Performance of young female swimmers in short, middle and long distance events

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Abstract

The aim of this study was to explain the role of anthropometric, physiological and technical parameters controlled by chronological age and maturity status in performance of young female swimmers (n=42; 13.3±0.57 years-old) in short (100 meters), middle (200 meters) and long distance events (800 meters). Hierarchical multiple regression analysis (stepwise method) was used to examine the variance of all races. Anaerobic power and critical speed explained 92% ($p<0.05$), 84% ($p<0.05$) and 99 % ($p<0.05$) of the variance in the average speed of, respectively, 100 meters, 200 meters and 800 meters front crawl. In spite of stroke parameters were not included in explanatory models, swimming index showed very high correlations with 100 m ($r=0.85$, $p<0.01$), 200 m ($r=0.69$, $p<0.01$) and 800 m ($r=0.72$, $p<0.01$). Performance of young female swimmers in short, middle and long distance races is explained predominantly by physiological components and in minor degree by technical efficiency.

Keywords: Youth; Physiology; Technical parameters; Swimming; Training.

Introduction

The participation of children and teenagers in swimming competitions has been raised the curiosity of researchers to a better understanding of training planning and competition analysis. The swimming performance depends on the improvement of propulsion and reducing drag (water resistance to movement of the swimmer) through the specific technique reflecting the ability of the swimmers to propel their body in water with low energy cost. The factors that maximize propulsion include anaerobic and aerobic metabolism, muscle power and technique while the factors that minimize the drag include anthropometry and body composition[1-2]. Moreover, the processes of growth and maturation influence the performance of young athletes[3] and the relationship of these processes with motor skills in sports training can lead to reflections of a more effective swimming program.

The literature of performance of young female swimmers approaches the subject with different aims. Regarding to the distance of race, many studies analyzed 100 meters front crawl[4-9], 100 meters butterfly[10], 100 meters breaststroke[11], 200 meters front crawl[6], 400 meters front crawl[5-6,12-14]. There are no studies that have researched long distance (800 meters freestyle) race with young female swimmers with focus on analysis of performance.

Although biological age has been considered in studies cited above in short and middle distance events, only two of them considered chronological age[5] and biological age[14] as control variables in their multidimensional analysis of performance. Not always the investigations discriminated the gender (male/female) in their analyses and also some studies have referenced the statistical results and conclusions grouping both genders[5,7-8,12,14].Often researchers have privileged the internal validity of the measures, i.e., not feasible for real situation of training (ecological validity with scientific criteria) with large groups, this issue may be a concern since is important to analyze all performance parameters in similar conditions of those that is usually done in a swimming pool[15]. In general, many papers focused on variables that could support the talent selection process, leaving to argue how variables could influence the youth training or even make changes in the structure of competitive swimming for young people.

In other words, there are great interests of researchers in comprehension of performance of young female swimmers, although results are nonconsensual due to different delimitations of their works. However, it is possible to state that, for a better scientific understanding of the phenomenon "performance of young swimmers", the type of event (race), a multidimensional analysis with anthropometric components, specific fitness, as well technical parameters and specific gender should be considered in the analysis of performance. Growth and maturational (chronological and biological age) aspects should be checked and added to the explanations when dealing with children and adolescents, mainly because this population may have different rates of growth and maturation[3]. Summing up, this research aims to:

1. Explore the relationship among physiological, technical and anthropometrical variables in short, middle and long distance events in female swimmers;
2. Explain the variance of performance in short, middle and long distance events in female swimmers using the concept of ecological validity, in other words, with measurements approved scientifically, but also, which could be available for practical situations to a better comprehension of institutions and coaches.

The hypothesis of this study is that female swimmers have anthropometrical, physiological (aerobic and anaerobic metabolism) and technical variables that explain their performance in short and middle distance events and that aerobic metabolism and technical parameters have greater prediction in long distance event.

Methods

This is a correlational study; the main concern is to find and to evaluate the intensity of relationship among dependent and independent variables.

Sample

Among four clubs invited to take part in this investigation, only three agreed to participate voluntarily and two of them were between the five best ranked clubs in that age- group in local state. Forty-two female swimmers (12 - 14 years-old) participated in this investigation. After knowing the purposes of the study, a consent form was given to the parents and/ or guardians in whom they authorized in writing the participation of the children/ guardians. In the research, this consent form is in accordance with the guidelines outlined by Ethics Committee of University. Swimmers had been competing at the regional and national levels at time of measurements. The sample was classified as pubescent in agreement with TANNER stages[16]. Subjects had a background of three to four years of regular training and the time of practice was about fifteen hours per week. During the testing period, the weekly training volume was around twenty kilometers and sessions were performed mainly at aerobic pace and technique drills.

Study Design

The measurements were undertaken over 2 days: on Day 1, anthropometric measures, self-assessment of sexual maturation, anaerobic power test, performance in 100 meters front crawl, while the performance of 200 meters and 800 meters front crawl were taken on Day 2 as displayed in FIGURE 1.

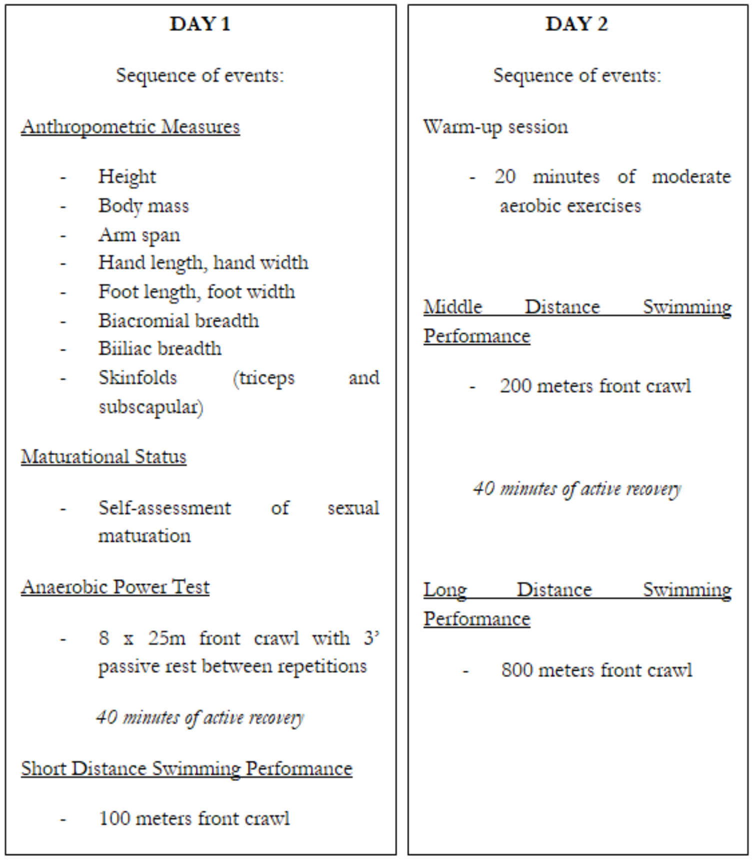

FIGURE 1 - Schematic representation of study design.

Anthropometric measures, sexual maturation and chronological age

Anthropometric measurements were taken before beginning of training and are described as follow: height, body mass, arm span, hand length, biacromial breadth, biiliac breadth, skinfolds (triceps and subscapular) were measured according to Lohman et al.[17]; hand width, foot width and foot length were measured according to Norton and Olds[18]. Body fat measurement was estimated according to the methods of Slaughter et al.[19]. Moreover, from the arm span and height measures, was calculated the Arm Span/Height Index[18], and from the biacromial and biiliac breadth measures, was calculated the Biacromial/Biiliac Index[18].

The self-assessment of sexual maturation was analyzed by drawings of representative stages for sexual pilosity (pubic hair) from one to five (stage one means biological immaturity while stage five means biological maturity) according Tanner stages[16].

Chronological age was obtained by birth date and described in decimals to assure the great variability of months of people with the same age.

Swimming performance

All tests were performed in a 50 meters pool (long course). Water temperature was kept between 25 and 28 degrees, as determined by FINA (Fédération Internationale de Natation). A stopwatch (Technos, YP2151/8P, BR) with precision of one hundredth of a second was used. The front crawl swimming was performed according to the regulations of FINA.

Anaerobic power test

Anaerobic power test[20] was performed by eight front crawl repetitions in a maximum effort, over a 25 meters distance (8 x 25m front crawl), with three minutes of passive rest among repetitions. Subjects began the swim in the water and researchers started the timing manually when swimmers feet left the wall of the pool and times were finished when any hand was achieving the distance of 25 meters. After eight repetitions, the average time was calculated and converted into average speed (m/sec) representative of each subject's performance. Athletes were not wearing bathing costumes that could offer potential hydrodynamic advantages. The warm-up session in the pool lasted around twenty minutes and was composed of technical and low intensity aerobic exercises.

Performance in the 100 meters front-crawl (short distance)

Performance in the 100 meters front crawl was measured in a maximum effort and start was given when the swimmers were in the water. This performance occurred after forty minutes of active recovery after the anaerobic power test with purpose of regenerate metabolic system[21]. Times were recorded in seconds and converted into speed (m/sec).

Performance in the 200 (middle distance) and 800 meters (long distance) front crawl

Performance in the 200 m and 800 m front crawl were done in a maximum effort with interval of forty minutes between repetitions with aerobic exercises of low intensity with purpose of regenerate metabolic system[21]. The times were recorded in seconds converted into speed (m/sec). The warm-up session in the pool lasted approximately twenty minutes supervised by swimmers coach and was composed of technical and moderate intensity aerobic exercises.

Critical Speed Estimation

The critical speed was obtained through a regression slope between the two distances (200 and 800 meters) and the time (seconds) obtained in each distance[22]. A greater velocity that can be maintained continually without fatigue defines Critical Speed[23]. The amount of work performed at the expense of the complete utilization of anaerobic stores and the mechanical power sustainable at the expense of the maximal O_2 consumption of the muscle group in question underlying the critical power definition[23]. Critical speeds must be calculated with exhaustive times situated between two and twenty minutes[24]. Studies have supported the critical speed evaluation method by two distances in swimming[6,25-26].

Stroke Rate, Stroke Length, Swimming Index

The stroke rate was determined from the elapsed time for three arm cycles between 15 meters and 45 meters of the first 100 meters of each distance swim (100m, 200m, 800m). The distance between 15 and 45 meters considered to eliminate the effects of starting from the wall and of turning. The timing was started when the right hand of the swimmer was entered the water and was stopped when the right hand of the swimmer was entered the water for the fourth time, completing three arm cycles. After that, was calculated the number of stroke cycles per second (cycle/s)[27].

The values for stroke length and swimming index were extracted from the measure of stroke rate, where:

a) Stroke length (m/cycle) = 100, 200, 800 swimming speed (m/sec) divided by stroke rate (cycles/s).

b) Swimming Index was calculated by multiplying the swimming speed (m/sec) by stroke length (m/cycle). This index assumes that, at a given speed, the swimmer who moves the greatest distance per stroke has the most efficient swimming technique[27].

Statistical analysis

Pearson's correlation coefficients were used to evaluate relationships between independent variables and swimming races; partial correlation coefficients were used to eliminate the effect of chronological age and maturational status between dependent and independent variables. Data were interpreted according the parameters of Fergunson[28] where very high if $0.81 \le r < 1.0$; high if $0.49 \le r < 0.81$; moderate if $0.16 \le r < 0.49$; weak if $0.04 \le r < 0.16$ and very weak if $r < 0.04$. The average speed during the 100, 200, 800 meters front crawl were considered as dependent variables and all other variables were considered independent variables on hierarchical multiple regression analysis (stepwise method), which was used to verify the combination of significant independent variables that could predict/explain the dependent variables. Both chronological age and maturational status were used as covariates in multiple regression models. All assumptions of multiple regression analysis were observed respecting the number of candidate variables limited to the minimum of one variable (n_v) in the model to each five subjects (n) of sample ($n / n_v \le 5$) i.e, $n_v \le 7$ in each model in the present study[29]. Furthermore, the total sample (n=42) was splitted randomly in two groups (group 1=80%;

group 2=20%). The group 1 (n=34) took part in all analysis to generate regression models and group 2 (n=8) was used in the validation process of models generated[30]. The power and effect size of the linear multiple regression were calculated using G*Power software v. 3.0.10 taking into account the sample size available and the number of variables predicted in each model. A p-value of 0.01 was used to select variables to be included in the multiple regression models, and a p-value of 0.05 was used to evaluate the fit of multiple regression models.. Statistical analyses were conducted using SPSS 13.0 (Chicago, IL).

Results

The descriptive values of subjects are displayed in TABLE 1 and were classified according each dimension of performance.

TABLE 1 - Mean ± Standard Deviation (SD), from chronological age, anthropometry, body composition, maturity status, physical conditioning, stroke parameters and short, middle and long distance races of young female swimmers.

n=34	Mean	SD
Decimal chronological age (years)	13.26	0.57
Anthropometry		
Body mass (kg)	50.69	7.36
Height (cm)	160.64	5.28
Arm Span (cm)	162.33	6.53
Arm span / height index	1.01	0.02
Hand length (cm)	17.34	0.68
Hand width (cm)	9.57	0.45
Foot length (cm)	24.00	1.06
Foot width (cm)	9.13	0.53
Biacromial breadth (cm)	35.61	1.72
Biiliac breadth (cm)	26.10	1.55
Biacromial/biiliac index	1.37	0.11
Body Composition		
Body fat (%)	18.32	4.60
Maturity Status		
Sexual maturity (Tanner Stages)	3.53	0.56
Specific Physical Conditioning		
Anaerobic power (m/sec)	1.47	0.12
Critical speed (m/sec)	1.05	0.08
Stroke Parameters		
Stroke rate (cycle/s)	0.72	0.06
Stroke length (m/cycle)	1.80	0.17
Swimming Index (m^2/cycle/s)	2.35	0.36
Short, middle and long distance races		
100 meters (m/sec) - short distance	1.30	0.11
200 meters (m/sec) - middle distance	1.18	0.09
800 meters (m/sec) - long distance	1.08	0.08

TABLE 2 presents the correlational analysis between three distances races and all independent variables. Since chronological age and maturity status showed themselves significantly correlated with almost all races (exception for maturity status and 800 meters race), it was decided to run partial correlations (controlled by both variables) to verify the specificity of relations between anthropometry, physical conditioning and stroking parameters with all races. Partial correlations showed that anthropometric variables aren't correlated with any distance race. However, physiological and stroke parameters continued keeping the effect on performances supposing that these variables are influenced by training.

TABLE 2 - Correlations (*r*) and partial correlations (partial *r* - *controlled by chronological age and maturity status*) of anthropometric, body composition, maturity status, physical conditioning and stroke parameters variables with short, middle and long distance races.

	100 m		200m		800m	
	r	partial *r*	*r*	partial *r*	*r*	partial *r*
Decimal chronological age	0.56**	n/a	0.39*	n/a	0.44*	n/a
Body mass	0.20	-0.05	0.13	-0.18	-0.08	-0.30
Height	0.43**	0.35	0.20	0.11	0.20	0.03
Arm Span	0.38*	0.33	0.27	0.12	0.23	0.10
Arm span / height index	0.05	0.08	0.22	0.06	0.15	0.17
Hand length	0.12	-0.07	0.04	-0.19	0.01	-0.12
Hand width	0.27	0.09	0.16	0.07	0.12	-0.01
Foot length	0.02	0.02	-0.08	-0.20	-0.24	-0.28
Foot width	0.07	0.09	-0.01	-0.11	-0.21	-0.24
Biacromial breadth	0.07	0.07	-0.01	0.02	0.06	0.02
Biiliac breadth	0.36*	0.30	0.25	0.20	0.16	0.11
Biacromial/biiliac index	-0.27	-0.20	-0.23	-0.15	-0.11	-0.09
Body fat	-0.15	-0.25	0.00	-0.21	-0.22	-0.27
Sexual Maturity	0.33*	n/a	0.42*	n/a	0.31	n/a
Anaerobic power	0.95**	0.92**	0.78**	0.80**	0.76**	0.67**
Critical speed	0.78**	0.70**	0.89**	0.86**	0.99**	0.99**
Stroke rate	0.45**	0.56**	0.38*	0.56**	0.36*	0.36
Stroke length	0.51**	0.40*	0.41*	0.29	0.44*	0.39
Swimming Index	0.85**	0.83**	0.69**	0.69**	0.72**	0.68**

*p<0.05;
**p<0.01;
n/a = not available.

In order to run the regression analysis of 100m, 200m, 800m both chronological age and maturity status were used as covariates. This allows us to understand in every explanatory model, the contribution of anthropometry, body composition and training (specific conditioning and stroke parameters). The TABLES 3, 4 and 5 show the linear multiple regression models for, respectively, 100, 200 and 800 meters.

TABLE 3 - Linear Multiple Regression Model for Performance in the 100-Meters Front Crawl Race among Young Female Swimmers.

N = 34		Beta Standard Coefficient	Linear B Model Coefficient	Significance Level	Colinearity	
					Tolerance	*VIF*
R= 0.97	Intercept		-0.15	0.34		
R^2= 0.93	Anaerobic Power	0.80	0.75	0.00	0.43	2.35
R^2aj.=0.92	Critical Speed	0.19	0.27	0.04	0.43	2.35
S.E= 0.03						

*p<0.05.

TABLE 4 - Linear Multiple Regression Model for Performance in the 200-Meters Front Crawl Race among Young Female Swimmers.

N = 34		Beta Standard Coefficient	Linear B Model Coefficient	Significance Level	Colinearity	
					Tolerance	*VIF*
R= 0.93	Intercept		0.25	0.18		
R^2= 0.86	Critical Speed	0.58	0.66	0.00	0.43	2.35
R^2aj.=0.84	Anaerobic Power	0.43	0.32	0.00	0.43	2.35
S.E= 0.04						

*p<0.05.

TABLE 5 - Linear Multiple Regression Model for Performance in the 800-Meters Front Crawl Race among Young Female Swimmers.

N = 34		Beta Standard Coefficient	Linear B Model Coefficient	Significance Level	Colinearity	
					Tolerance	*VIF*
R= 0.99	Intercept		0.05	0.15		
R^2= 0.99	Critical Speed	0.92	0.93	0.00	0.46	2.35
R^2aj.=0.99	Anaerobic Power	0.10	0.07	0.00	0.43	2.35
S.E= 0.00						

*p<0.05.

In hierarchical regression analysis, the covariates are mandatory to be included in the models, for this reason, both chronological age and maturity status were included in the models, however, in any of the models those variables contributed significantly to explain short, middle or long distance races, that is why the variables were not included in TABLES 3, 4 and 5.

The second important finding is that any anthropometric, body composition or stroke parameters were not included in explanatory models of any distance race. This was expected for anthropometry and body composition since they were not correlated with any race as showed in partial correlations (TABLE 2). Nonetheless, was not expected that stroke parameters would not be included in the models. It means that physiological variables, expressed by anaerobic power and critical speed are strongly related to performance in many distances of swimming.

Taken into account the sample of study (n=34) and the number of predictors in all three linear regression models (two predictors for each model as seen in TABLES 3, 4 and 5), the significant results ($p < 0.05$) with sufficient power (80%), an effect size of 0.35 derivate a power of 0.84, which means that is more than expected by scientific community (a regular value is 0.80) giving an a exact probability of error (p) of 0.04.

To evaluate the validity of the prediction models, was used the technique of the predicted results versus actual results[30] on group 1 sample (80%; n=34) and after that, the same procedure was done with group 2 sample (20%; n=8). The results are displayed in TABLE 6.

TABLE 6 - Correlation between actual results and predicted results in order to validate the models obtained in linear regression analysis.

Sample	*Distances*	*Correlations (r) between Actual results x Predicted results*
80% (n = 34)	100 meters	0.97**
	200 meters	0.93**
	800 meters	0.99**
20% (n = 8)	100 meters	0.95*
	200 meters	0.73
	800 meters	0.98**

*Correlation is significant at the 0.05 level; **Correlation is significant at the 0.01 level.

As we may see, the models were validated for 100 (p<0.05) and 800 meters (p<0.01). The same not occurred for 200 meters in spite of high correlation between actual and predicted results in group 2.

The assumptions of normality for all dependent and independent variables in the models were checked and are reported by Shapiro-Wilk test (standardized x unstandardized residuals values). This test assumes that all variables are normally distributed when p value is higher than 0.05[29]. The values are reported as follows: a) 100 meters (p=0.586); b) 200 meters (p=0.663); c) 800 meters (p=0.608).

All these findings conduct us to a better comprehension of physiological dimension of female athletes in puberty and the analysis of anaerobic and aerobic energetic components related to the time of each distance race.

Discussion

The results presented in TABLE 2 (r) for chronological age and maturity status are in total accordance with Maglischo[20], who stated that performance of age-group swimmers are usually associated with chronological age and maturity status as observed. However, it is necessary a better comprehension of how these two variables are related with other determinants of performance since, they were not predictors in any explanatory models (TABLE 3).

The most recent study for young swimmers provided by Sokołowski et al.[9] showed significant correlations between velocity at respiratory compensation point (r=0.81; p<0.01), velocity at anaerobic threshold (r=0.53; p<0.05), velocity at VO_{2MAX} (r=0.47; p<0.05), stroke length (r=0.61; p<0.01), swimming index (r=0.81; p<0.01) and velocity of 100 meters crawl in girls with similar mean chronological age (13.4 ± 0.26 years) compared to the girls in this study (13.3 ± 0.55 years). The present study showed significant correlations (non-partial) with swimming index (r=0.85; p<0.01), critical speed (r=0.78; p<0.01), stroke length (r=0.51; p<0.01) (TABLE 2) meaning that as aerobic components as stroke parameters are strongly related to performance of short distance race. Noriega -Sanches et al.[7] found the forced inspiratory volume in the first second (aerobic - pulmonary component variable) as only explanatory variable contributing in 52% of variance for girls (15 years and older). Otherwise, Geladas et al.[4] explained only 17 % of in girls (12.68±0.06 years) by height, hand length and horizontal jump, notwithstanding, there wasn't any anthropometrical or physical capacity variables that were high or very high correlated with performance. Morais et al.[8] were able to explain 69% of variance in 100 meters with a special intention to provide a deep insight of how determinants variables interplay or interact on explanation of performance, but they didn't discriminate the results among genders, which do not allow any statement of performance for each gender.

It was not found in any comparative study above, a representative anaerobic variable that could explain the results in 100 meters, however, from the contribution of energy systems related to the duration of maximal effort, the anaerobic component is predominantly related to performance which have an approximated duration until 75 - 90 seconds[21,31].

In the only study able to compare performance of young female swimmers in 200 meters Mezzaroba et al.[6] found that stroke length, stroke index (stroke parameters) and lactate minimum (aerobic component variable) explained 99% of variance of 200 meters. It should be noted that the range of chronological age comprise people from 10 to 16 years-old, and this large range may cause conflicts when we stand to analyze performance of people in a critical maturational development. This can be viewed when comparing time results with the actual work, the average speed for 200 meters in the present study is 1.18m/s (85 seconds) (TABLE 1), this is the almost the same average speed reached by sample in 100 meters in Mezzaroba et al.[6] study (1.19±0.11 m/s), i.e., the levels of performance are completely different; comparing both studies within the same race (200 meters) (1.18±0.09 m/s x 1.08±0.09 m/s) the difference is approximately eight seconds in advantage for the present study reinforcing the critical difference of performance when analyzing people from diverse chronological age and maturational status.

Furthermore, the present work showed that critical speed (r=0.86, p<0.01), anaerobic power (r=0.80, p<0.01) and swimming index (r=0.69, p<0.01) were the most correlated variables with 200 meters and critical speed and anaerobic power explained together 84% of variance in 200 meters. In general, aerobic power, anaerobic power and stroke parameters play important roles in middle distance, despite the fact that stroke parameters were not included in the explanatory model (TABLE 4).

There were no studies in the literature able to establish any comparison with 800 meters race for young female swimmers. With the easy access to performance of short and middle distance events, researchers have more difficult to measure performance of young athletes in longer distances. Nonetheless, the present study found the most significant explanatory model when compared with short and middle distances, it was found that long distance race is 99% explained by critical speed and in a small percentage, but still significant in the model, explained by anaerobic power (TABLE 5).

The presence of anaerobic and aerobic components on all explanatory models for three distances may be explained by some physiological mechanisms like lower anaerobic power in younger people. These mechanisms include lower levels of phosphofrutokinase (PFK), lower sympathoadrenal acitivity, maturational differences in muscle fiber distribution, contractile properties and lower levels of testosterone[32-34]. Moreover, youngers have less quantity of stored glycogen in their muscles and less concentration of creatine phosphate (CP)[35]. With less anaerobic capacity between child and adults, the difference between aerobic capacity and total physiological capacity is shorter than adults[20]. It is suggested that hormonal changes occurring during puberty and neurological adaptations (improved motor coordination) are the most important contributors to anaerobic function during growth[33]. Furthermore, most expressive results from aerobic component is explained by higher body mass, height, chronological age and maturity compared with their peers[32-33,36]. There are studies reminding us that in spite of anaerobic component has lower trainability and genetic factors account for approximately 50% of total variance[33], the aerobic capacity can be trained[32,37]. In relation to short races, like 100 meters, swimmers must possess a strong aerobic capacity because a good level of aerobic capacity speeds up the regeneration process between intensive workouts[38].

Summing up, it is clearly evidenced that for short, middle or long distance races, anaerobic power, critical speed and stroke parameters are the best determinants for performance in young female swimmers, even when are measured by different protocols. As mentioned at introduction of this work, all procedures used in this study are reliable and related to previous scientific findings and for those institutions / instructors that are not able to acquire expensive materials, may be very well assisted by less expensive procedures.

Study Limitations

From a biomechanical point of view, the stroke rate was measured during the first 100 meters of each race. In this case, for analysis of 200 and 800 meters, the stroke rate may modify along the course and for this reason, the value applied on correlation and multiple regression analysis of middle and long distance races could be overestimated.

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Conflicts of interest

The authors report there is no competing interest to declare.

Resumo

Desempenho de jovens nadadoras em provas de curta, média e longa distância.

O objetivo deste estudo foi explicar o papel dos parâmetros antropométricos, fisiológicos e técnicos controlados pela idade cronológica e pelo estado maturacional no desempenho de jovens nadadoras (n=42; 13.3±0.57 anos) em provas de curta (100 metros), média (200 metros) e longa distância (800 metros). Uma análise de regressão múltipla hierárquica (método stepwise) foi utilizada para examinar a variância de todas as provas. A potência anaeróbica e a velocidade crítica explicaram respectivamente, 92% ($p<0.05$), 84% ($p<0.05$) e 99 % ($p<0.05$) da variância na velocidade média dos 100 metros, 200 metros e 800 metros nado crawl. Apesar dos parâmetros técnicos de nado não serem incluídos nos modelos explanatórios, o índice de eficiência de nado mostrou altas correlações com 100 metros ($r=0.85$, $p<0.01$), 200 metros ($r=0.69$, $p<0.01$) e 800 metros ($r=0.72$, $p<0.01$). O desempenho de jovens nadadoras em provas de curta, média e longa distância é explicado predominantemente por componentes fisiológicos e em menor grau pela eficiência técnica.

Palavras-chave: Jovens; Fisiologia; Parâmetros técnicos; Natação; Treinamento.

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