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Kinanthropometric Comparison between Young Elite Kayakers and Canoeists

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ABSTRACT

The aims of this study were to describe and compare kinanthropometric characteristics of elite young kayakers and canoeists and to compare their proportionality with Olympic paddlers. One hundred and twenty young elite sprint paddlers (66 kayakers and 58 canoeists), aged 13- and 14-years-old, were assessed using a battery of 32 anthropometric dimensions. Somatotypes, Phantom Z-scores and corrected girths were calculated. Comparison between kayakers and canoeists showed that kayakers had greater height, body weight, sitting height, arm span and upper body lengths, breadths and girths than canoeists. Higher proportional humerus breadth and arm girths were also found in kayakers. However, canoeists had higher Z-scores in femur breadth. Olympic paddlers had higher proportional dimensions in upper body girths, and biacromial breadth in both disciplines. Mean somatotypes of kayakers were best described as balanced mesomorphs, while canoeists were ecto-mesomorphs. Differences between kayak and canoe paddlers may be explained by the continual need for physical development in kayakers, in order to remain competitive, compared to the young canoeists' need to place much greater emphasis on the development of their technical ability. 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

A considerable amount of literature has been published on anthropometric and body composition differences between playing positions. Most of these studies were focused on team sports such as soccer[1,2], rugby, Australian and American football[3–5], volleyball[6], basketball[7–9], and water-polo[10]. All pointed out that there were significant differences between playing position. Furthermore, in individual sports some differences have been found between athletics disciplines[11], swimming styles[10] or lightweight and open-class rowing[12,13].

Both sprint kayaking and canoeing differ from rowing in that rowers sit backwards, facing the stern of the boat and the oar is attached to the boat sitting on a rowlock, whereas paddlers move in the direction of the view and the paddle is not attached to anything but the hands of the kayaker or canoeist. There are also some differences between sprint kayaking and canoeing. In kayak, the paddler is seated and the force is transmitted to the boat through the seat and the foot-rest, whereas canoeists are in a high kneeling position (up on one knee) in the boat. Furthermore, kayakers propel by means of a double-blade paddle alternately on both sides of the boat and steering is accomplished with a rudder attached with cords to a tiller controlled by the feet, while canoeists do it with a single-blade paddle always on the same side of the canoe and use steering strokes to control their direction.

During the last 30 years, a considerable amount of literature has been published on biomechanical analysis of paddling technique[14–19] and analyzing pacing strategies[20–22] for both canoeing and kayaking. However, only a few research reports deal with the comparison of anthropometric attributes of elite kayakers and canoeists. In a review of the science and medicine of canoeing and kayaking, Shephard[23] reported the results published by Ar-

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mand[24], where kayakers were a little taller and 6.0 kg heavier than canoeists, while Hirata[25] found a mean difference of 3.5 cm in stature and 2.9 kg in body mass between kayakers and canoeists who won a gold medal at the Montreal, Tokyo and Munich Olympic Games. Misigoj-Durakovic & Heimer[26] examined the morphological characteristics of 29 sprint paddlers (18 kayakers and 11 canoeists), candidates for the 1987 Universiade, concluding that there were no significant differences between the two disciplines. At the Sydney 2000 Olympic Games, sprint and slalom kayak and canoe paddlers were measured in the Oz2000 Sydney Olympic Rowing, Canoeing and Kayaking anthropometry project[27,28]. Ridge *et al.*[28] compared 12 slalom kayakers with 19 slalom canoeists, and found that canoe paddlers possessed a greater sum of 8 skinfolds and consequently higher ratings of endomorphy. There was also a trend for canoeists to have a greater thigh girth than kayakers, which could be attributed to a large thigh skinfold.

In Spain, 13 and 14 year-old paddlers compete over 3000 m in single kayak or canoe in National Cups, and at the National Championship over 1000 m in single, double or quadruple boats. Once the competition season has finished, National Development Camps are held in order to facilitate the technical and morphological evolution of the young paddlers. These camps provide an opportunity to carry out comprehensive anthropometric investigations. Therefore, the aims of this study were: to utilize the opportunity of the Development Camps (1) to describe and compare body dimensions, somatotype and proportionality of elite male young kayakers and canoeists; (2) to compare the proportionality of young kayakers and canoeists with Olympic paddlers; and (3) to establish an anthropometric profile for 13 and 14 year-old kayakers and canoeists to be used for talent identification and training.

Materials and Methods

Participants

One hundred and twenty four young elite male sprint paddlers (66 kayakers and 58 canoeist; 13- and 14-year-olds) 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. 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 boys before participation.

Data collection

All variables (listed in Table 1) were measured by a Level 2 anthropometrist certified by the International Society for the Advancement of Kinanthropometry (ISAK), in accordance with the ISAK guidelines[29]. 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, respectively, used for data analyzis. The technical error of measurement scores was required to be within 5% for skinfolds and within 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 Phantom Z-scores were calculated for all variables. The equations of Carter & Heath[30] were used to calculate anthropometric somatotypes and the Phantom Stratagem[31] was used to calculate Z-scores of each raw variables. Body mass index (BMI), sums of six and eight skinfolds were calculated. Girths were corrected for the skinfold at the corresponding site using the formula: corrected girth = girth – (π · skinfold thickness).

Data were analyzed separately for kayakers and canoeists. 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 (kayakers and canoeists) 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 anthropometric absolute size of the two groups. Comparison between kayakers and canoeists revealed that kayakers had higher values in all the variables analyzed, with the same chronological age. Significant differences were found in body mass, stretch stature, sitting height, arm span, arm length, all the breadths except for the transverse chest and femur breadths and all the girths with the exceptions of the upper- and mid-thigh girths. The findings of the current study were consistent with those of Shephard[23] who reported a higher body mass and stretch stature in elite kayakers and contrast with those of Misigoj-Durakovic & Heimer[26]. Another important finding was that the greatest differences between kayakers and canoeists were found in upper body measures such as trunk and arm breadths and girths. Prior studies had noted the importance of these measures and their relationships with race performance in kayaking[32–34]. However these associations had not previously been described in canoeing. In terms of sums of six and eight skinfolds, the results obtained by kayakers and canoeists

TABLE 1
GENERAL CHARACTERISTICS AND ABSOLUTE SIZE OF YOUNG SPRINT KAYAKERS AND CANOEISTS

Variable	Kayakers (N=66)	Canoeists (N=58)
Age (years)	13.69±0.58	13.65±0.62
Paddling experience (years)	3.92±1.89**	2.97±1.40
Weekly training (hours)	7.20±1.55	7.16±1.44
Body mass (kg)	59.96±9.31*	55.08±12.06
Sum 6 skinfolds[a] (mm)	64.86±23.67	64.70±37.76
Sum 8 skinfolds[b] (mm)	82.13±30.55	80.57±47.64
Stretch stature (cm)	168.75±6.58**	163.71±8.72
Sitting height (cm)	88.29±4.23**	85.07±5.30
Arm span (cm)	172.82±8.19**	167.87±11.00
Arm length (cm)	31.38±1.59**	30.46±1.91
Forearm length (cm)	24.28±1.51	23.80±2.11
Biacromial breadth (cm)	37.63±2.06**	36.13±2.63
Biiliocristal breadth (cm)	29.18±2.67*	28.16±2.61
A-P chest depth (cm)	19.09±1.48*	18.38±1.81
Transverse chest breadth (cm)	27.42±2.06	26.72±2.58
Humerus breadth (cm)	6.93±0.34**	6.59±0.53
Femur breadth (cm)	9.73±0.50	9.64±0.60
Wrist breadth (cm)	5.62±0.30**	5.40±0.38
Arm girth relaxed (cm)	26.67±2.70**	24.98±2.82
Corrected arm girth (cm)	23.55±2.26**	21.85±2.20
Arm girth flexed and tensed (cm)	29.60±2.72**	27.57±2.75
Forearm girth (cm)	25.03±1.87**	23.53±1.95
Wrist girth (cm)	16.23±0.89**	15.64±1.17
Chest girth (cm)	86.16±5.87**	82.75±8.35
Waist girth (cm)	73.80±6.50*	70.69±8.92
Hip girth (cm)	87.95±6.21*	85.27±7.44
Upper-thigh girth (cm)	53.50±5.11	51.69±5.49
Mid-thigh girth (cm)	47.84±4.06	46.29±4.76
Corrected mid-thigh girth (cm)	43.42±3.15*	41.77±3.89
Calf girth (cm)	33.62±2.54*	32.48±3.05
Corrected calf girth (cm)	30.41±2.08**	28.95±2.78
Ankle girth (cm)	22.47±1.40*	21.83±1.85

[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 canoeists (*p<0.05; **p<0.01)

were similar. These results differed from Ridge *et al.*[28] who found a greater sum of six and eight skinfolds in elite slalom canoeists (kayakers: 31.3±5.7 mm and 45.8±9.0 mm, respectively; canoeists: 38.1±5.5 mm and 57.1±9.4 mm, respectively), but they were broadly consistent with those reported by Misigoj-Durakovic & Heimer[26] in sprint paddlers (sum of five skinfolds: kayakers: 29.8±8.0 mm; canoeists: 31.9±7.7 mm).

These results may be explained by the fact that those beginning paddling activities usually start in kayaking, because it is easier to keep the stability in learner kayaks. Subsequently some paddlers change to canoeing as their competitive discipline, though most of them keep on kayaking and do not change. Those who continue as kayakers must continue to improve their strength in order to remain competitive. Those who change to canoeing, however, need to adapt to an event which places far greater emphasis on technique since canoeists paddle without the help of a rudder and on only one side of the canoe. It is difficult to keep the canoe going in the right direction in good conditions and much more difficult in windy conditions. Therefore, particularly in young canoeists, paddling technique is far more important than physical development in order to achieve good results.

Furthermore, the ratio of kayakers to canoeists in the National Competitions run by the Royal Spanish Canoeing Federation in the seasons 2006, 2007 and 2008 was approximately 3:1. Thus, it is easier to be selected for the Annual National Development Camps in canoeing (than in kayaking) because there are only a third as many competitors. This difference in the number of competitors in each discipline could be considered as a limitation of this study.

Proportionality

Body mass index did not show any significant difference between kayakers (20.97±2.35 kg m^2) and canoeists (20.34±3.09 kg·m^2).

Table 2 shows that the kayakers possessed significant higher proportional humerus breadth and arm relaxed, flexed and tensed, and corrected arm and forearm girths than canoeists. Nevertheless, canoeists had higher *Z*-scores in femur breadth. This result may be explained by the fact that the implication of leg muscles in the paddling movement in canoeing is greater than in kayaking[17]. No significant differences were found in proportional characteristics in the rest of the measures.

The proportionality characteristics of young kayakers and canoeists compared to Olympic paddlers[27] are displayed in Figure 1. The differences between the young and word-class paddlers were similar in both disciplines. As expected, the Olympic paddlers were proportionally larger in all measures except the sum of eight skinfolds and femur breadth. The larger proportional skinfold sum in the young confirmed the proportionally leaner physique of the elite paddlers, whereas the larger proportional femur breadth typified the morphology of 13 and 14 year old boys (as compared to fit adults) whether they be paddlers or not.

Somatotype

Individual and mean somatoplots for young kayakers and canoeists are presented in Figure 2. With mean so-

TABLE 2
RELATIVE SIZE CHARACTERISTICS FROM PHANTOM *Z-SCORES* OF YOUNG SPRINT KAYAKERS AND CANOEISTS

Variable	Kayakers (N=66)	Canoeists (N=58)
Z Body mass	–0.39±0.75	–0.40±0.94
Z Sum 6 skinfolds[a]	–1.47±0.67	–1.42±1.10
Z Sum 8 skinfolds[b]	–1.47±0.69	–1.45±1.10
Z Sitting height	–0.20±0.45	–0.33±0.65
Z Arm span	0.26±0.54	0.28±0.69
Z Arm length	–0.50±0.62	–0.49±0.57
Z Forearm length	–0.06±0.86	0.11±0.94
Z Biacromial breadth	–0.05±0.74	–0.26±0.83
Z Biiliocristal breadth	0.32±1.23	0.24±1.14
Z A-P chest depth	1.26±0.90	1.17±1.22
Z Transverse chest breadth	–0.15±1.07	–0.10±1.08
Z Humerus breadth	1.45±0.83*	1.06±1.02
Z Femur breadth	0.62±1.00*	1.07±1.04
Z Wrist breadth	1.63±0.99	1.45±0.96
Z Arm girth relaxed	0.00±1.03*	–0.41±1.00
Z Corrected arm girth	0.88±1.00**	0.34±0.89
Z Arm girth flexed and tensed	0.18±0.97**	–0.33±0.91
Z Forearm girth	0.07±1.11**	–0.48±1.06
Z Wrist girth	0.03±1.06	–0.14±1.15
Z Chest girth	–0.19±0.90	–0.37±1.24
Z Waist girth	0.56±1.28	0.36±1.89
Z Hip girth	–1.07±0.88	–1.09±0.96
Z Upper-thigh girth	–0.44±1.09	–0.50±1.11
Z Mid-thigh girth	–1.09±0.77	–1.12±0.83
Z Corrected mid-thigh girth	–0.99±0.71	–1.10±0.78
Z Calf girth	–0.58±1.02	–0.65±1.04
Z Corrected calf girth	0.23±0.95	–0.07±1.13
Z Ankle girth	0.72±0.99	0.73±1.03

[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 canoeists (*p<0.05; **p<0.01)

matotypes of 2.7–4.8–3.1, the kayakers were best described as balanced mesomorphs, while the canoeists, at 2.6–4.5–3.2, were ecto-mesomorphs. The somatotype attitudinal mean (SAM), as a measure of the average dispersion of individual somatotypes from the group mean, indicated a higher homogeneity in kayakers (1.49) than in canoeists (1.71).

The young male paddlers were less lean, robust musculoskeletally and compact than Olympic sprint (1.6–5.7–2.2) and slalom (1.7–5.4–2.5) paddlers[27, 28]. The somatotype for both disciplines was similar in kayakers and canoeists. The main difference with respect to Olympic

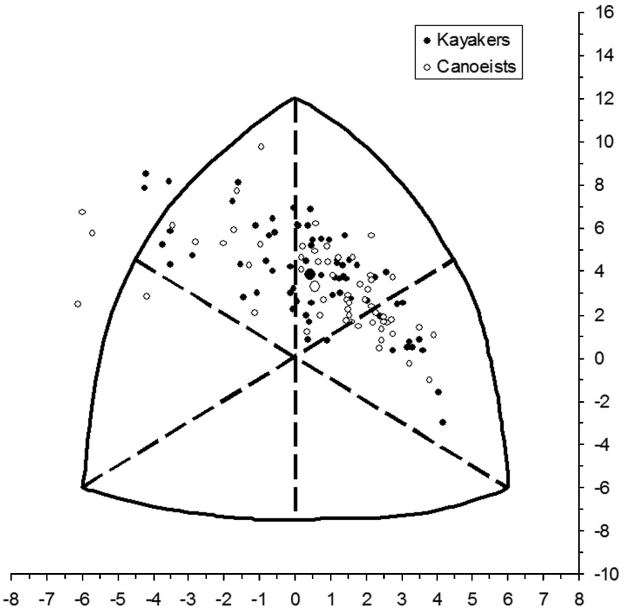

Fig. 1. Proportionality (Phantom Z-Scores) of young kayakers and canoeists comparing with Olympic paddlers[27].

paddlers' somatotype lays in a lower mesomorphy, as was

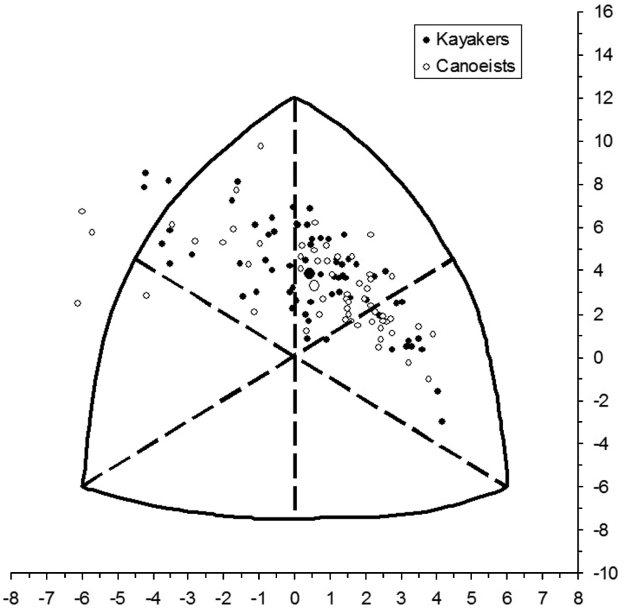

Fig 2. Somatoplots of sprint kayakers and canoeists. Large circle = mean profile each group.

to be expected because of significant age difference. The variation from the mean somatotype was higher in young paddlers than in Olympic sprint paddlers[27], with SAM values of 1.1.

The somatotype attitudinal distance (SAD) between the mean somatotype of young paddlers and Olympic

sprint paddlers was 1.7 and 1.9 for kayakers and canoeists, respectively. Furthermore, the lower heterogeneity and values of SAD from the somatotype of Olympic paddlers and the higher mesomorphy could be related with the necessity of a greater physical development to achieve a good result and for being selected in National Development Camps in young kayakers.

Conclusions

One of the more significant findings emerging from this study is that young kayakers were heavier, taller, with greater sitting height, arm span, arm length, upper body breadths and girths than canoeists. These differences may be explained by the continued need for physical development in kayakers, in order to remain competitive, whereas young canoeists need to place a much greater emphasis on the development of their technical ability. Mean somatotypes of both kayakers and canoeists were very similar, although kayakers were best described as balanced mesomorphs, while canoeists were ecto-mesomorphs. Proportionality is a useful tool for talent identification; Olympic paddlers had higher proportional dimensions in arm flexed and tensed, chest and waist girths, and biacromial breadth than young paddlers. This study offers the anthropometric profile of the young elite kayakers and canoeists, which could be used as a guideline for talent identification in sprint canoeing and kayaking.

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KINANTROPOMETRIJSKE USPOREDBE IZMEĐU MLADIH VRHUNSKIH KAJAKAŠA I KANUISTA

S A Ž E T A K

Ciljevi ovog istraživanja bili su opisati i usporediti kinanthropometrijske karakteristike vrhunskih mladih kajakaša i kanuista te usporediti njihovu proporcionalnost s olimpijskim veslačima. Stotinu i dvadeset mladih vrhunskih sprint veslača (66 kajakaša i 58 kanuista), u dobi od 13 i 14 godina, ocijenjeni su pomoću baterije s 32 antropometrijske mjere. Izračunati su somatotipovi, Z-rezultat i ispravljeni omjeri. Usporedba između kajakaša i kanuista pokazala je da su kajakaši viši, imaju veću tjelesnu težinu, sjedaću visinu, raspon ruku i dužinu gornjeg tijela, duljine, širine i opsege nego kanuisti. Viša proporcionalna širina humerusa i opsega ruke su također u kajakaša. Međutim, kanuisti imaju veće Z-rezultate u širini bedrene kosti. Olimpijski veslači su veći u proporcionalni dimenzijama gornji dijela tijela, opsega i biakromijalne širine, u obje discipline. Srednji somatotipovi za kajakaše najbolje je opisati kao uravnoteženi mezomorfni, dok su kanuisti su ekto-mezomorfni. Razlike između veslača kajaka i kanua mogu objasniti trajne potrebe za tjelesnim razvojem u kajakaša, kako bi ostali konkurentni, u usporedbi s mladim kanuistima, gdje su potrebe i puno veći naglasak na razvoj njihove tehničke sposobnosti. Podaci u ovoj studiji mogu se koristiti kao smjernica za otkrivanje talenta u sprint veslanju kanua i kajaka.