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Section III – Sport, Physical Education & Recreation

Morphological Characteristics of Young Elite Paddlers

by

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The aims of this study were to describe kinanthropometric characteristics of elite male and female young paddlers and to compare their proportionality with Olympic paddlers. **.** *One hundred and eighty seven young elite sprint paddlers (124 males and 63 females), aged 13 and 14 years, were assessed using a battery of 31 anthropometric dimensions. Somatotypes, Phantom Z-scores and corrected girths were calculated. Comparison between the 13 and 14 year old paddlers showed that 14 year old males had greater height, body weight, sitting height, arm span and upper body lengths, breadths and girths than their 13 year old counterparts, whereas 14 year old female paddlers only differed significantly from the 13 year olds in biacromial breadth and corrected arm girth. Mean somatotypes of male paddlers were best described as balanced mesomorphs, while female paddlers were centrals. Olympic paddlers had higher proportional dimensions in upper body girths, and biacromial breadth in both genders. The data provided in this study could be used as a guideline for talent identification in sprint canoeing and kayaking.*

Key words: Anthropometry, adolescent, somatotype, proportionality, canoeing/kayaking

Introduction

Kinanthropometric evaluation has been one of the most used tactics within a multidisciplinary approach to talent identification in different sports (Reilly, 2008). Moreover, the anthropometric profiles of World-class athletes offer useful data for coaches when initially selecting talented individuals for development programs (Ackland et al., 2003). Both sprint kayakers and canoeists have been measured in several studies (Cermak et al., 1975; Shephard, 1987; Fry and Morton, 1991; Misigoj-Durakovic and Heimer, 1992; Aitken and Jenkins, 1998; Ackland et al., 2003; van Someren and Palmer, 2003). Sprint kayaking is characterised by exceptional demands on upper body performance

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(Michael et al., 2008), and sprint elite paddlers possess unique characteristics, not commonly observed in the general population (Ackland et al., 2003). These included an above-average body mass attributable to a high lean body composition, large upper body girths and breadths, low measures of adiposity, prevalence of mesomorphy and homogeneity in shape and physical size. Additionally, some studies found significant correlations between performances in different competition distances and some of the anthropometric variables cited above. Sitting height and chest girth correlated well with race time in 1000 m events (Fry and Morton, 1991), chest girth and humerus breadth with 500 m race time (van Someren and Howatson, 2008) and 200 m performance with arm, arm flexed and tensed, forearm and chest girths and humerus breadth (van Someren and Palmer, 2003).

Taking into account the special characteristics of elite paddlers, anthropometric assessment and monitoring of adolescent paddlers is vital to control the training process. Furthermore, this information may be useful in position crew configuration and boat and paddle set-up (Ong et al., 2005) and as a reference for coaches of young categories. However, there is a paucity of normative data on the morphological characteristics of young elite paddlers as opposed to young rowers (Bourgois et al., 2000; 2001). For those authors, an examination of the anthropometric characteristics of young athletes may help coaches and sport scientists to achieve a better understanding of performance, by providing information for formulating strategies. In Spain, 13 and 14 year old paddlers compete over 3000 m in single kayak or canoe, and at the National championship over 1000 m in single, double or quadruple boats. Once the competitive period has finished, National Development Camps are held in order to better manage the technical and morphological evolution of the best young paddlers in each category. These events provide an opportunity to carry out a comprehensive anthropometric investigation in order to identify the special morphological characteristics of young elite paddlers, if any, and thus better contribute to the talent identification process.

Therefore, the aims of this study were: (1) to describe body dimensions, somatotype and proportionality of elite male and female young paddlers and compare them with the normal population; (2) to compare the anthropometric data between 13 and 14 year olds; (3) to compare proportionality between young paddlers, Olympic paddlers and the normal population; and (4) to establish an anthropometric profile chart for 13 and 14 year old paddlers to be used for training and talent identification.

Methods

Participants

One hundred and eighty seven young elite sprint paddlers (60 and 64 male 13 and 14 year olds, respectively; 32 and 31 female 13 and 14 year olds, respectively) were measured using a battery of 32 anthropometric dimensions. They were selected by the Royal Spanish Canoeing Federation as the best in their categories to participate in the 2006, 2007 and 2008 National Development Camps. Some paddlers were selected in two consecutive years; as a result of a good paddling performance in both years. Where this occurred, their respective annual data was included in both year cohorts. The Institutional Ethical Committee of the University of Murcia approved the study and written informed consent form was obtained from the parents of all the children before participation.

Data collection

All variables (shown in Table I) 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 et al., 2006).

Variables 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.

The technical error of measurement scores was less than 5% for skinfolds and less than 1% for the remaining variables.

Body mass was measured using a SECA 862 (SECA, Germany), stretch stature, sitting height, arm span, 2 direct lengths and 7 breadths with a GPM anthropometer (Siber-Hegner, Switzerland), 11 girths with a metallic non-extensible tape Lufkin W606PM (Lufkin, USA) and 8 skinfolds with a Harpenden skinfold caliper (British Indicators, UK).

Data Analysis

Means, standard deviations and *Z-scores* were calculated for all variables. The equations of Carter and Heath (Carter and Heath, 1990) were used to calculate anthropometric somatotypes and the Phantom Stratagem (Ross and Marfell-Jones, 1991) was used to calculate *Z-scores* of each raw variables.

Girths were corrected for the skinfold at the site using the formula: corrected girth = girth – (π x skinfold thickness). Body mass index (BMI) and the sum of six and eight skinfolds were calculated.

Data were analyzed separately for males and females. The hypotheses of normality and homogeneity of the variance were analyzed via Kolmogorov-Smirnov and Levene tests, respectively. Parametric analysis was performed because the data were normally distributed. An independent t-test was conducted to examine differences between both groups (13 and 14 year olds) for all dependent variables. *P*-values less than 0.05 were considered statistically significant. Analyses were performed using the SPSS 15.0 statistical software package.

Results and discussion

Absolute body size

Table 1 presents the absolute anthropometric size of the four groups. Comparison between 13 and 14 year old male paddlers revealed that, as expected, the 14 year old group was heavier, taller, with greater sitting height, arm span, arm and forearm lengths and upper body breadths. In addition, 14 year old male paddlers had significantly greater girth measurements than the 13 year olds for the relaxed arm, flexed and tensed arm, forearm, chest, hip, mid-thigh and corrected arm and mid-thigh. There were significant differences in biacromial breadth and corrected arm girth between both 13 and 14 year old female groups. In terms of sums of six and eight skinfolds, 14 year olds were leaner than 13 year old paddlers for both males and females, but these differences were not significant.

The 14 year old female paddlers did have higher values than the 13 year olds in most of the measurements, but significant differences were only found in biacromial breadth and corrected arm girth.

Given the influence of biological maturation, (determined for Mirwald et al. (2002) as the age of peak height velocity, from 13.4 to 14.2 year-old in males, and from 11.6 to 12.5 year-old in females), the lack of differences between the two girls groups is most likely because both groups had already reached biological maturity, whereas the larger number of differences obtained between the two male groups could be explained by the greater influence of maturity in the older group. We would also expect differences to be compounded by the longer training history of the older groups. However, whereas this may have been the case for the boys, there was little evidence of it in the girls.

Interestingly, in the male categories, most of the significant differences found in stature, body mass and trunk and arm girths and breadths are in accordance with the differences between elite paddlers and normal population reported in previous studies (Cermak et al., 1975; Tesch and Lindeberg, 1984; Aitken and Jenkins, 1998). These findings mirror those investigations which found that international level kayakers had significantly greater upper body measurements than national level kayakers (Fry and Morton, 1991; van Someren and Palmer, 2003).

The study population, both male and female paddlers, lay between the 50th and 75th percentiles for body mass (13 year old boys: 48.3 – 57.2 kg; 14 year old boys: 56.9 – 65.4 kg; 13 year old girls: 50.4 – 57.4 kg; 14 year old girls: 52.2 – 58.5 kg) and near the 75th percentile for stretch stature (13 year old boys: 163.5 cm; 14 year old boys: 170.8 cm; 13 year old girls: 161.0 cm; 14 year old girls: 165.0 cm) by age group in the growth tables of the Spanish population (Carrascosa et al., 2008). This location identified the young paddlers as much taller, but only a little heavier than the mean of the Spanish normal population. These 14 year old measurement findings are consistent with data provided by anthropometric studies of Spanish schoolchildren of the same age which found a 3-4 cm and 2 kg lower stature and body mass, respectively, in 14 year old boys (Rubio and Franco, 1995; Ureña, 2000).

Table 1

Absolute size of 13 and 14 year-old sprint paddlers

	Females		Males	
Variable	13 year old (*n*=32)	14 year old (*n*=31)	13 year old (*n*=60)	14 year old (*n*=64)
Age (years)	13.11 ± 0.27**	14.11 ± 0.32	13.15 ± 0.31**	14.16 ± 0.31
Paddling experience (years)	3.18 ± 0.75	3.82 ± 1.24	3.08 ± 1.52*	3.83 ± 1.85
Weekly training (hours)	7.15 ± 1.60	7.21 ± 1.65	7.03 ± 1.59	7.34 ± 1.49
Body mass (kg)	54.85 ± 8.17	56.27 ± 7.46	54.73 ± 10.67**	60.44 ± 10.49
Sum 6 skinfolds[a] (mm)	89.73 ± 23.29	88.28 ± 21.72	66.2 ± 30.10	63.45 ± 31.87
Sum 8 skinfolds[b] (mm)	114.89 ± 30.58	112.09 ± 27.94	83.16 ± 38.36	79.74 ± 40.42
Stretch stature (cm)	162.41 ± 5.65	164.86 ± 5.26	163.49 ± 7.71**	169.12 ± 7.39
Sitting height (cm)	85.82 ± 2.99	87.25 ± 2.98	85.12 ± 4.83**	88.35 ± 4.68
Arm span (cm)	164.86 ± 8.57	165.9 ± 6.08	166.75 ± 9.80**	174.02 ± 8.65
Arm length (cm)	30.20 ± 1.60	30.65 ± 1.42	30.3 ± 1.75**	31.55 ± 1.64
Forearm length (cm)	23.35 ± 1.33	23.55 ± 1.04	23.36 ± 1.81**	24.7 ± 1.60
Biacromial breadth (cm)	34.83 ± 1.48*	35.72 ± 1.74	35.46 ± 4.36**	37.85 ± 2.24
Biiliocristal breadth (cm)	29.92 ± 3.09	30.45 ± 2.81	27.95 ± 2.58**	29.41 ± 2.61
A-P chest depth (cm)	17.61 ± 1.73	17.49 ± 1.31	18.31 ± 1.62**	19.17 ± 1.62
Transverse chest breadth (cm)	26.35 ± 1.49	26.68 ± 1.57	26.16 ± 2.14**	27.97 ± 2.18
Humerus breadth (cm)	6.09 ± 0.30	6.18 ± 0.32	6.69 ± 0.51	6.84 ± 0.41
Femur breadth (cm)	9.09 ± 0.56	9.02 ± 0.52	9.67 ± 0.58	9.71 ± 0.52
Wrist breadth (cm)	5.09 ± 0.25	5.06 ± 0.30	5.48 ± 0.35	5.55 ± 0.36
Arm girth relaxed (cm)	25.39 ± 2.26	26.49 ± 2.49	25.18 ± 2.94**	26.53 ± 2.68
Corrected arm girth (cm)	20.93 ± 1.44*	21.96 ± 1.84	21.91 ± 2.27**	23.54 ± 2.21
Arm girth flexed and tensed (cm)	27.02 ± 2.05	27.95 ± 1.65	27.80 ± 2.81**	29.45 ± 2.78
Forearm girth (cm)	22.94 ± 1.51	23.52 ± 2.37	23.69 ± 1.98**	24.93 ± 1.93
Wrist girth (cm)	14.84 ± 0.85	14.71 ± 0.73	15.85 ± 1.07	16.05 ± 1.07
Chest girth (cm)	84.66 ± 5.28	84.98 ± 4.28	82.01 ± 7.14**	86.96 ± 6.68
Waist girth (cm)	68.84 ± 5.53	68.10 ± 4.25	70.96 ± 8.78	73.65 ± 6.69
Hip girth (cm)	90.76 ± 6.90	92.29 ± 6.12	85.07 ± 6.9*	88.22 ± 6.63
Upper-thigh girth (cm)	54.63 ± 5.47	54.73 ± 4.18	52.06 ± 5.42	53.22 ± 5.25
Mid-thigh girth (cm)	47.24 ± 4.10	47.95 ± 3.79	46.07 ± 4.27*	48.09 ± 4.43
Corrected mid-thigh girth (cm)	40.90 ± 3.48	41.30 ± 3.03	41.43 ± 3.11**	43.79 ± 3.67
Calf girth (cm)	33.23 ± 2.53	33.32 ± 2.21	32.78 ± 2.59	33.37 ± 3.04
Corrected calf girth (cm)	28.59 ± 2.22	28.51 ± 1.94	29.33 ± 2.13	30.11 ± 2.82
Ankle girth (cm)	21.92 ± 1.53	21.56 ± 1.57	22.05 ± 1.62	22.28 ± 1.69

[a]Sum of triceps, subscapular, supraspinale, abdominal, front thigh and medial calf.
[b]Sum of triceps, subscapular, biceps, iliac crest, supraspinale, abdominal, front thigh and medial calf.
Significant difference from 14-year-old paddlers ($p < 0.05$; **$p < 0.01$).*

However, differences were almost non-existent in these measurements between 13 year old young male paddlers and schoolboys (stature: 162.55 ± 9.07 cm; body mass: 55.35 ± 10.87 kg) (Rubio and Franco, 1995). Female 13 and 14 year old paddlers were 3-4 cm taller and from 3 kg heavier to 1 kg 1ighter than schoolgirls of the same age (Rubio and Franco, 1995; Ureña, 2000).

On the other hand, data reported by Berral et al. (2001) showed a schoolchildren population, both males and females, with lower values in stature and body mass compared with the studies cited above and with our results.

The magnitude of the differences of Berral's study, however, (9 cm shorter and 10 kg lighter than male paddlers, and 5-6 cm and 5 kg, shorter and lighter, respectively than female paddlers, in 13 and 14 year olds) bring into question the study's validity as being representative of the normal school population.

Leone et al. (2002) described the anthropometric characteristics of Canadian elite adolescent female athletes (14.3 ± 1.3 year-olds; range 12-17 year-olds) from four different sports. Comparing with our results, we found that female paddlers were taller and heavier than figure skaters (stature: 154 ± 7 cm; body mass: 46.6 ± 8.0 kg), swimmers (stature: 162 ± 6 cm; body mass: 54.3 ± 6.9 kg), tennis players (stature: 161 ± 6 cm; body mass: 50.6 ± 8.3 kg) and similar to volleyball players (stature: 163 ± 5 cm; body mass: 57.7 ± 8.3 kg).

Other studies provide information about the anthropometry of young female climbers (Watts et al., 2003), handball players (Zapartidis et al., 2009) and swimmers (Latt et al., 2009). Stretch stature, body mass and arm span in handball players (164.31 ± 6.35 cm; 57.06 ± 8.75 kg; 166.60 ± 8.32 cm, respectively) and swimmers (164.7 ± 7.3 cm; 55.8 ± 8.8 kg; 167.7 ± 7.3 cm, respectively) were similar to the results obtained by female paddlers. Nevertheless, the climbers were shorter statured (151.3 ± 11.9 cm) and weighed less (40.6 ± 9.6 cm). Two studies made of young elite male handball players, Spanish (Ibnziaten et al., 2002) and Greek (Zapartidis et al., 2009), showed that these athletes were more than 5 cm taller and 6 kg heavier than the young male paddlers of our study. Thus, stretch stature, body mass and arm span were not too different in young elite paddlers from age-matched normal population and athletes. Probably, it is not necessary to have an above-average body size for reaching a high performance during these ages. Therefore the use of these measurements in talent identification may be of limited use.

Humerus, femur and wrist breadths and arm girth flexed and tensed were lower in 14 year old Spanish male (6.42 ± 0.46 cm, 9.14 ± 0.47 cm, 5.50 ± 0.48 cm and 27.67 ± 3.12 cm, respectively) and female (5.69 ± 0.56 cm, 8.47 ± 0.56 cm, 4.87 ± 0.36 cm and 25.50 ± 3.41 cm, respectively) schoolchildren (Ureña, 2000) than in young elite paddlers, even in the 13 year old ones. But calf girth were similar in schoolgirls (32.78 ± 3.23 cm) and higher in schoolboys (34.48 ± 3.17 cm) than in young paddlers. Ibnziaten et al. (2002), provided data about girths and breadths in male handball players. They found greater measurements for both 13 and 14 year old than male paddlers in chest (13 year olds: 85.45 cm; 14 year olds: 88.16 cm), upper thigh (13 year olds: 54.85 cm; 14 year olds: 56.16 cm) and calf (13 year olds: 35.63 cm; 14 year olds: 36.49 cm) girths and femur breadth (13 year olds: 10.26 cm; 14 year olds: 10.55 cm). Meanwhile the values of arm girth relaxed (13 year olds: 26.09 cm; 14 year olds: 26.88 cm) and humerus breadth (13 year olds: 6.75 cm; 14 year olds: 6.90 cm) were very close to those results obtained in our study. Humerus and femur breadths and arm and calf girths were also provided by Leone et al. (2002). Volleyball players had the largest breadths (femur: 9.31 ± 0.50 cm; humerus: 6.40 ± 0.33 cm) and calf girths (34.4 ± 2.2 cm) than the rest of athletes including female paddlers. Arm girth were higher in female paddlers comparing with figure skaters (24.4 ± 2.3 cm) and tennis players (25.5 ± 2.8 cm), similar to volleyball players (26.6 ± 2.2 cm) and lower than swimmers (27.8 ± 1.8 cm). Furthermore, female paddlers had the lowest, close to figure skaters' values (33.0 ± 2.7 cm) in calf girth.

Thus, young paddlers had large upper body breadths and girths, typical in elite paddlers, compared to age-matched schoolchildren and similar to other athletes, especially with regard to arm girth. Nevertheless, the differences in the dimensions of the lower limbs were minor in young paddlers compared to the normal population.

Therefore one of the most important characteristics for talent identification could be large measurements in arm girth (relaxed, flexed and tensed) and humerus breadth.

The young female and male paddlers had a considerably lower sum of six skinfolds than 14 year old schoolchildren described by Ureña (2000) (boys: 75.91 ± 29.55 mm; girls: 101.92 ± 28.22 mm) and 13 and 14 year olds reported by Rubio and Franco (1995) (14 year old boys: 81.83 mm; 13 year old boys: 89.12 mm; 14 year old girls: 106.96 mm). Nevertheless, 13 year old schoolgirls had a similar sum of 6 skinfolds than age matched paddlers (88.36 mm). These findings are also consistent with the literature showing that very low ratings of adiposity had been described in elite paddlers comparing with non-athletes population (Shephard, 1987; Fry and Morton, 1991; Ackland et al., 2003).

Interestingly, when comparing with athletes of the same age, sums of five skinfolds (excluding front thigh skinfold from sum of six skinfold used in this study) were lower in all the groups of female athletes studied by Leone et al. (2002) (from 47.4 ± 12.3 mm in figure skaters to 63.1 ± 15.5 mm in volleyball players) than in female paddlers (13 year old: 69.5 ± 19.6 mm; 14 year old: 67.1 ± 17.5 mm). These differences could be explained, by a much higher amount of weekly training (an average of 18 hours / week in the other sports) and by the fact that the sports analysed had a lower initial age of practice than canoeing. The sum of biceps, triceps, subscapular and iliac crest skinfolds was also described for 13 and 14 year old male soccer players and for the normal population (Moreno et al., 2004).

In accordance with the results obtained in the female category, adiposity of young male paddlers (sum of 4 skinfolds: 37.5 ± 15.9 mm and 34.5 ± 17.8 mm for 13 and 14 year olds, respectively) was higher than those reported in soccer players (13 year olds: 28.0 mm; 14 year olds: 26.3 mm) and a reference population (13 year olds: 33.0 mm; 14 year olds: 30.2 mm) of the same age. The lower sum of skinfolds in soccer players could be identified with a greater emphasis on large muscle activity in soccer, but it was not clear as to why the paddler skinfolds were slightly larger than the reference population.

Table 2

Relative size characteristics from Z-scores of 13 and 14 year old sprint paddlers

	Females		Males	
Variable	13 year old (*n*=32)	14 year old (*n*=31)	13 year old (*n*=60)	14 year old (*n*=64)
Z Body Mass	-0.18 ± 0.90	-0.34 ± 0.60	-0.40 ± 0.83	-0.39 ± 0.86
Z Sum 6 skinfolds[a]	-0.64 ± 0.69	-0.73 ± 0.63	-1.37 ± 0.87	-1.51 ± 0.91
Z Sum 8 skinfolds[b]	-0.61 ± 0.72	-0.71 ± 0.64	-1.39 ± 0.89	-1.53 ± 0.92
Z Sitting height	0.01 ± 0.45	0.04 ± 0.51	-0.29 ± 0.59	-0.23 ± 0.52
Z Arm span	0.06 ± 0.97	-0.15 ± 0.36	0.16 ± 0.56*	0.37 ± 0.65
Z Arm length	-0.51 ± 0.59	-0.51 ± 0.50	-0.56 ± 0.64	-0.44 ± 0.54
Z Forearm length	-0.08 ± 0.75	-0.18 ± 0.78	-0.19 ± 0.91*	0.21 ± 0.85
Z Biacromial breadth	-0.80 ± 0.82	-0.60 ± 0.85	-0.32 ± 0.74*	0.02 ± 0.80
Z Biiliocristal breadth	1.43 ± 1.68	1.47 ± 1.48	0.14 ± 1.24	0.42 ± 1.12
Z A-P chest depth	0.70 ± 1.3	0.40 ± 0.92	1.13 ± 1.09	1.30 ± 1.03
Z Transverse chest breadth	-0.17 ± 0.86	-0.22 ± 0.66	-0.40 ± 1.04**	0.13 ± 1.04
Z Humerus breadth	-0.27 ± 0.84	-0.29 ± 0.81	1.38 ± 1.00	1.16 ± 0.88
Z Femur breadth	0.02 ± 1.12	-0.44 ± 1.04	1.15 ± 1.03**	0.53 ± 0.96
Z Wrist breadth	0.44 ± 0.81	0.06 ± 1.04	1.76 ± 0.95*	1.34 ± 0.96
Z Arm girth relaxed	-0.12 ± 0.94	0.20 ± 1.09	-0.30 ± 1.08	-0.09 ± 0.98
Z Corrected arm girth	-0.06 ± 0.76	0.33 ± 1.04	0.39 ± 0.96**	0.85 ± 0.96
Z Arm girth flexed and tensed	-0.46 ± 0.85	-0.24 ± 0.61	-0.21 ± 0.96	0.09 ± 0.97
Z Forearm girth	-0.77 ± 1.06	-0.61 ± 1.54	-0.34 ± 1.10	-0.04 ± 1.12
Z Wrist girth	-1.10 ± 1.15	-1.62 ± 0.98	0.20 ± 1.01*	-0.28 ± 1.13
Z Chest girth	0.17 ± 0.96	-0.03 ± 0.66	-0.49 ± 1.08*	-0.07 ± 1.04
Z Waist girth	0.05 ± 1.19	-0.37 ± 0.74	0.44 ± 1.87	0.49 ± 1.29
Z Hip girth	0.07 ± 1.10	0.10 ± 0.83	-1.11 ± 0.92	-1.06 ± 0.91
Z Upper-thigh girth	0.33 ± 1.22	0.15 ± 0.85	-0.39 ± 1.14	-0.54 ± 1.05
Z Mid-thigh girth	-0.81 ± 0.89	-0.82 ± 0.75	-1.15 ± 0.76	-1.06 ± 0.83
Z Corrected mid-thigh girth	-1.25 ± 0.94	-1.31 ± 0.72	-1.18 ± 0.65	0.92 ± 0.81
Z Calf girth	-0.18 ± 1.04	-0.37 ± 0.79	-0.49 ± 0.93	-0.73 ± 1.10
Z Corrected calf girth	-0.13 ± 1.11	-0.41 ± 0.82	0.16 ± 0.88	0.03 ± 1.18
Z Ankle girth	0.95 ± 1.15	0.41 ± 1.09	0.94 ± 0.99*	0.53 ± 0.99

*[a]Sum of triceps, subscapular, supraspinale, abdominal, front thigh and medial calf.[b]Sum of triceps, subscapular, biceps, iliac crest, supraspinale, abdominal, front thigh and medial calf. Significant difference from 14-year-old paddlers (*p < 0.05; **p < 0.01)*

Thus, young paddlers possessed anthropometric characteristics similar to other age matched athletes, especially with regard to stature, body mass, arm span and arm girth. The adiposity of the paddlers was highest of all the studies compared. This result contrasted with low levels of adiposity of elite kayakers reported by different studies (Fry and Morton, 1991; Ackland et al., 2003).

Although van Someren and Palmer (2003) indicated that extreme leanness was not a necessary attribute for success in 200 m events. However, given that young paddlers only compete over the significantly greater distances of 1000 and 3000 m, the level of adiposity might be an important factor. In this regard, Jackson (1995) indicated that the most important parameters which influenced the boat speed were total weight (paddler, boat and paddle) and the skin friction drag; for example, an increase in total weight of 1% should lead to a decrease in speed of 0.26% in a single kayak.

Thus, low measures of adiposity were advantageous in decreasing the total weight of the system and therefore the wetted area of the hull and friction drag. On the other hand, high adiposity could be related to physical growth and biological maturation at these ages despite the training process.

Proportionality

Body mass index did not show any significant difference between 13 year old (20.75 ± 2.53 kg m^2) and 14 year old (20.64 ± 1.91 kg m^2) male paddlers, nor 13 year old (20.31 ± 2.72 kg m^2) and 14 year old (21.01 ± 2.72 kg m^2) female paddlers. Table 2 shows that the 14 year old male paddlers possessed significantly higher proportional arm span, biacromial and transverse chest breadths and corrected arm, and chest girths than their 13 year old counterparts. Nevertheless, the 13 year old male group had higher *Z-scores* in femur and wrist breadths and wrist and ankle girths. No significant differences were found in proportional characteristics between 13 and 14 year old female paddlers.

Proportionality characteristics of young male and female paddlers comparing with the Olympic paddlers (Ackland et al., 2003) are displayed in Figures 1 and 2, respectively. Differences between young and word-class paddlers were similar in both genders. Young paddlers had a lower proportional body mass than Olympic paddlers and were near 1.0 *Z-score* below when comparing the sum of eight skinfolds, thereby indicating a leaner physique of the elite paddlers. Clearly, the main differences between young and Olympic paddlers were located in arm flexed and tensed, chest and waist girths, followed by the biacromial breadth, with lower *Z-scores* in the younger group. On the other hand, young paddlers possessed a higher proportionality in femur breadth than the Olympic paddlers. All the differences found were in accordance with the unique characteristics of the elite sprint paddler.

For the purpose of comparing proportionality of 14 year old schoolchildren, *Z-scores* were calculated from the mean values provided by Ureña (2000) (Figures 3 and 4).

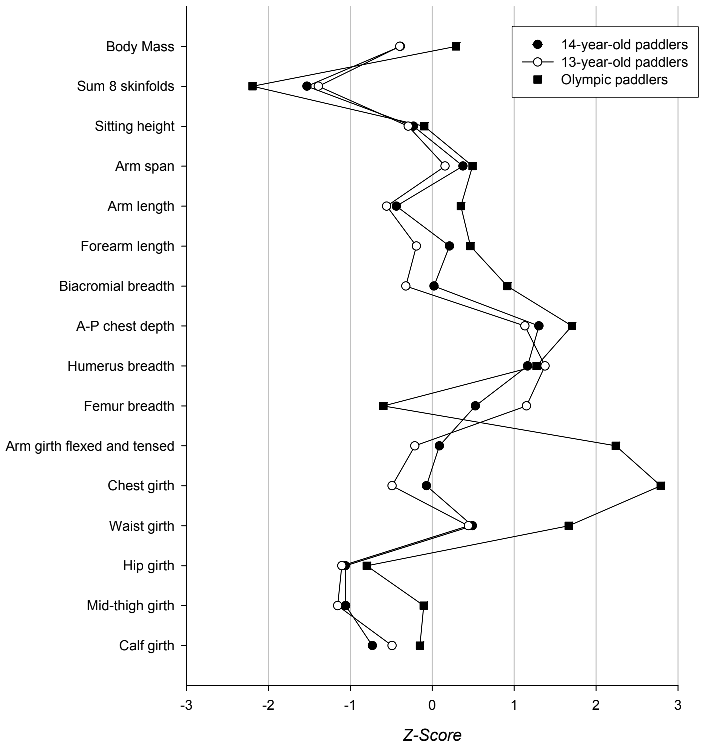

Figure 1

Proportionality (Z-Scores) of young male paddlers comparing with Olympic paddlers (Ackland et al., 2003)

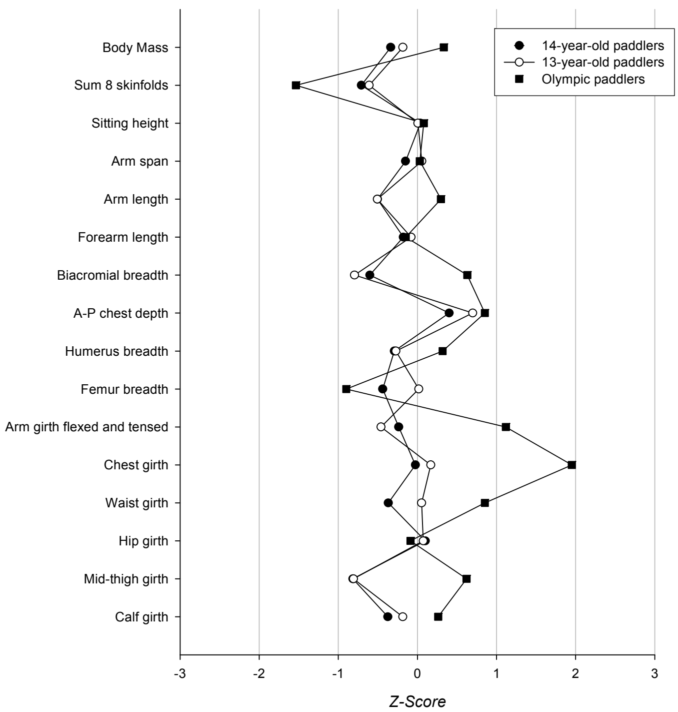

Figure 2

Proportionality (Z-Scores) of young female paddlers comparing with

Olympic paddlers (Ackland et al., 2003

)

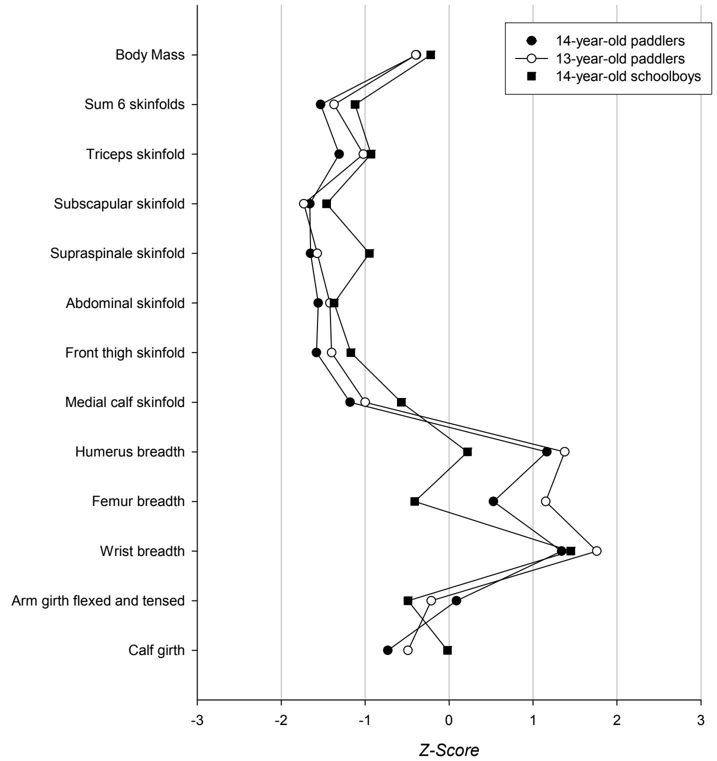

Figure 3

Proportionality (Z-Scores) of young male paddlers comparing with 14 year old schoolboys (Ureña, 2000)

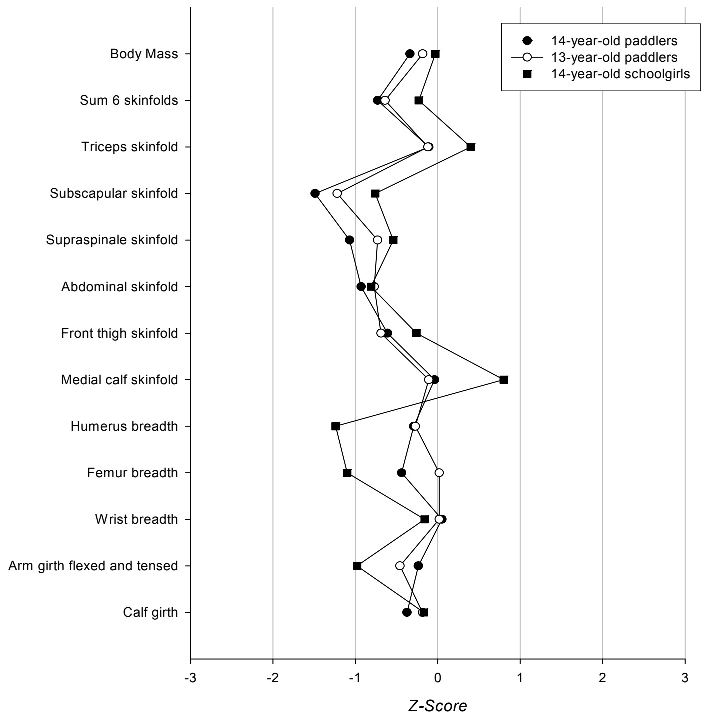

Figure 4

Proportionality (Z-Scores) of young female paddlers comparing with 14 year old schoolgirls (Ureña, 2000)

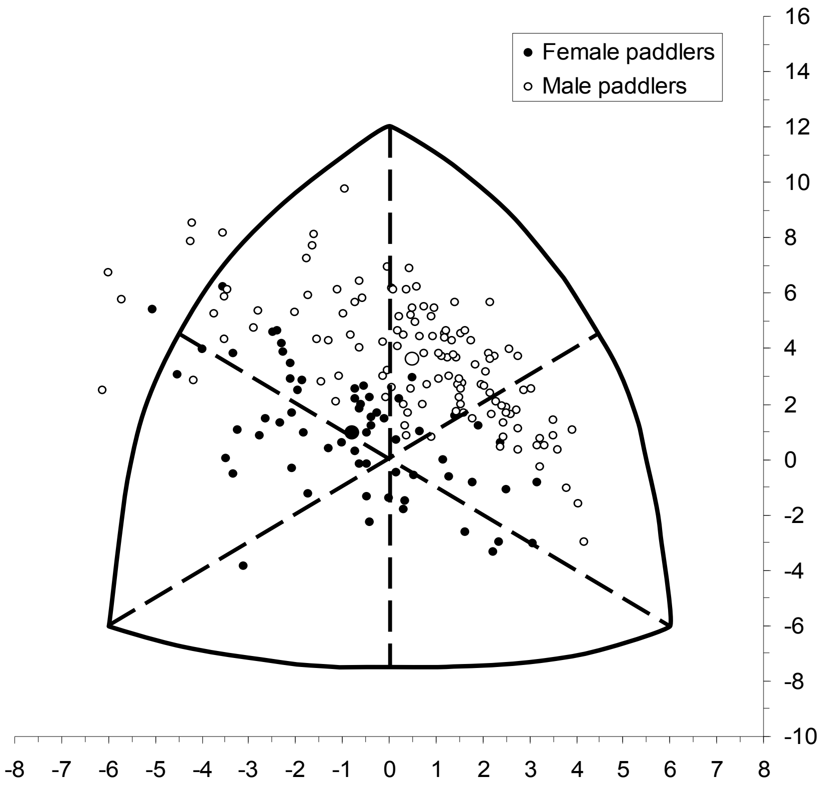

Figure 5

Somatoplots of 13 and 14 year old male and female sprint paddlers. The large circles show the mean profile for each group

The lower adiposity of young paddlers was shown in sum of six and each individual skinfold for both genders. Furthermore, young paddlers possessed significant higher proportional humerus and femur breadths and arm girth flexed and tensed than schoolchildren, with lower *Z-scores* in calf girth. These comparisons highlighted the importance of a leaner physique and large proportional breadths and developed upper body muscularity to achieve a good paddling performance. Unfortunately, the low number of measures provided in the reference population did not allow any further comparisons.

Somatotype

Individual and mean somatoplots for young male and female paddlers are presented in Figure 5. Mean somatotypes of female 13 (3.8-3.8-2.8) and 14 (3.6-3.7-3.0) year-olds demonstrate that these paddlers were best described as centrals, while 13- (2.7-4.8-3.1) and 14- (2.6-4.6-3.1) year-old male paddlers were balanced mesomorphs. The somatotype attitudinal mean (SAM), as a measure of the average dispersion of individual somatotypes from the group mean, indicated a higher homogeneity structure in 14 year old female paddlers (1.27) than in the 13 year olds

(1.66). Male paddlers had a lower homogeneity structure than females, with 1.58 and 1.63 scores of the SAM for 13 and 14 year old groups, respectively.

Mean somatoplots for male and female young paddlers comparing with Olympic paddlers (Ackland et al., 2003) and schoolchildren (Rubio and Franco, 1995; Ureña, 2000) are displayed in Figure 6. Mean somatotype for both 13 and 14 year old female paddlers displayed higher ratings for endomorphy and ectomorphy and a lower rating for mesomorphy than female Olympic sprint paddlers (2.4-4.6-2.3) (Ackland et al., 2003). Similar results were found comparing with Olympic slalom paddlers (2.4-4.1-3.0), but with similar ratings for ectomorphy (Ridge et al., 2007). Whereas, endomorphy and mesomorphy were considerably higher and lower, respectively in non-athlete girls of the same age (endomorphy: from 3.8 to 4.7; mesomorphy: from 2.9 to 3.3) (Rubio and Franco, 1995; Ureña, 2000).

The young male paddlers were less lean, less robust musculoskeletally and less compact than Olympic sprint (1.6-5.7-2.2) and slalom (1.7-5.4-2.5) paddlers (Ackland et al., 2003; Ridge et al., 2007). Comparing with 13 and 14 year olds normal population, young male paddlers possessed higher ratings of mesomorphy (from 4.0 to 4.4) and ectomorphy (from 2.4 to 2.9) and a lower endomorphy (from 3.2 to 3.6) (Rubio and Franco, 1995; Ureña, 2000). The somatotype for both ages was very similar in males and females. The main difference with respect to Olympic paddlers' somatotype lies in a lower mesomorphy, as was to be expected because of the young age of the paddlers.

The variation from the mean somatotype was higher in young paddlers than in Olympic sprint paddlers (Ackland et al., 2003), with SAM values of 1.1 and 1.0 respectively for male and female categories. On the other hand, schoolchildren of the same age showed a considerably higher heterogeneity with SAM values of 1.88 for both males and females than young paddlers (Ureña, 2000). This indicates that despite being the best for their age, the group is still young enough for members to be able to record a good performance even if far from the normative profile.

Conclusions

Young elite male and female paddlers present general anthropometric characteristics similar to young athletes who practice other sports, but with slightly larger upper body dimensions. Mean somatotypes of female paddlers were best described as centrals, while male paddlers were balanced mesomorphs. Fourteen year-old male paddlers were heavier, taller, with greater sitting height, arm span, arm and forearm lengths, upper body breadths and girths than their 13 year old counterparts. However, 13 and 14 year old female paddlers only differed in biacromial breadth and corrected arm girth. The differences between young paddlers and other schoolchildren and between 13 and 14 year-old paddlers mirrored those reported between elite paddlers and the normal population. Proportionality is a useful tool for talent identification; Olympic paddlers had higher proportional dimensions in arm flexed and tensed, chest and waist girths, and biacromia breadth in both genders. This study offers the anthropometric profile of the young male and female elite paddler, which could be used as a guideline for talent identification in sprint canoeing and kayaking.

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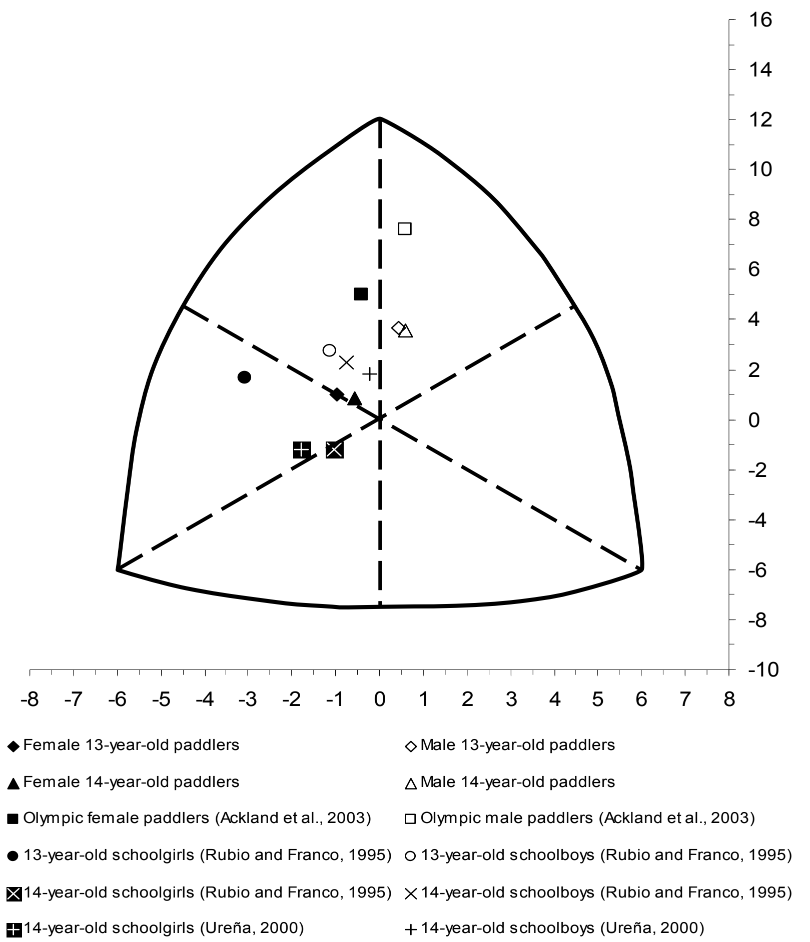

Figure 6

Somatotype of 13- and 14-year-old male and female sprint paddlers comparing with Olympic paddlers (Ackland et al., 2003) and schoolchildren (Ureña, 2000; Rubio and Franco, 1995)

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