Original article

Anthropometric profile of young triathletes and its association with performance variables

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Summary

The different nature of each discipline in triathlon makes consensus difficult for optimal anthropometric factors for a high global performance, especially in young people. The aim was to analyse the correlation of the cineanthropometric factors with the performance observed in the different test. Young triathletes (44 male and 20 female) were subjected to a full anthropometric measurement as well as to the performance assessment (100 m and 400 m in swimming, cycling critical power and 1000 m run). Variables were subject to a normal test (Shapiro-Wilk) and correlational analysis (coefficient of Spearman). The results show that both in the 100 m and 400 m test, basic body measures, Biacromial and Biiliocrestal diameters, as well as arm perimeters, thigh and chest (perimeters only in girls) have the highest correlations with performance. The cycling test shows a moderately significant and negative correlation (p = .556) between the leg fold and the relative critical power only in girls. Finally, run correlated negative to the percentage of fat mass in both sexes (boys: p = -.323; girls: p = -.646). Results indicate that arm span and height should be taken into account in swimming performance, as well as the fat tissue in career performance, especially in girls by professionals involved in the development process and selection of talent in young triathletes.

Key words:
Anthropometry. Triathlon. Talent. Growth. Maturation.

Perfil antropométrico de jóvenes triatletas y su asociación con variables de rendimiento

Resumen

La diferente naturaleza de cada disciplina en triatlón dificulta el consenso en relación a los factores antropométricos óptimos para un alto rendimiento global, especialmente en jóvenes. Por eso, el objetivo fue analizar la correlación de los factores cineantropométricos con el rendimiento observado en los diferentes test. Triatletas infantiles y cadetes (44 masculinos y 20 femeninos) fueron sometidos a una medición antropométrica completa, así como a la evaluación del rendimiento (100 m y 400 m en natación, potencia crítica en ciclismo y 1.000 m en carrera). Las variables fueron sometidas a una prueba de normalidad (Shapiro-Wilk) y un análisis correlacional (coeficiente de correlación de Spearman). Los resultados muestran que tanto en el test de 100 m como en el de 400 m, las medidas corporales básicas, los diámetros Biacromial y Biileocrestal, así como los perímetros del brazo, muslo y tórax (perímetros sólo en chicas) tienen las correlaciones más altas con el rendimiento. En el test de ciclismo se observa una correlación moderadamente significativa y negativa (p = -0,556) entre el pliegue de la pierna y la potencia crítica relativa sólo en chicas. Finalmente, el test de carrera a pie correlacionó negativamente con el porcentaje de masa grasa en ambos sexos (Chicos: p = -0,323; chicas: p = -0,646). Estos resultados indican que se deberían tener en cuenta, especialmente, la estatura y la envergadura en el rendimiento en natación, así como el tejido graso en el rendimiento de carrera, especialmente en chicas, por aquellos profesionales que intervienen en el proceso de desarrollo y selección de talento en jóvenes triatletas.

Palabras clave:
Antropometría. Triatlón. Talento. Crecimiento. Maduración.

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Introduction

Triathlon is a combined endurance sport involving back-to-back swimming, cycling and running events. Numerous studies have shown that not only physiological aspects such as economy of movement or VO_2max[1,2] but also anthropometric factors influence performance in the sport[3]. The differences between the three disciplines making up triathlon hinder consensus when it comes to drawing firm conclusions regarding the optimal anthropometric factors for high overall performance because such factors do not affect the three events in equal measure[4]. The specific somatotypes of swimmers, cyclists and runners reveal dissimilar values[5-7] which are hard to extrapolate to the optimum specific somatotype of the triathlete.

In general, performance in triathlon in adults has been linked to taller individuals, longer lower limbs contributing to running performance[8] and longer upper limbs facilitating swimming performance[9,10]. Triathletes would also appear to be smaller than swimmers and more akin to runners and road cyclists[3].

Body mass is another prominent factor to take into account in endurance sports, especially in those in which the athletes need to carry their own body weight[11].

Landers *et al.*[9] observed that senior triathletes performed significantly better than junior triathletes, showing that lower fat mass was the characteristic most related to overall success in the sport. Body segment length was also seen to be important to performance, especially in swimming.

Canda *et al.*[3] described the complete anthropometric profile of the triathlete and found that, in the men, juniors triathletes had less body mass and were shorter both in height and sitting height than senior triathletes. The junior triathletes, both male and female, also presented greater fat percentages and values related to endomorphy than the seniors. At the same time, in boys they only noticed differences in the anterior thigh skinfold, which was smaller for triathletes categorised as level 1, when comparing according to performance level. In contrast, they observed a lower percentage of fat, lower values of endomorphy and a greater muscle percentage in level 1 female triathletes.

Accordingly, after evaluating a sports orientation programme in Belgium, Pion *et al.*[7] noted that the factor which most differentiated triathletes from other athletes was the body fat percentage and performance in the endurance test.

Unlike a few years ago, more triathletes are now trained from an early age and, therefore, changes can be observed in their body morphology[4]. Consequently, the aim of this study was to analyse the extent to which kineanthropometric factors and performance in the tests for each of the disciplines making up the triathlon were correlated in young athletes.

Method

Participants

A total of 64 U14 and U16 triathletes (44 male and 20 female) took part in the research. The triathletes who took part in this research trained for a total of 6-10 hours a week, split, roughly, into 2-3 hours swimming, 1-2 hours running and 2-3 hours cycling. All the triathletes had to meet the following inclusion criteria: (one) to have between 2 and 4 years' experience in triathlon, (two) to belong to a club and have a coach responsible for their training and (three) to perform all the performance tests rating over 8.5 on the Borg scale. All the participants and/or their parents/guardians signed the informed consent (1978 Declaration of Helsinki, revised in 2008) and were informed of the benefits, risks and objective of the study, the protocol for which had been previously approved by the Ethics Committee at the University of Alicante (UA-2016-06-0).

Procedure and instruments

The anthropometric measurements were taken following the international standards set by ISAK[12]. The data were collected by an ISAK level II anthropometrist, taking into account the intraobserver variability associated with measurements indicated in 2019 (5% for skinfolds and 1% for other measurements). The approved, calibrated anthropometric equipment used consisted of: a wall-mountable height rod (precision: 1 mm); Tanita scales (precision: 100 g); a Rosscraf narrow, non-stretching metal measuring tape (precision: 1 mm), a Holtain small diameter bone pachymeter (precision: 1 mm); a Holtain skinfold calliper (precision: 0.2 mm). Basic measurements were taken: skinfolds, perimeters and bone diameters. The measurements of these variables were used to calculate fat mass[13], bone mass[14] and muscle mass[15], following the specifications for children and adolescents. To calculate the somatotype, the average somatotype was determined using the method devised by Heath-Carter and the classification of somatotype categories according to Duquet and Carter[16].

Several performance tests were then carried out for each discipline. The swimming and running tests were held in the same day; in the morning the anthropometric measurements were taken and the swimming test was conducted (9 a.m.), and the running test was conducted in the afternoon (6 p.m.). All the triathletes did the same warm-up for both swimming and running. The next day there was a session so the participants could familiarise themselves with the velodrome and then the cycling test was conducted. At the end of each test, the athletes were asked individually to rate their perceived exertion in conditions of confidentiality[17,18] in order to ensure the assessment of maximum capacity for each test.

Swimming test. The swimming tests consisted of a 100-metre and then a 400-metre freestyle test[19,20], starting from the water and touching the wall in a heated, in a 25-metre, indoor pool.

3-min all-out cycling test. The cycling test was conducted in a velodrome between 9 and 11 a.m. All the triathletes did the same warm-up (adapted from Burnley *et al.*) [21]. The power data were collected using a power meter (Powertap G3, precision: ± 1.5%) on the rear wheel (Zipp 404 carbon) and a bike computer (Garmin Edge 810). For inclusion in the analysis of the data for the cycling test, the data had to reflect a reproducible power profile and the maximum power peak had to be reached in the first 5 seconds[21,22]. The open-source software Golden Cheetah for MAC OS X (v. 3.4) was used to import the data to a spreadsheet (Microsoft Excel 2016).

Running test. The 1000-metre running test[23] was conducted on a 400-m synthetic race track.

Statistical analysis

The dependent variables were subjected to a test of normality (Shapiro-Wilk). Spearman's rank correlation coefficient was calculated. The significance level was set at 0.05 in all cases. Statistical analysis of the data was carried out using version 24 of IBM® SPSS® (Statistics Package for the Social Sciences) MAC and Microsoft Excel 2016® for MAC.

Results

Characteristics of the sample

Table 1 shows by sex all the variables of the sample which were analysed.

100-metre swimming test (Swm100)

The stroke rate -SR- showed no significant correlation with any of the variables in either sex. Stroke length -SL- and mean speed -MS- gave the highest positive correlations with the basic measurements (height, arm span, etc.) and with the biceps and leg skinfolds in the boys. In the girls, the greatest positive correlation was observed with wrist and thorax diameters. In both sexes, positive correlations were registered between both the biacromial and bicristal diameters, and swimming speed.

400-metre swimming test (Swm400)

The SR seen during the test did not give any notable correlations with any of the anthropometric variables of either sex. Meanwhile, as with the data collected in the 100-m test, both SL and MS showed moderately positive correlations with the basic measurements (height, sitting height, arm span and body mass), but only in boys. In the male triathletes, it was observed that those with smaller biceps, thigh and leg skinfolds, sum of the 8 skinfolds and fat mass percentage swam the 400-m test more quickly. Moderate positive correlations involving wrist diameter, bone mass and biacromial and bicristal diameters were only observed in the girls. As occurred with the girls in the 100-m test, the highest correlations were between arm, leg and thorax perimeter, and SL and MS.

3-min all-out cycling test (Cyc 3min all-out)

In female triathletes, a significant but moderate negative correlation (p = -0.556) was registered between the leg skinfold and the power to-weight ratio. In male triathletes, no such significant correlation was seen. Moderate correlations were observed between absolute critical power and body mass, as well as sitting height and leg length in the boys, and height, arm span and leg length in girls.

Table 1. Characteristics of the participants (Mean ± standard deviation).

	Male (N=44)	Fem (N=20)	Total (N=64)
Age (years)	14.5±1.5	14.7±1.3	14.6±1.4
Height (m)	167.4±10.5	162.0±6.4	165.0±9.2
Sitting height (m)	85.9±6.3	82.8±5.0	84.8±6.0
Arm span (m)	169.6±10.8	162.6±6.4	166.5±9.7
Body mass (kg)	56.8±9.4	51.6±6.8	54.5±8.7
Leg length (m)	81.6±6.3	78.4±3.9	80.5±5.7
Subscapular (mm)	6.9±2.6	8.6±2.8	7.6±2.8
Triceps (mm)	7.7±4.7	11.8±3.4	9.3±4.7
Biceps (mm)	4.1±3.6	6.6±2.1	5.1±3.3
Iliac crest (mm)	10.6±5.9	12.7±5.0	11.4±5.6
Supraspinal (mm)	7.2±4.4	8.8±4.1	7.8±4.3
Abdominal (mm)	10.8±6.8	14.1±6.0	12.1±6.6
Thigh (mm)	12.5±7.4	20.2±4.4	15.5±7.4
Leg (mm)	8.3±6.2	12.5±4.1	9.9±5.8
Σ 8 skinfolds (mm)	63.9±42.1	76.6±44.3	69.3±43.1
Relaxed arm (mm)	27.4±2.8	24.4±1.9	26.2±2.9
Contracted arm (mm)	29.2±2.8	24.9±1.7	27.5±3.2
Maximum thigh (mm)	49.0±3.6	46.6±2.8	48.3±3.5
Maximum leg (mm)	34.8±2.2	32.9±2.1	34.1±2.3
Thorax (mm)	85.5±6.7	77.8±6.5	83.0±7.5
Wrist (cm)	5.4±0.3	4.9±0.2	5.2±0.3
Humerus (cm)	6.8±0.3	6.0±0.2	6.5±0.4
Femur (cm)	9.3±0.5	8.6±0.3	9.0±0.6
Biacromial (cm)	36.4±2.8	34.7±2.0	35.7±2.6
Bicristal (cm)	25.9±2.0	25.0±1.6	25.5±1.9
Endomorphy	2.5±1.1	3.0±1.0	2.7±1.1
Mesomorphy	4.2±1.0	3.0±0.6	3.6±0.8
Ectomorphy	3.2±0.9	3.6±0.6	3.4±0.8
Fat mass (kg)	9.1±4.3	10.2±3.3	9.6±3.8
% fat mass	14.6±5.2	19.6±4.5	17.1±4.9
Skeletal muscle mass (kg)	32.9±4.1	19.7±6.4	26.3±5.3
% skeletal muscle mass	54.5±2.0	38.2±10.5	46.4±6.2
Bone mass (kg)	10.9±1.4	8.8±0.8	9.8±1.1
% bone mass	18.1±1.5	17.2±4.1	17.6±2.8
Swm100 SR (strokes per minute)	45.2±6.1	41.4±5.0	43.6±6.0
Swm100 SL (cm per stroke)	55.9±10.8	57.8±9.2	56.7±10.1
Swm100 MS ($m \cdot s^{-1}$)	1.3±0.2	1.2±0.1	1.3±0.2
Swm400 SR (strokes per minute)	37.3±4.4	33.7±4.3	35.7±4.7
Swmt400 SL (cm per stroke)	55.6±10.5	60.4±31.0	57.8±22.4
Swm400 MS ($m \cdot s^{-1}$)	1.1±0.2	1.0±0.2	1.0±0.2
Cyc 3min all-out CP(W)	275.5±56.4	198.0±39.1	247.6±62.8
Cyc 3min all-out PWr ($W \cdot kg^{-1}$)	4.5±0.5	3.8±0.5	4.3±0.5
Run 1.000m MS ($km \cdot h^{-1}$)	18.5±1.7	15.8±1.6	17.3±2.1

Male: male; Fem: female; SR: stroke rate; SL: stroke length; MS: mean speed; CP: critical power; PWr: power-to-weight ratio.

Running test (Run1000)

In the boys, a low correlation was recorded between sitting height and arm span, and performance in the running test. A low negative correlation was also observed with the thigh and calf skinfolds; that is to say, the greater the skinfold, the lower performance. In the girls, there was a moderate negative correlation between the calf, biceps, triceps and abdominal skinfolds, and performance. Finally, there was a correlation with the fat mass percentage in both sexes, more notable in the girls (Table 2, Figure 1, Figure 2 and Figure 3).

Discussion

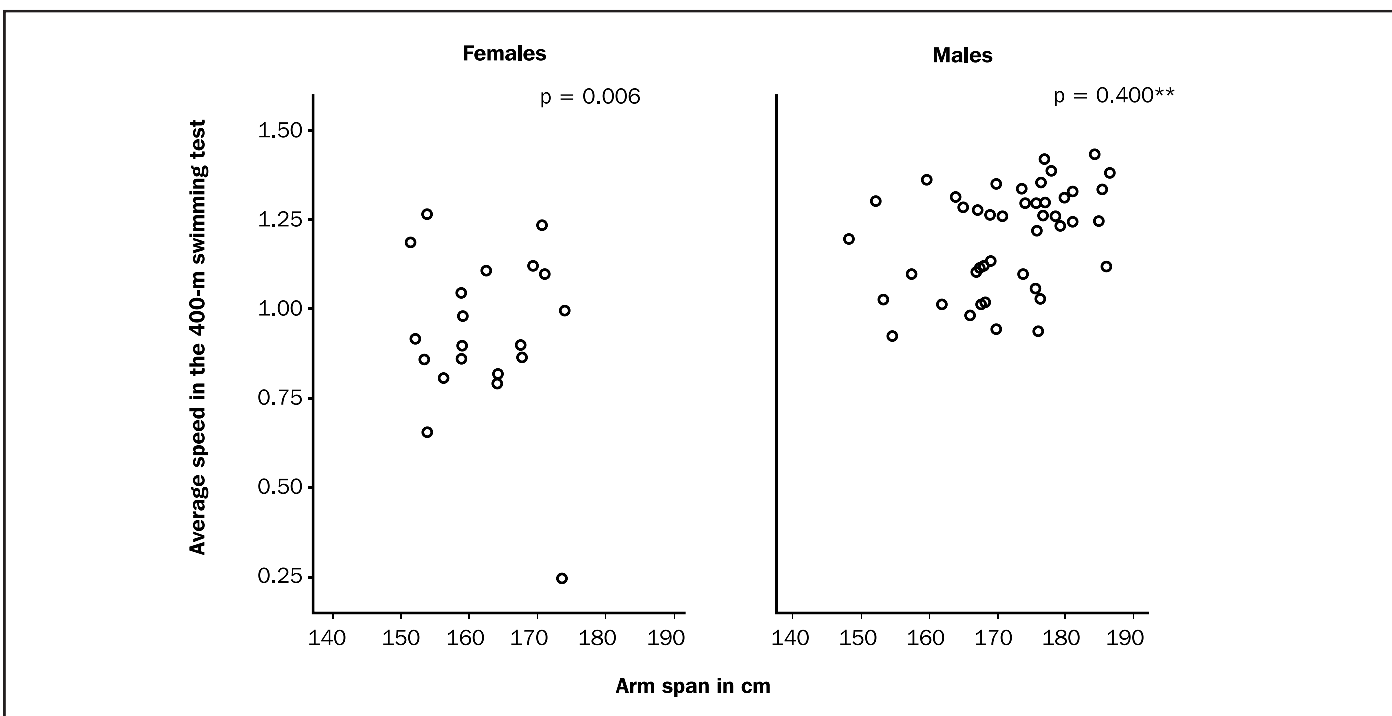
Firstly, of the basic measurements, the arm span variable correlated positively with performance in both swimming tests for young triathletes, a result consistent with other studies[9,10,24,25]. Height would also seem to be quite decisive for performance in the 400-m swimming test, and leg length would appear to be more closely related to performance over shorter distances, as suggested in other sources[26].

Height and sitting height are both very important measurements when it comes to assessing an individual's maturational status, as reflected in the equation for determining Peak Height Velocity[27]. Growth and development may be particularly relevant to performance at these ages[28]. However, the same behaviour is not observed in girls. Given that they usually mature two years earlier than boys, it is possible that the results in girls result from the fact that the vast majority were at or had already passed Peak Height Velocity[29]. In a similar vein, Moreira *et al*.,[10] highlighted differences in swimming speed over 25 m after 10 weeks of rest, attributing the difference especially to the effects of growth.

In the males, the fat mass percentage was negatively correlated with performance in the two swimming tests and in the running test, results consistent with other studies[7,30]. More specifically, the biceps and thigh skinfolds, and the sum of the 8 folds were the factors most correlated with performance in both the swimming tests, while the thigh and leg skinfolds both correlated negatively with performance in the 400-m swimming test and the 1,000-m running test.

In the cycling test, no correlation with the power-to-weight ratio was observed in the males, these results agreeing with those registered by Landers *et al*.[9]. These authors found no relationship in their factor analysis between the factor they called segmental length and cycling performance in elite junior and senior triathletes, even though this study was conducted at a time when drafting was not permitted. In the girls, the biceps and thigh skinfolds were negatively correlated with the power-to-weight ratio. Although some studies correlate a low fat percentage with cycling performance[31], it may be that this effect is not observed in adolescents because most triathlons are held on flat ground and with drafting, and the importance of fat tissue may not be so relevant in this form of the discipline. The greatest correlation values for absolute critical power in the cycling test were found to be

Figure 1. Relationship between the triathletes' arm span in cm and mean speed in the 400-m swimming test by sex.



ρ: Spearman's rank correlation coefficient: ** p <0.01.

Table 2. Spearman's rank correlation coefficient for the anthropometric measurements and the different performance tests.

	100-m swimming test				400-m swimming test				Cycling test				Running test	
	Male		Fem		Male		Fem		Male		Fem		Male	Fem
	SL	MS	SL	MS	SL	MS	SL	MS	CP	PWr	CP	PWr	MS	VMS
Height (m)	0.497**	0.369**	0.219	0.250	0.382**	0.341**	0.379**	0.322*	0.339	-0.076	0.636*	-0.454	0.318*	-0.146
Sitting height (m)	0.469**	0.541**	0.263	0.340	0.381**	0.498**	0.371*	0.418*	0.625**	0.276	0.357	-0.385	0.379**	0.199
Arm span (m)	0.463**	0.436**	0.361**	0.414**	0.438**	0.400**	0.561**	0.006	0.332	-0.085	0.789**	-0.393	0.368**	-0.215
Body mass (kg)	0.503**	0.400**	0.290*	0.393**	0.443**	0.366**	0.526**	0.452**	0.611**	0.168	0.807**	-0.429	0.209	-0.079
Leg length (m)	0.331*	0.265*	0.384*	0.403*	0.272	0.267	0.510**	0.439*	0.585**	0.286	0.846**	-0.257	0.218	-0.231
Subscapular (mm)	-0.161	-0.231	0.107	0.229	-0.072	-0.266	0.274	0.242	-0.002	-0.299	0.715**	-0.161	-0.251	-0.300
Triceps (mm)	-0.286	-0.150	0.035	0.015	-0.160	-0.203	0.122	0.038	0.434*	0.154	0.726**	-0.356	-0.168	-0.595**
Biceps (mm)	-0.447**	-0.481**	0.045	0.109	-0.274	-0.536**	0.197	0.164	0.266	0.088	0.448	-0.305	-0.357*	-0.486*
Iliac crest (mm)	-0.264	-0.161	0.243	0.373	-0.107	-0.185	0.520	0.376	0.053	0.024	0.549*	-0.542*	-0.059	-0.289
Supraspinal (mm)	-0.340*	-0.269	0.024	0.206	-0.204	-0.290	0.360	0.221	0.292	0.070	0.760**	-0.231	-0.137	-0.315
Abdominal (mm)	-0.298	-0.245	0.206	0.254	-0.160	-0.223	0.372	0.237	0.406*	0.235	0.782**	-0.270	-0.236	-0.469*
Thigh (mm)	-0.378*	-0.344*	0.077	0.069	-0.243	-0.373*	0.264	0.096	0.432*	0.181	0.768**	-0.265	-0.363*	-0.192
Leg (mm)	-0.453**	-0.465**	-0.206	-0.294	-0.306*	-0.505**	-0.135	-0.341	-0.010	0.096	0.499	-0.556*	-0.363*	-0.600**
Σ 8 skinfolds (mm)	-0.339*	-0.316*	0.132	0.196	-0.152	-0.359*	0.351	0.192	-0.210	-0.088	0.638*	-0.077	-0.300	-0.392
Relaxed arm (mm)	0.122	0.012	0.288	0.531**	0.168	0.064	0.578**	0.633**	0.215	0.114	0.761**	-0.361	<0.001	0.262
Contracted arm (mm)	0.153	0.111	0.360	0.615**	0.212	0.121	0.614**	0.704**	0.565**	0.217	0.777**	-0.386	-0.032	0.385
Maximum thigh (mm)	-0.118	-0.081	0.377	0.583*	-0.018	-0.018	0.618*	0.731**	0.424*	0.089	0.779**	-0.186	0.109	0.600
Maximum leg (mm)	0.103	0.088	0.190	0.268	0.079	0.004	0.413*	0.389	0.508*	0.076	0.393	-0.714	0.224	0.070
Thorax (mm)	0.281	0.271	0.532*	0.766**	0.257	0.335	0.907**	0.738**	0.435*	0.184	0.640*	-0.286	0.328	0.433
Wrist (cm)	0.287	0.303*	0.577**	0.587**	0.135	0.240	0.587**	0.547**	0.482	-0.024	0.107	-0.214	0.385*	0.055
Humerus (cm)	0.166	0.216	0.313	0.335	0.076	0.252	0.460*	0.351	0.508*	0.234	0.235	-0.237	0.353*	0.125
Femur (cm)	-0.271	-0.274	0.106	0.061	-0.467**	-0.283	0.260	0.184	0.508*	0.302	0.212	-0.152	0.178	-0.171
Biacromial (cm)	0.471**	0.486**	0.279	0.446*	0.410**	0.423**	0.504**	0.483**	-0.094	0.180	-0.757**	0.321	0.309	0.136
Bicristal (cm)	0.392**	0.509**	0.287	0.473**	0.360**	0.492**	0.455*	0.495**	0.550**	0.202	0.229	-0.472	0.227	-0.335
Endomorphy	-0.287	-0.267	0.035	0.145	-0.142	-0.310*	0.246	0.135	0.451*	0.297	0.442	-0.460	-0.064	0.350
Mesomorphy	-0.282	-0.243	0.101	0.254	-0.279	-0.191	0.149	0.287	0.297	0.151	0.682**	-0.307	-0.245	-0.515
Ectomorphy	0.322*	0.220	-0.256	-0.578**	0.235	0.218	-0.617**	-0.551**	0.299	0.323	0.018	-0.089	0.024	-0.209
Fat mass (kg)	-0.258	-0.197	0.148	0.221	-0.149	-0.276	0.395	0.252	-0.403	-0.281	-0.446	0.171	-0.154	-0.344
% fat mass	-0.384*	-0.348*	-0.131	-0.165	-0.228	-0.434**	-0.017	-0.462*	0.334	0.062	0.811**	-0.275	-0.443**	-0.684*
Skeletal muscle mass (kg)	0.309*	0.247	0.248	0.293	0.291	0.281	0.433*	0.381	0.041	0.001	0.611*	-0.214	0.276	-0.243
% skeletal muscle mass	0.029	-0.092	0.079	0.148	0.220	-0.112	0.146	0.250	0.582**	0.143	0.793**	-0.286	-0.110	-0.127
Bone mass (kg)	0.257	0.229	0.432*	0.472*	0.059	0.216	0.636**	0.557**	-0.428*	-0.210	0.504	-0.036	0.346	0.018
% bone mass	0.034	-0.009	-0.213	-0.496*	-0.217	-0.032	-0.580**	-0.530**	0.522**	0.170	0.725**	-0.482	0.084	-0.251

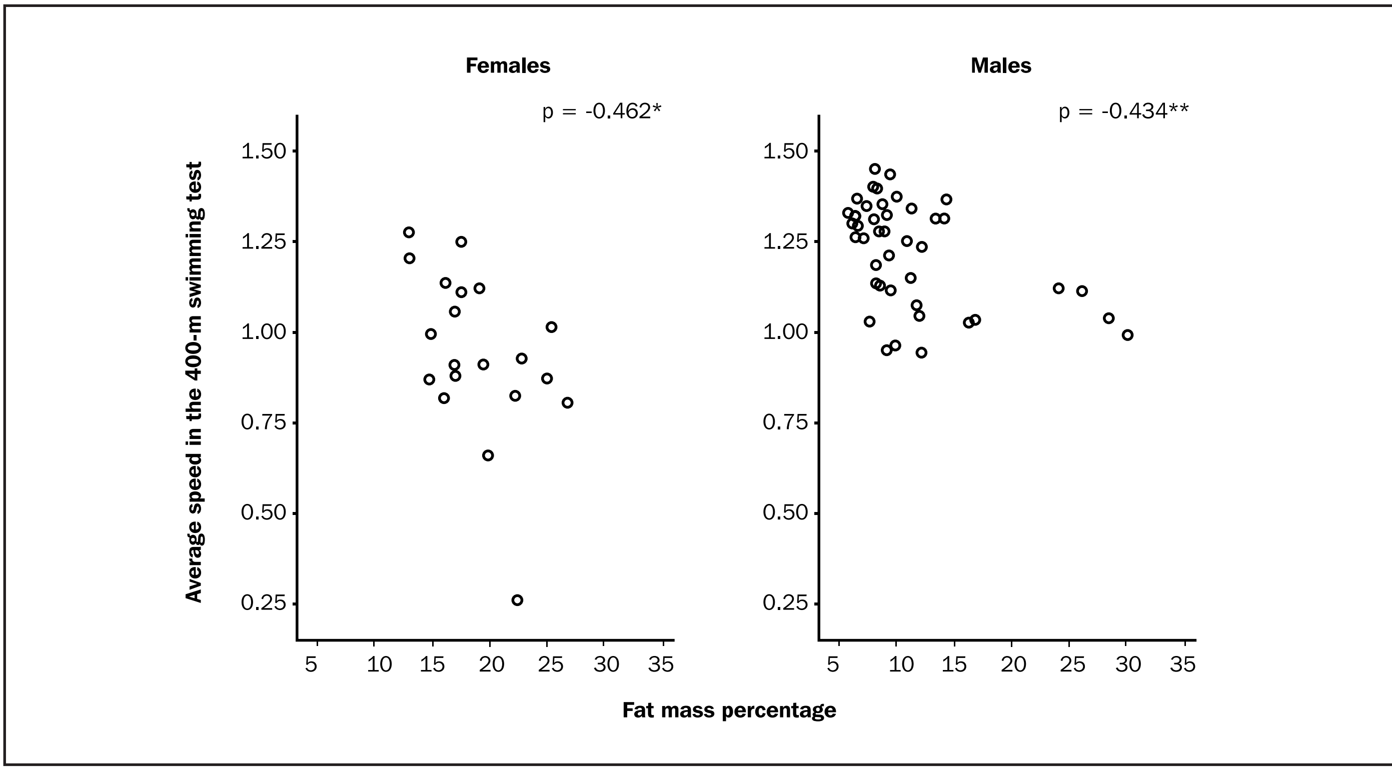
Male: male; Fem: female; SR: stroke rate; SL: stroke length; MS: mean speed; CP: critical power; PWr: power-to-weight ratio.
*p<0.05; **p<0.01.

with the basic measurements, particularly body mass in both sexes. It would seem reasonable to suppose that the heavier the triathlete, the easier a greater absolute critical power. However, it is unclear how this may affect overall competition performance. For this reason, the triathletes' power-to-weight ratio is discussed more fully, this being the most reliable and valid approach[32].

In the running test, the fat percentage was negatively correlated with performance, especially the triceps, biceps, abdominal and leg skinfolds. These folds, it should be noted, are the most sensitive to training and diet[33]. Although this study did not collect data on stride rate and length, the results of the running test with young triathletes showed no relationship with those observed with adults[8], where taller athletes perform better overall in triathlon thanks to their greater stride length.

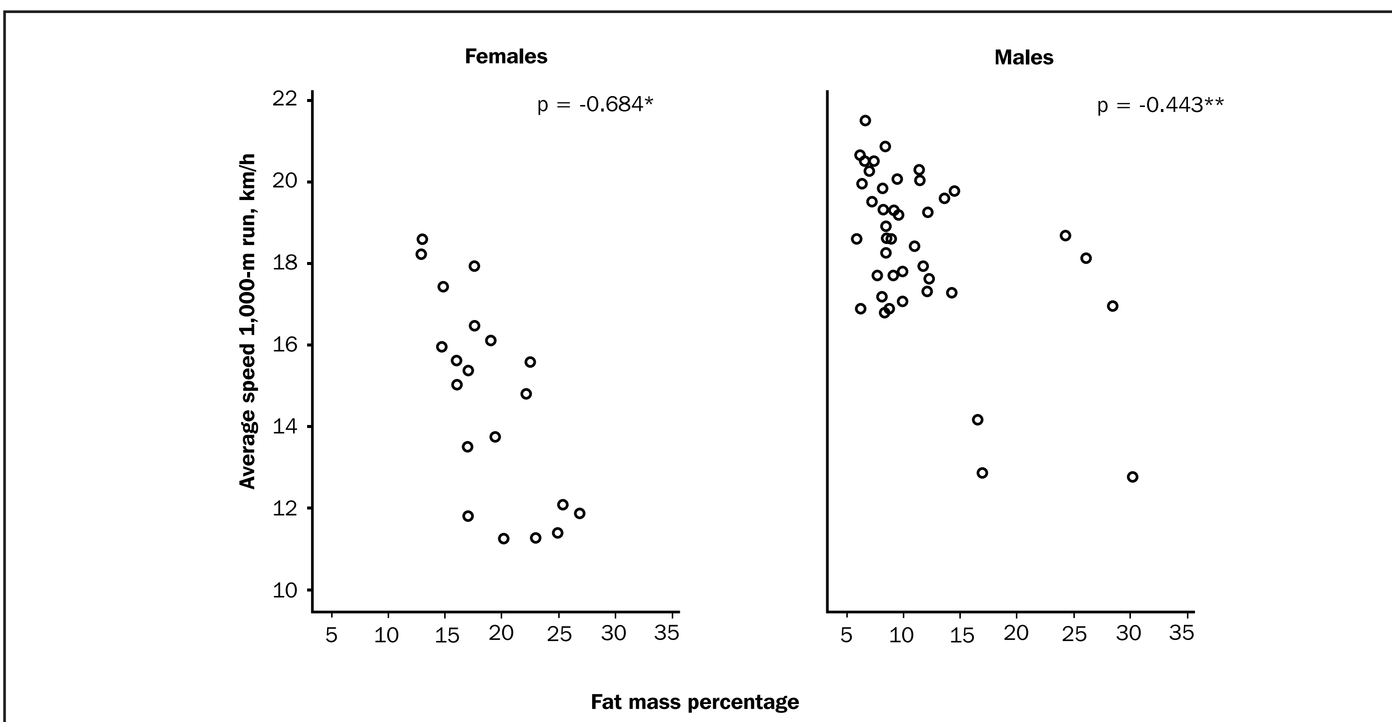
Finally and in view of the results of this study, its most noteworthy limitation is that the point of development of the triathletes was not taken into consideration, something which would be particularly impor-

Figure 2. Relationship between the triathletes' fat mass percentage and mean speed in the 400-m swimming test by sex.



ρ: Spearman's rank correlation coefficient: *p<0.05; **p<0.01.

Figure 3. Relationship between the triathletes' fat mass percentage and mean speed in the 1,000-m running test by sex.



ρ: Spearman's rank correlation coefficient: *p<0.05; **p<0.01.

tant in order to arrive at firmer conclusions. Nor did the design of the study take into account other factors which can affect the development of sporting talent, such as psychological factors, social factors, relative age and so on.

Conclusions

Sports coaches and managers should consider this study for their day-to-day work, taking into account the following for young triathletes who are still growing:

– Arm span favours swimming performance, meaning that comparing two individuals at different points of development could mean overlooking sporting talent.
– The fat mass percentage is a determining factor for performance in triathlon at all ages, thereby suggesting the convenience of a good grounding and education in balanced, healthy eating habits to control optimum individual weight.
– An individual's point of development is also key, peak height velocity representing a turning point involving significant charges in the athlete's proportions and somatotype. The coaches of young athletes, therefore, should know and apply the formula to calculate peak height velocity with a standard error of ±12 months.
– Cycling performance, particularly the power-to-weight ratio, would seem to be the least sensitive area to the effect of anthropometric characteristics, maybe due to the shorter distances or the drafting effect, but is nonetheless important for a good overall result.

Conflict of Interests

The authors declare that they are not subject to any type of conflict of interest.

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