Alacid, F.; Martínez, I.; López-Miñarro, P.A. y Muyor, J.M. (2014). Características antropométricas y del material en kayakistas adolescentes de aguas tranquilas / Anthropometric and equipment characteristics in adolescent sprint kayakers. Revista Internacional de Medicina y Ciencias de la Actividad Física y el Deporte, vol. 14 (55) pp. 451-464. Http://cdeporte.rediris.es/revista/revista55/artcaracteristicas333.htm

ORIGINAL

ANTHROPOMETRIC AND EQUIPMENT CHARACTERISTICS IN ADOLESCENT SPRINT KAYAKERS

CARÁCTERÍSTICAS ANTROPOMÉTRICAS Y DEL MATERIAL EN KAYAKISTAS ADOLESCENTES DE AGUAS TRANQUILAS

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Códigos UNESCO / UNESCO Code:: 2411.06 Fisiología del ejercicio / Exercise Physiology. 2402.03 Antropometría y Antropología Forense / Anthropometry and Forensic Anthropology.
Clasificación del Consejo de Europa a / Council of Europe Classification: 9. Cinantropometría / Kineanthropometry

Acknowledgements: Trabajo realizado en el marco de ayudas a la investigación del Consejo Superior de Deportes, con el proyecto “Influencia de factores antropométricos, somatotipo corporal, morfotipo raquídeo y capacidad física en el rendimiento de canoístas y kayakistas de categoría infantil” (Código: 04/UPR10/06).

ABSTRACT

The aims of this study were to describe kinanthropometric characteristics and equipment set-up of male and female young kayakers and to look for correlations between both variables. Ninety one young sprint kayakers (45 males and 46 females), aged 13 and 14 years old, were assessed using a battery of 12 anthropometric and 5 equipment dimensions. Comparison between the 13- and 14-year-old kayakers showed that 14-year-old males had greater body and equipment dimensions than their 13-year-old counterparts, whereas there were no significant differences between 13- and 14-year-old female kayakers in both anthropometric and equipment set-up dimensions. Stretch stature and arm span were the variables which greater coefficient correlations showed with total paddle length and seat - feet bar distance. The data presented in this paper may provide important information to adjust equipment sep-up in order to optimise comfort and performance in young kayakers.

KEY WORDS: anthropometry, canoeing, competition equipment, adolescence.

RESUMEN

Los objetivos de este estudio fueron describir las características antropométricas y la configuración del material utilizado por 91 kayakistas españoles adolescentes de 13 y 14 años, de aguas tranquilas y buscar correlaciones entre ambas variables. Se valoraron las características antropométricas y las dimensiones del material de competición de noventa y un kayakistas de aguas tranquilas (45 hombres y 46 mujeres), de 13 y 14 años de edad. Los hombres kayakistas de 14 años presentaron valores superiores a los de 13 años en cuanto a dimensiones antropométricas y del material de competición, mientras que no se encontraron diferencias significativas entre las variables analizadas entre las mujeres kayakistas de 13 y 14 años. La talla y envergadura presentaron las mayores correlaciones con la longitud de la pala y la distancia asiento - reposapiés. La información aportada por este trabajo podría ser de utilidad para ajustar las dimensiones del material de competición, optimizando así el confort y rendimiento en kayakistas jóvenes.

PALABRAS CLAVE: antropometría, piragüismo, material de competición, adolescencia

INTRODUCTION

The equipment optimization is very important in competitive sport for obtaining maximum performance, athlete's comfort and injury prevention. The equipment assessment has traditionally been conducted in which an implement is considered a key to athletic success, such as golf, hockey or pole vault (Shan, 2008). In rowing, important research have also developed, analyzing the relationship between the equipment set-up and anthropometric measurements with physical capacity, kinematics and performance (Barrett & Manning, 2004; Caplan & Gardner, 2005).

In canoeing, the coaches have traditionally used body dimensions to determine the length of the paddle in order to find the ideal length. Toro (1986) proposed the one in which the competitor is able to grab the paddle tip when it is installed in a vertical position close to the paddler. Szanto y Henderson (2004) recommend this method as a good starting point for setting-up the total length of the paddle. However, they consider little appropriate measures such as sitting height, shoulder width (biacromial breadth), arm length, or the strength of the subject. Nevertheless, Sánchez y Magaz (1993) pointed out that to accurately determine this dimension it is necessary an analysis of the paddle technique based on the following aspects:

- Respect the correct entry angle of the paddle during the catch phase.
- The trajectory of the pusher arm should be parallel to the water. If the paddle is too long the hand will rise too high above the head.
- Too long paddle hinders maximum stroke rate.
- The sensations of paddler, as to the application of maximum strength on each stroke and the possibility of increasing the stroke rate during the final moments of the competitions or in fatigue situations.

To get the right grip, the kayak paddle has traditionally placed on the head, keeping the same distance between the hands and the blades, while both elbows should be 90º flexed (Toro, 1986; Szanto & Henderson, 2004). This method has been widely reported in canoeing, as it is used in other modalities such as white water (Ferrero, 2006).

To determine the blade length and width, kayakers based on their age, level of learning, strength and technique style, should test different dimensions of the blade to select, under the supervision of the coach, that best fits to their paddling (Szanto & Henderson, 2004).

However, the process of choosing the blade dimensions is usually guided by the manufacturer recommendations, since they design models for different categories.

Furthermore, the paddle set up is not subject to any special regulation, except that paddles can not be attached to the kayak (ICF, 2007; RFEP, 2007). However, boats are restricted in terms of their characteristics, especially in length and shape. Thus, the possibilities of adapting them to the paddler dimensions are usually made in factories, developing different boats models by the weight or the hip width of the athletes. Therefore, one of the few dimensions to set-up in kayaking is the distance between the seat and footrest. This measure is mainly conditioned by paddling technique. In the starting position the knees should be slightly flexed (110-120), allowing the pedalling movement without reaching the full knee extension (Sánchez & Magaz, 1993). Thus, the main criterion used to obtain this distance is the comfort of the kayaker in the movement of flexion and extension of the knees.

First scientific approach to equipment set-up was performed by Ong *et al.* (2005, 2006). Paddle dimensions and distance between the seat and footrest were analyzed in kayakers who participated in 2000 Olympic Games in Sydney in order to establish the differences between the slalom and sprint canoeing as well as among the best paddlers and the rest of the athletes. Furthermore, correlations with different anthropometric measurements were also analyzed. Subsequently, they used the previously determined correlations to analyze paddling technique in three kayakers using different paddle set-up.

However, although anthropometric and proportionality characteristics have been previously analyzed in young paddlers (Alacid, Marfell-Jones, López-Miñarro, Martínez & Muyor, 2011; Alacid, Lopez-Miñarro, Martínez & Ferrer, 2011), no published studies have analyze the size and equipment set-up in young kayakers. These dimensions should be checked and adapted regularly since young paddlers body is under maturation process. Therefore, the aims of this study were 1) to describe the anthropometric characteristics and competition equipment set-up used by young (13 and 14 years-old) men and women kayakers. 2) to determine the relationship between anthropometric dimensions and competition equipment set-up.

METHODS

Participants

Ninety one young kayakers (45 males and 46 females) participated in this study. They were selected by the Royal Spanish Canoeing Federation as the best in their categories to participate in the 2006 and 2007 National Development Camps, under the National Technification Programme conducted by the National Sports Council.

Written informed consent form was obtained from the parents of all the children before participation.

Los palistas fueron agrupados en función de la categoría y edad, es decir, se crearon grupos de hombres y mujeres kayakistas, siendo estos divididos por edades, por lo que los que cumplieron 14 años en el año que asistieron a la

concentración fueron de la categoría A, mientras que los que cumplieron 13 años, de la categoría B. La tabla 1 muestra la distribución de la muestra por categorías, así como su edad y años de práctica.

Participants were grouped by category and age: groups of men and women kayakers were created, and these groups were divided by age. Those paddlers who turned 14 years old in that attended the National Camp were from category A, while those who met 13 years, from category B. Table 1 shows the distribution of the sample categories, age and years of practice.

Table 1. Distribution of the sample categories, age and years of practice.

Categories	MKA	MKB	FKA	FKB
Number of paddlers	23	22	23	23
Age (years)	14.26 ± 0.29	13.19 ± 0.32	14.12 ± 0.35	13.14 ± 0.29
Years of practice (years)	4.53 ± 2.12	3.82 ± 1.60	3.67 ± 1.14	3.27 ± 1.01

MKA: male kayak A. MKB: male kayak B. FKA: female kayak A. FKB: female kayak B.

Procedures

All variables (shown in Table 2) were measured by a Level 2 anthropometrist certified by the International Society for the Advancement of Kinanthropometry (ISAK), in accordance with the ISAK guidelines (Marfell-Jones, Olds, Stewart & Carter, 2006). Measures were taken twice, (or three times if the difference between the first two measures was greater than 5% for skinfolds and 1% for the rest of the dimensions), with the mean (or median) values used for data analysis.

Body mass, stretch stature, arm span, sitting height, four lengths (arm, forearm, thigh and leg) and four breadths (biacromial, transverse and anterior-posterior chest and biiliocristal) were measured.

Body mass was measured using a SECA 703 (SECA, Germany) with a precision of 100 g; arm spam with a metallic non-extensible tape Lufkin W606PM (Lufkin, USA); stretch stature, sitting height, direct lengths and breadths with a GPM anthropometer (Siber-Hegner, Switzerland) with a precision of 0.1 cm.

The equipment dimensions used by the kayakers were measured: paddle length, blade length and width, hand grips, and the distance from the lowest point of the seat and the footrest. The procedure for each of the measurements was as follows (Ong *et al.*, 2005) (figure 1):

- Paddle length: horizontal distance between blade tips.
- Blade width: maximum width of the blade.

- Blade length: maximum length of the blade, from the blade tip to the place where it joins the shaft.

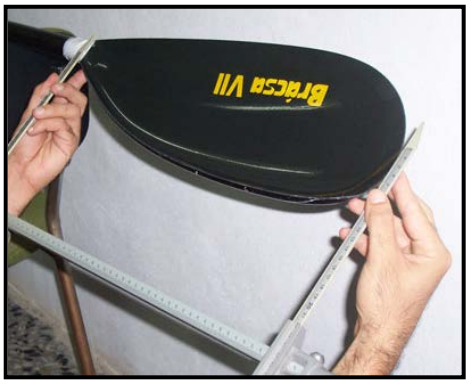
- Hand grips: horizontal distance between the knuckles of the third digits with the athlete asked to adopt their usual grip.

- Seat – footrest distance: minimum distance between the lowest point of the seat (supporting place of the ischial tuberosity) and the foot bar.

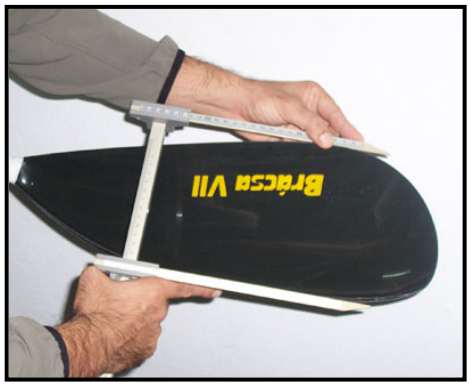
Paddle length and seat – footrest distance were measured with a metallic non-extensible tape Lufkin W606PM (Lufkin, USA). Hand grips and blade dimensions were measured with a GPM anthropometer (Siber-Hegner, Switzerland). In both cases the accuracy of the instruments was 0.1 cm and the results were expressed in centimetres.

Data Analysis

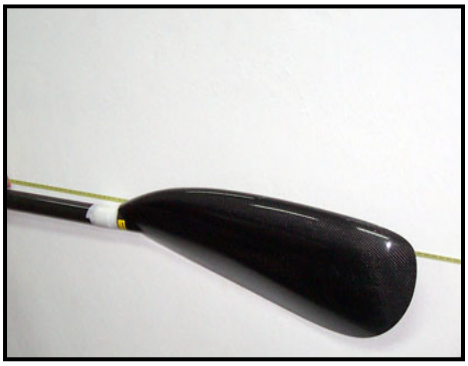
Descriptive statistics including means and standard deviations were calculated. The normality of the variables was analysed with the Kolmogorov-Smirnov test. Because the distribution was normal, one-way analysis of variance (ANOVA) with repeated measures was used to detect differences between categories. If a significant *p*-value was identified for the main effect, pairwise comparisons were made using the Bonferroni *post hoc*. The relationship between anthropometric variables and equipment characteristics was analyzed by calculating the Pearson correlation coefficient. The data were analyzed using SPSS 15.0. The level of significance was set at $p \leq 0.05$.



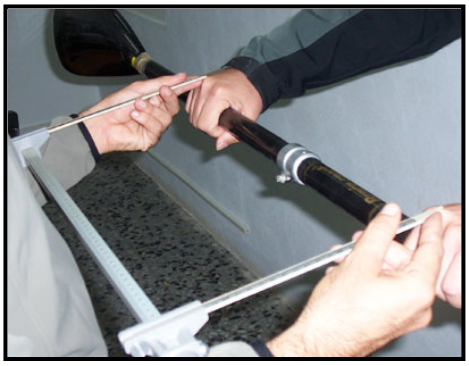
Blade length



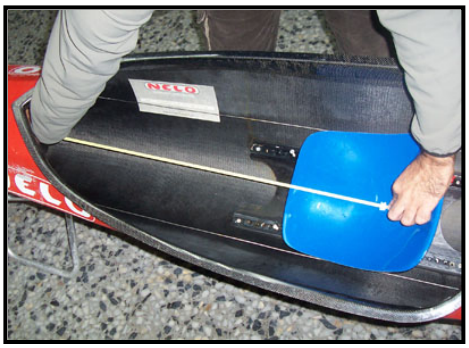
Blade width



Paddle legth



Hand grips



Seat – footrest distance

Figure 1. Equipment measures.

RESULTS

Table 2 presents the anthropometric characteristics of the paddlers and the differences between groups. Male kayakers A had the highest values in all variables analyzed, except biiliocristal breadth, with significant differences in most of them. Furthermore, no significant differences were found between women kayakers A and B.

Table 2. Anthropometric characteristics of the paddlers.

Categories	MKA (n=23)	MKB (n=22)	FKA (n=23)	FKB (n=23)
Stretch stature (cm)	173.14 ± 4.92	165.01 ± 5.58*	165.07 ± 5.69*	163.19 ± 5.82*
Body mass (kg)	64.54 ± 8.60	56.28 ± 9.09	55.75 ± 7.72*	55.86 ± 8.83*
Arm span (cm)	178.36 ± 5.74	168.82 ± 6.41*	166.83 ± 5.83*	166.24 ± 9.23*
Sitting heigth (cm)	90.94 ± 3.42	86.15 ± 4.23*	87.03 ± 3.20*	86.05 ± 3.13*
Arm length (cm)	32.21 ± 1.30	30.42 ± 1.22*	30.79 ± 1.40*	30.42 ± 1.70*
Fore arm length (cm)	24.90 ± 1.02	23.16 ± 1.49*	23.40 ± 1.04*	23.20 ± 1.37*
Thigh length (cm)	38.81 ± 2.00	36.36 ± 2.19*	36.54 ± 2.83*	35.81 ± 2.12*
Leg length (cm)	35.78 ± 2.17	34.12 ± 1.61	34.36 ± 1.88	33.68 ± 2.31*
Biacromial breadth (cm)	39.06 ± 1.04	36.36 ± 2.06*	35.75 ± 1.98*	34.81 ± 1.71*
Transverse chest breadth (cm)	28.39 ± 1.81	26.42 ± 1.69*	26.53 ± 1.67*	26.40 ± 1.61*
A-P chest depth (cm)	19.83 ± 1.41	18.87 ± 1.49	17.48 ± 1.25*	17.77 ± 1.86*
Biiliocristal breadth (cm)	31.54 ± 1.72	29.19 ± 1.96*	31.73 ± 1.76†	31.49 ± 1.80†

MKA: male kayak A. MKB: male kayak B. FKA: female kayak A. FKB: female kayak B. A-P: anterior-posterior. * $p < 0.05$ significant differences from MKA. † $p < 0.05$ significant differences from MKB.

In the same way as with anthropometric variables, male kayakers A used an equipment set-up significant larger than the other categories. No significant differences between groups of women kayakers in the equipment dimensions were found (table 3).

Table 3. Equipment dimensions used by kayakers.

Categories	MKA (n=23)	MKB (n=22)	FKA (n=23)	FKB (n=23)
Paddle length (cm)	211.12 ± 3.36	205.75 ± 6.16*	205.83 ± 5.52*	203.24 ± 6.34*
Blade width (cm)	15.82 ± 0.66	15.15 ± 0.58*	15.11 ± 0.86*	15.31 ± 0.63*
Blade length (cm)	49.02 ± 2.05	47.05 ± 2.30*	46.60 ±1.67*	46.66 ± 1.52*
Hand grip (cm)	71.74 ± 3.70	67.78 ± 4.52*	68.40 ± 5.19	67.19 ± 5.52*
Seat – footrest distance (cm)	89.80 ± 3.39	85.75 ± 4.48*	84.28 ± 5.66*	84.98 ± 3.57*

MKA: male kayak A. MKB: male kayak B. FKA: female kayak A. FKB: female kayak B. * $p < 0.05$ significant differences from MKA.

Table 4 and 5 show the correlations between the equipment dimensions and the hand grip with the anthropometric variables.

Paddle length showed significant correlations with stretch stature and arm span in all categories, with values ranging from *r* = 0.43 to *r* = 0.74. Other significant correlations were found with sitting height in men kayakers B and women kayakers A (*r* = 0.47 and *r* = 0.59, respectively); with arm length in male kayakers A and women kayakers B (*r* = 0.56 and *r* = 0.63, respectively); with biacromial breadth in men and women kayakers B (*r* = 0.60 and *r* = 0.68, respectively); and with biiliocristal breadth kayakers in men kayakers A and B (*r* = 0.43 and *r* = 0.64, respectively).

The hand grip showed significant correlations in the younger categories, with stretch stature in male kayakers B (*r* = 0.42), and with the stretch stature, arm span and biacromial breadth in women kayakers B (*r* = 0.54, *r* = 0.44 and *r* = 0.42, respectively).

Table 4. Coefficient correlations (*r*) between anthropometric variables and equipment set-up in male kayakers.

Variables	MKA			MKB		
	Paddle L	Hand G	Seat-F	Paddle L	Hand G	Seat-F
Stretch stature	0.46†	-0.12	0.68*	0.74*	0.42†	0.59*
Body mass	0.27	-0.18	0.46†	0.56*	0.37	0.51†
Arm span	0.43†	0.09	0.79*	0.54*	0.30	0.69*
Sitting heigth	0.40	-0.11	0.45†	0.47†	0.15	0.39
Arm length	0.56†	-0.15	0.54	0.26	-0.28	0.34
Fore arm length	0.27	0.27	0.49	0.34	0.13	0.28
Thigh length	0.16	0.00	-0.05	0.54†	0.00	0.13
Leg length	0.31	-0.08	0.53	0.23	0.31	0.43
Biacromial breadth	0.36	0.29	0.38	0.60*	0.19	0.46†
Transverse chest breadth	0.13	-0.22	0.17	0.44†	-0.03	0.23
A-P chest depth	-0.02	-0.14	-0.05	0.30	0.44	0.51
Biiliocristal breadth	0.43†	-0.07	0.53	0.64*	0.35	0.38

* $p < 0{,}001$; † $p < 0{,}05$. MKA: male kayak A. MKB: male kayak B. Paddle L: paddle length. Hand G: hand grip. Seat-F: seat – footrest distance. A-P: anterior-posterior.

The seat to footrest distance significantly correlated with stretch stature, body mass and arm span in all categories (from *r* = 0.46 to *r* = 0.79). Significant correlations were also found with sitting height in men and women kayakers A (*r* = 0.45 and *r* = 0.43, respectively), and with biacromial breadth in male kayakers B (*r* = 0.46).

Table 5. Coefficient correlations (*r*) between anthropometric variables and equipment set-up in female kayakers.

Variables	FKA			FKB		
	Paddle L	Hand G	Seat-F	Paddle L	Hand G	Seat-F
Stretch stature	0.60*	0.40	0.71*	0.49†	0.54*	0.71*
Body mass	0.45†	0.17	0.69*	0.41	0.32	0.53*
Arm span	0.53*	0.26	0.72*	0.54*	0.44†	0.56*
Sitting heigth	0.59*	0.36	0.43†	0.17	0.32	0.31
Arm length	0.35	0.13	0.62	0.63*	0.42	0.67
Fore arm length	0.31	0.07	0.36	0.56†	0.45	0.58
Thigh length	0.49†	0.57	0.42	0.45†	0.49	0.46
Leg length	0.14	0.27	0.40	0.49†	0.37	0.58
Biacromial breadth	0.40	-0.17	0.34	0.68*	0.42†	0.40
Transverse chest breadth	0.48†	0.24	0.74	0.21	0.09	0.29
A-P chest depth	0.02	-0.09	0.26	0.14	0.01	0.17
Biiliocristal breadth	0.37	0.29	0.60	0.37	0.32	0.52

* $p < 0{,}001$; † $p < 0{,}05$. FKA: female kayak A. FKB: female kayak B. Paddle L: paddle length. Hand G: hand grip. Seat-F: seat – footrest distance. A-P: anterior-posterior

Blade dimensions did not present significant correlations with anthropometric variables, and in most cases were lower than $r = 0.35$.

DISCUSSION

The aims of this study were to describe the anthropometric characteristics and equipment set-up in young kayakers and to identify relationships between both variables. The main contribution of this study is that the anthropometric differences found between male kayakers A and the other categories moved in a similar way to the equipment set-up. The 14 years-old male kayakers used longer paddles, wider hand grips and greater distances between the lowest point of the seat and the footrest. In fact, the absence of significant differences in anthropometric variables among women kayakers A and B, was also reflected in the lack of differences in the dimensions of the equipment. Furthermore, the anthropometric variables that best correlated with the paddle length and the seat-footrest distance were stretch stature and arm span in most groups analyzed. This may indicate that these anthropometric measures are used to define the properties of the competition equipment.

After comparing the dimensions of paddle with the guidelines provided by Toro (1986), we found that the values of our paddlers are much lower. In addition, the blade length is within the ranges established in this reference, while the width of the sheet is lower in the present study. All these differences are mainly attributable to the differences between the blades described by Toro (1986) and

currently used in kayaking, and because these recommendations were probably aimed to senior paddlers.

Most current data provided by Ong *et al*. (2005), corresponding to the equipment set-up used by men and women kayakers participating in the 2000 Olympics Games in Sydney, we found 10 cm lower values in the paddle length male and female kayakers A, with a higher difference in male kayakers B (15 cm). Similarly, the blade length used by elite men and women kayakers was from 2.0 to 3.5 cm higher than the used in our study, these differences was slightly lower in male kayakers A. Blade width was about 1 cm narrower in young paddlers. These results point out the greater physical, technical and muscular development of elite paddlers from adolescent paddlers.

The differences between elite kayakers and the participants of our study in the distance from the lowest point of the seat to footrest are similar to those found in the length of the lower limbs when comparing these populations. With values of about 95 cm in elite male kayakers compared to 89.8 $\pm$ 3.4 cm a male kayakers A and 85.8 $\pm$ 4.5 cm male kayakers B. With similar comparisons in women elite kayakers (87.2 $\pm$ 6.0 cm) and women kayakers A and B (84.3 $\pm$ 5.7 and 85.0 $\pm$ 3.6 cm, respectively).

The paddle length significant correlated with nearly all basic measures in all categories. Other studies that have related the anthropometric variables and the paddle length. Ong *et al*. (2006) expressed this variable as the 121.4% of the stretch stature and the 118.3% of the arm span in elite kayakers, results very similar to those found in our study respect to stretch stature (121.9% in a male kayakers A, from 124.5 to 124.7% in the other categories) and arm span (118.4% in a male kayakers A, from 121.9 to 123.4% in the other categories). Furthermore, Alacid *et al*. (2006) in a sample of paddlers of different categories belonging to the same canoeing club, found high correlations between the paddle length and the stretch stature and arm span, and significantly lower correlations with sitting height, coinciding with the results of our study. Another aspect of the study of Alacid *et al*. (2006) is that correlations were higher in the senior category (from r = 0.91 to r = 0.97) than in cadet and junior categories (from r = 0.62 to r = 0.67), which could indicate a better equipment set-up in paddlers with a greater experience. Or that in growth stages of the athlete when the equipment is usually provided by the club, coaches do not fit the paddle dimensions in order to avoid that it could be too short in a brief period of time. In this sense, in our study we did not find higher correlations in 14 years-old than in 13 years-old paddlers. In fact, male kayakers A was the category with less significant correlations between the anthropometric variables and the paddle length.

The distance between the seat and footrest significantly correlated with basic measures. Ong *et al*. (2005), found that stretch stature is the best measure to predict the distance between the lowest point of the seat and footrest. This distance can be expressed as the 51.4% of the stretch stature (Ong et al., 2006), which coincides with the result obtained in our study where this distance can be expressed from the 51.1 to 52.0% of the stretch stature. However, in our

study, the arm span was the measure with the highest correlations in three of the four categories of kayakers analyzed, followed by the stretch stature. Correlations with body mass, sitting height and biacromial breadth were also found, but in all cases with lower values than stretch stature and arm span.

Only men and women kayakers B, obtained significant correlations between the hand grip and the stretch stature, adding arm span and biacromial breadth in women kayakers in B. This result contrasts with the relations established by Ong *et al*. (2005, 2006), elite kayakers expressed this distance in terms of the stretch stature or by the 170.2% of the diameter breadth. This percentage is much higher than the 183.7 and 186.4% in male kayakers A and B and the 191.3 and 193.0% in women kayakers A and B, respectively.

In conclusion, 14 years-old male kayakers had anthropometric measures and equipment set-up higher than 13 years-old male and 13 and 14 years-old female kayakers. By contrast, no significant differences in anthropometric characteristics were found, nor in the equipment dimensions used by 13 and 14 years-old female kayakers. On the other hand, paddle length and seat - footrest distance had higher correlations with stretch stature and arm span, so that these body measures could be used as criteria for determining these dimensions.

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