition is affected by many variables. The impact of morphology on athlete performance (i.e., test time) in long distance events and, in particular, in tests of 10.000 m has been studied since the beginning of the twentieth century. However, our study found no significant association between age, stature, body mass and BMI and time at the 5.000 m race.

Although some studies²² have highlighted the predicted power of skinfolds to explain the running time at the 10.000 m, the variables considered in this study, differ from the earlier ones (anthropometric) and uses the results of body composition analysis.

When we talk about body composition we refer to the study of different chemical components of the human body. A detailed analysis allows the quantification of a wide variety of body components such as water, proteins, fat, glycogen, minerals and other components. Notwithstanding the body relative proportions of these components are relatively identical in all individuals the amount of each constituent varies from individual to individual especial when speaking about athletic populations.

This subject is of considerable interest considering the significant interaction among energy consumption, functional capacity and body composition. Information on body composition, with regard to exercise and sport, can also be important not only because its significant effect on athletic performance but also because exercise can alterate its variables. Finally, body composition provides information on specific adaptations to different physical training regimens.

Thus, fluctuations in body weight cannot be adequately interpreted unless the quantitative variations of its components are taken into account. Physical activity has an effect on body composition, especially on skeletal muscle. Skeletal muscle is the largest non-adipose tissue component considering the tissue-system level and it plays an important role in physical activity and many biochemical processes²³. Fat-free mass has commonly been used as a surrogate measure of skeletal muscle mass. So, one of the most important components of fat free mass is total protein (which composes soft lean mass together with water). The in protein differences among runners can be a result of time, duration and intensity of train.

Our results show a negative association among protein and time at 5.000 m race showing that bigger muscles or protein values are important to achieve better results. The same is also true when considering soft lean mass and free fat mass ($r = -0.61$ for the two correlations) both dependent on the quantity of protein component. Although fat free mass does not always accurately reflect specific changes in muscle mass or differences in muscle mass among individuals in this study fat free mass (absolute) presented, in fact, a negative

and significant association with the testing time in the 10.000 m, allowing us predicting 10.000 m time with a high percentage of success (98.1%).

Recreational 10.000 m runners train for less overall kilometers per week, and at a lower velocity, than runners at a higher level. However, the results suggest that the volume and intensity of training in endurance athletes influence performance even when we compare recreational athletes like ours with elite athletes. Indeed, it is accepted the significant association between the load parameters and performance of endurance athletes²²⁻²⁴. Thus, although recreational 10.000 m runners train regularly less the effects of the load parameters are similar and can emphasize the differences in athletic performance.

However, the known association between train velocity and time at 5.000 m race in competitions with the same distance (i.e., 10.000 m) together with the results of this study (significant association with body composition) suggest that athletes morphology suffered adaptations (induced by training) allowing them to be more efficient.

The present finding indicates that as exercise performance increases along an intensity dependent continuum there are corresponding and interdependent increases in response intensity along perceptual (RPE) and physiological demonstrating a positive relation. The results show that RPE responses at the end of the first 5.000 m (RPE 11) could be used as an applied validation criterion to predict the final time in the 10.000 m road race. These findings are in agreement with previous applications in out-comes underlying effort continua models.

Accordingly, results are consistent with the Borg's effort continua model. A secondary purpose of the present investigation was to establish concurrent validity between morphologic and physiological variables and the RPE responses. The linear regression of the third model showed that the rating of perceived exertion (Borg 6-20) at half road race and absolute fat free mass were related to 10.000 m race time. Also, these reports are in agreement with a larger sample to verify the association between RPE and the [Lac], which demonstrated to be positive and moderate in the present research ($r=0.59$).

Regarding the third model of the present study, it observed that the combination of morphologic (Model 1: FFM) and physiological variables (Model 2: RPE) improved the prediction of the running time in the 10.000 m. However, the explanatory power of the first model is very similar to that presented in this morphologic and functional model (Model 3; FFM and RPE). Moreover, although the model is significant, the RPE variable is not significant. That fact weakens the model and attaches the greatest importance to the morphologic and physiological models.

This demonstrates that the power of the first and the second models allow us to affirm that both are appropriate (in a simply way) to predict the final time of 10.000 m in road recreational female runners. In other words, the present study clearly shows that FFM and RPE at half road race are significant predictors of 10.000 m performance. Thus, a thorough assessment of an individual's performance in a long distance event can include the perception that the athlete is under the physiological response of her body to stress at half race i.e., the RPE (using Borg 6-20 scale) seem to be a valid tool to predict women performance in 10.000 m recreational road race.

This investigation is limited to the rather small simple size of 11 female 10.000 m road runners athletes. Nevertheless, the number of participants seems quite representative due to the low number of recreational female athletes generally participating in 10.000 m races. In fact, other studies on female runners were not able to recruit more female athletes, even at events with more participants²⁵⁻²⁶. A further limitation is the fact that food and fluids intake was not recorded.

Conclusions

This paper intended: (1) to verify the association between the half 10.000 m race time, morphologic characteristics and physiological responses at half race (i.e., 5.000 m); and (2) to observe the predictor variables of 10.000 m road race time, in recreational female runners.

The results show that RPE responses at the end of the first 5.000 m could be used as an applied validation criterion to predict the final time in the 10.000 m road race. These findings are in agreement with previous applications in out-comes underlying effort continua models. Accordingly, results are consistent with the Borg's effort continuous model. A secondary purpose of the present investigation was to establish concurrent validity between morphologic and physiological variables and the RPE responses. The linear regression models showed that the rating of perceived exertion (Borg 6-20) at half road race and absolute fat free mass were related to 10.000 m race time.

Also, these reports are in agreement with a larger sample to verify the association between RPE and the [Lac], which demonstrated to be positive and moderate in the present research. Regarding the third model, it observed that the combination of morphologic (Model 1: FFM) and physiological variables (Model 2: EPR) improved the prediction of the running time in the 10.000 m. Indeed, the force of the first and the second models allow us to affirm that both are appropriate (in a simply way) to predict the final time of 10.000 m in road recreational female runners.

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