Short report

Anthropometric characteristics of elite male junior rowers

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Abstract

During the 1997 Fédération Internationale des Sociétés d'Aviron World Junior Rowing Championships, anthropometric data on 383 male junior rowers were assessed. With 430 participating athletes, the sample represented 89% of the population. In addition to age, 27 dimensions were measured: body mass, six heights or lengths, four breadths, 10 girths, and six skinfolds. The elite male junior rowers were tall (187.4 (5.8) cm; mean (SD)) and heavy (82.2 (7.4) kg), with larger length, breadth, and girth dimensions than a nationally representative sample of Belgian boys of the same chronological age. A rowing specific anthropometric profile chart with norms was constructed. The stature of the junior rowers is similar to that of adult heavyweight elite rowers, except that the junior rowers are lighter. Compared with non-finalists, finalists are heavier (but still lighter than the adult heavyweight elite rower) and taller, with greater length, breadth (except for the bicristal diameter), and girth dimensions.

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Elite athletes of different sports differ in physical and physiological characteristics. We expected the elite athlete to represent an expression of heredity, physical training, nutrition, and sociocultural factors. Description and analysis of top level athletes include kinanthropometry, which is the study of human size, shape, proportion, composition, and gross motor function in order to understand growth, exercise performance, and maturation.[1] The chosen variables can be restricted to anthropometric dimensions. The quantification of physique, which can be called anthropometry, of top level athletes is a reference in relating sports performance and body structure.

Rowing has been extensively studied.[2] Anthropometric data for adult male and female rowers emphasise the importance of body mass[3] and body size[4–7] for rowing performance. The profile of male junior rowers may be used in evaluating models for talent identification.[8] To establish a "sport specific" anthropometric profile, a certain number of elite athletes from the same sport or event, measured for several anthropometric dimensions in standardised circumstances, are necessary.[8] The 1997 World Junior Rowing Championships provided the opportunity to carry out a comprehensive anthropometric investigation.

The aims of this study were to: (*a*) describe the body size of male junior rowers; (*b*) compare the anthropometric data of finalists (those rowers who were ranked in the top six) and non-finalists; (*c*) establish a rowing specific anthropometric profile chart for male juniors to be used for rowing training and performance.

Methods

SAMPLE

Forty three countries participated in the male events of the 1997 World Junior Rowing Championships, and participants from 41 countries were measured. Anthropometric data were collected on 383 junior male rowers, who included competitors and reserves (4.4% of the total sample). Coxwains were not measured. With 430 participating male athletes, the sample represented 89% of the population. Most of the rowers were from Europe (83.8%) and most were white (91.6%). For all rowing events, 80–100% of the competitors were measured, including 83% of the winners and medallists as well as 89% of the finalists. The age of the junior rowers varied between 15.1 and 18.6 years with a mean of 17.8 (0.7) years. They trained 7 to 10 times (10–15 hours) a week.

DATA COLLECTION

The protocols and techniques for this project were approved by the board of the Fédération Internationale des Sociétés d'Aviron. When the rowers arrived, they completed a form requesting certain personal and training data. Techniques were based on the procedures given by Claessens *et al*.[9] For some measurements, the procedures outlined by Lohman *et al*,[10] Norton *et al*,[11] and Ross and Marfell-Jones[12] were followed. The selected anthropometric dimensions were based on (*a*) the factor analytical classification of physique to characterise the

Table 1 Descriptive anthropometric characteristics for male junior rowers compared with Belgian reference data[16]

Dimension	Male jnior rowers (n=383)			Belgian median (n=1098)
	Mean	SD	Range	
Body mass (kg)	82.2	7.4	60.0–108.1	64.7
Stature (cm)	187.4	5.8	167.6–201.5	175.4
Sitting height (cm)	96.8	3.2	87.5–106.7	91.4
Leg length (cm)	90.7	3.8	78.3–99.1	84.0
Arm length (cm)	82.9	3.3	71.6–92.6	—
Biacromial diameter (cm)	41.5	1.7	37.0–48.7	39.1
Bicristal diameter (cm)	30.3	1.6	26.2–39.1	—
Humerus width (cm)	7.6	0.3	6.4–8.6	7.0
Femur width (cm)	10.3	0.6	8.7–18.2	9.6
Biceps girth (cm)*	32.9	1.9	27.4–40.0	28.1
Upper arm girth (cm)†	29.8	1.9	24.1–36.3	—
Forearm girth (cm)	28.6	1.3	24.3–33.3	—
Thigh girth (cm)	57.9	3.3	48.5–68.2	51.3
Calf girth (cm)‡	37.7	1.9	32.8–44.8	34.9
Biceps skinfold (mm)	3.9	1.0	2.0–9.3	—
Triceps skinfold (mm)	7.9	2.2	3.8–15.9	6.8
Subscapular skinfold (mm)	8.9	1.6	5.7–16.5	8.3
Suprailiac skinfold (mm)	6.6	2.2	3.5–18.0	7.7
Thigh skinfold (mm)	11.5	3.8	5.0–25.7	—
Calf skinfold (mm)	8.4	3.0	3.2–21.5	—

*Maximum girth of the tensed upper arm (maximum flexed); †midway between acromium and olecranon, arm relaxed; ‡maximum girth.
—, data not available.

different components of body build,[13] (*b*) the measurements as used in studies on male and female rowing athletes,[4–7 14 15] and (*c*) the measurements used in the physical fitness surveys on Belgian boys[16] for reference.

After each subject had been "landmarked", they were directed to one of the five stations for measurement. Each anthropometrist took the same measurements and was assisted by a recorder. In addition to age, the following measures were obtained: body mass; stature; sitting height; acromial height; radial height; dactylion height; tibial height; leg length (stature minus sitting height); arm length (acromial height minus dactylion height); biacromial diameter; bicristal diameter; humerus and femur widths; biceps, upper arm, forearm, thigh, and calf girths; and biceps, triceps, subscapular, suprailiac, thigh, and calf skinfolds. All bilateral measurements were obtained from the left side of the body.[8]

DATA ANALYSIS

Variables were tested for their skewness. Except for the biceps skinfold, the suprailiac skinfold, and the calf skinfold, all other variables fitted to a normal distribution. Mean, standard deviation, and minimum and maximum values are presented.

As most of the subjects were European and white, normative reference data (for the age closest to the mean chronological age of the male junior rowers) of Belgian secondary schoolboys aged 17.5–18 years were used for comparison.[16] A profile chart with norms, using percentiles (P values of 5, 10, 25, 50, 75, 90, 95), was constructed. To compare the anthropometric data of finalists and non-finalists, an independent two sample *t* test analysis was carried out. The 1% level was chosen to represent statistical significance. The statistical analysis system programme[17] was used.

Table 2 Independent two sample t test summary of significant anthropometric differences for male junior rowers by performance: finalists (n=144) versus non-finalists (n=222)

Dimension	Finalists (n=144)	Non-finalists (n=222)	p Value
Body mass (kg)	84.8 (7.1)	80.6 (7.0)	<0.01
Stature (cm)	189.3 (5.0)	186.3 (6.1)	<0.01
Sitting height (cm)	97.6 (2.9)	96.2 (3.3)	<0.01
Leg length (cm)	91.6 (3.5)	90.1 (4.0)	<0.01
Arm length (cm)	83.7 (3.0)	82.4 (3.4)	<0.01
Biacromial diameter (cm)	41.9 (1.6)	41.3 (1.7)	<0.01
Humerus width (cm)	7.7 (0.3)	7.6 (0.3)	<0.01
Femur width (cm)	10.4 (0.5)	10.2 (0.5)	<0.01
Biceps girth (cm)*	33.5 (1.8)	32.6 (1.9)	<0.01
Upper arm girth (cm)†	30.4 (1.8)	29.6 (1.9)	<0.01
Forearm girth (cm)	29.1 (1.2)	28.2 (1.3)	<0.01
Thigh girth (cm)	58.7 (3.4)	57.5 (3.2)	<0.01
Calf girth (cm)‡	38.1 (1.9)	37.5 (1.9)	<0.01
Triceps skinfold (mm)	7.5 (1.9)	8.2 (2.3)	<0.01

Values are mean (SD).
*Maximum girth of the tensed upper arm (maximum flexed); †midway between acromium and olecranon, arm relaxed; ‡maximum girth.

Table 3 Anthropometric profile chart for male junior rowers (n=383)

Body dimension	Percentiles						
	5	10	25	50	75	90	95
Body mass (kg)	69.8	73.0	77.2	81.9	87.0	92.3	94.7
Stature (cm)	177.3	179.2	183.6	187.6	191.4	195.2	196.6
Sitting height (cm)	91.5	92.7	94.5	96.7	98.9	100.8	102.3
Leg length (cm)	84.4	85.3	88.1	90.8	93.3	95.9	97.3
Arm length (cm)	77.7	78.5	80.8	83.0	85.2	87.0	88.4
Biacromial diameter (cm)	38.6	39.4	40.4	41.5	42.5	43.5	44.2
Bicristal diameter (cm)	27.9	28.4	29.3	30.2	31.1	32.2	33.0
Humerus width (cm)	7.1	7.2	7.4	7.6	7.8	8.0	8.2
Femur width (cm)	9.6	9.8	10.0	10.3	10.6	11.0	11.1
Biceps girth (cm)	29.7	30.5	31.6	33.1	34.3	35.3	35.8
Upper arm girth (cm)	26.6	27.3	28.5	30.0	31.2	32.1	32.8
Forearm girth (cm)	26.5	27.0	27.6	28.5	29.5	30.3	30.7
Thigh girth (cm)	52.7	53.8	55.5	58.0	60.2	62.0	63.4
Calf girth (cm)	34.4	35.1	36.6	37.8	39.0	40.0	40.7
Biceps skinfold (mm)	2.7	2.9	3.2	3.6	4.4	5.4	5.9
Triceps skinfold (mm)	5.0	5.3	6.3	7.7	9.1	10.7	12.1
Subscap. skinfold (mm)	6.6	7.1	7.8	8.7	9.6	10.9	11.5
Suprailiac skinfold (mm)	4.3	4.6	5.1	6.1	7.6	9.5	10.5
Thigh skinfold (mm)	6.5	7.1	8.7	10.9	13.6	16.4	18.0
Calf skinfold (mm)	4.8	5.3	6.3	7.8	9.9	12.5	14.2

Results

Comparisons between male junior rowers and the normative reference group show that the rowers are heavier (+ 17.5 kg), taller (+ 12.0 cm), and have a greater sitting height (+ 5.4 cm) and longer legs (+ 6.7 cm) (table 1). Junior rowers also have higher values for biacromial diameter (+ 2.4 cm), humerus width (+ 0.6 cm), femur width (+ 0.7 cm), biceps girth (+ 4.8 cm), thigh girth (+ 6.6 cm), and calf girth (+ 2.8 cm). As compared with the reference group, male junior rowers also have higher values for the triceps (+ 1.1 mm) and subscapular (+ 0.6 mm) skinfolds, but a smaller suprailiac skinfold (− 1.1 mm).

Finalists are heavier and have higher values for length, breadth (except for the bicristal diameter), and girth dimensions than the non-finalists (table 2). No significant differences are recorded between finalists and non-finalists for skinfold thicknesses, except for the triceps skinfold.

Table 3 gives an anthropometric profile chart. The scores for 20 anthropometric dimensions are located on the chart together with the corresponding percentile values—for example, P5, P10, P25, P50, P75, P90, and P95.

Table 4 Comparison of mean age, stature, and weight of male junior and elite heavyweight and lightweight rowers competing in international tournaments

Category	n	Age (y)	Stature (cm)	Body mass (kg)	Reference
Juniors					
German national team 1975	27	18.0	186.6	81.6	Ditter and Nowacki[23]
British and Greek national team 1985	8	17.6	190.2	83.1	Koutedakis and Sharp[24]
Belgian national team 1988	10	17.0	186.8	81.2	J Bourgois and J Vrijens
German national team 1989	19	17.5	191.5	83.7	Steinacker *et al*[25]
World Championships 1997	383	17.8	187.4	82.2	Present study
Elite heavyweight					
Olympic Games 1968	85	24.3	185.1	82.6	De Garay *et al*[18]
Olympic Games 1976	65	24.2	191.3	90.0	Carter *et al*[26]
FISA champions	14	25.6	192.0	93.0	Secher[19]
FISA competitors	13	25.1	189.0	84.0	Secher[19]
Dutch national team 1988	18	24.1	190.0	79.3	Rienks *et al*[27]
Elite lightweight					
World Championships 1985	144	24.3	180.7	70.3	Rodriguez[6]

Discussion

Rowing is a strength endurance type of sport, and body size and mass are undoubtedly performance related factors.[2 3 18 19] An anthropometric profile of young rowers was carried out using a standard test battery, which includes body mass, stature, length, and breadth variables for the estimation of skeletal robustness, arm and leg girths for the evaluation of muscle development, and skinfold thicknesses for the estimation of fat mass and fat-free mass.[8] The individual data were compared with a reference group. A further step is the construction of a profile chart with norms. The American College of Sports Medicine[20] argues that youngsters should, if possible, be counselled towards sports that are realistic given the individual body type.

The male junior rowers were 7% taller and 27% heavier than the reference group.[16] On the basis of the descriptive data for 14 male adult champions,[21] Shephard[2] concluded that outstanding rowers are 10% taller and 27% heavier than the general Canadian population. Malina[22] suggested that there is no effect of regular training for rowing on statural growth and noted that rowers are already taller than average during childhood, maintaining their position relative to reference data during childhood and adolescence.

Table 4 gives a comparison of the mean age, stature, and body mass of male junior[23–25] (J Bourgois and J Vrijens, personal communication) and senior[6 18 19 26 27] rowers competing in international championships. The mean stature of elite junior rowers varies between 187 and 192 cm, which is similar to the adult heavyweight elite rower (185–192 cm). On the other hand, heavyweight rowers seem to be heavier (79–93 kg) than the elite junior rowers (81–84 kg). Weight classification is part of rowing in World Championships (since 1974) and in Olympic Games (since 1996) at the senior level, but not at the junior level. The physical characteristics of male elite lightweight rowers (maximal weight for a single rower less than 72.5 kg and an average for every boat, except the single scull, of 70.0 kg) differ from their heavier peers and junior rowers (table 4). Our group of junior rowers are on average 6.7 cm taller and 11.9 kg heavier than lightweight rowers.[6]

Junior rowers have greater length dimensions and greater breadths and girths than the reference group[16] and lightweight rowers[6] but lower values (except for the bicristal diameter) than heavyweight rowers[26] (table 5). Sklad *et al*[28] found that a year of training increased arm and chest circumferences, and relative body mass in 41 male junior rowers aged 17–18 years.

The most able young rowers could be distinguished by their stature, skeletal robustness, and muscular development.[29] This is supported when comparing the anthropometric characteristics of finalists and non-finalists. Finalists were heavier and taller, with higher values for length, breadth (except for the bicristal diameter), and girth dimensions (table 2). Data for adult heavyweight rowers indicate that winners are consistently heavier and taller than the average for competitors participating in World Championships and Olympic Games.[19 30] Rodriguez[6] found that lightweight medallists are lighter (−0.6 kg) than non-medallists, with higher values for length, breadth, and girth dimensions.

Calculated from the mean values in the different studies,[6 16 26] junior rowers seem to have a lower sitting height relative to stature (51.6%) and a higher leg length relative to stature (48.4%) compared with the normative reference group[16] (52.1% and 47.9% respectively) and the heavyweight Olympic rowers[26] (52.1% and 47.9% respectively). No differences were found between junior rowers and elite lightweight rowers.[6] Long legs increase the drive phase of the rowing stroke.

As compared with Olympic heavyweight rowers,[26] junior rowers have somewhat higher values for the subscapular, thigh, and calf skinfolds, but a lower value for the triceps skinfold (table 5). Considerably thinner skinfolds were found in elite lightweight rowers.[6]

To evaluate the physical characteristics of junior rowers, an anthropometric profile chart was constructed (table 3). This profile gives an overall evaluation of the body characteristics of a subject in relation to his group. The chart can

Table 5 Comparison of mean length, breadth, girth, and skinfold measurements of male junior rowers (present study), elite heavyweight[26] and lightweight[6] rowers competing in international tournaments

Body dimensions	Elite heavyweight (n=65)	Elite ligthweight (n=144)	Male junior rowers (n=383)
Sitting height (cm)	99.7	93.8	96.8
Tibial height (cm)	51.4	—	50.4
Leg length (cm)	91.7	87.6	90.7
SHSR (%)	52.1	51.5	51.6
LLSR (%)	47.9	48.5	48.4
Biacromial diameter (cm)	42.5	36.0	41.5
Bicristal diameter (cm)	30.2	28.5	30.3
Humerus width (cm)	7.8	—	7.6
Femur width (cm)	10.4	—	10.3
Biceps girth (cm)	—	30.7	32.9
Forearm girth (cm)	30.3	25.6	28.6
Thigh girth (cm)	60.3	51.0	57.9
Calf girth (cm)	39.3	34.4	37.7
Triceps skinfold (mm)	8.4	5.5	7.9
Subscapular skinfold (mm)	8.7	8.0	8.9
Thigh skinfold (mm)	10.8	8.0	11.5
Calf skinfold (mm)	6.3	5.4	8.4

SHSR, sitting height to stature ratio; LLSR, leg length to stature ratio

be used as a screening device and the interpretation of any profile should therefore be seen in its specific individual context.

In conclusion, elite male junior rowers are tall and heavy, with greater length, breadth, and girth dimensions than a reference group of the same chronological age. Within the group of elite male junior rowers, significant differences exist between finalists and non-finalists in length, breadth, and girth dimensions and for body mass. The anthropometric profile chart is a useful instrument for coaching and advising. It allows sport scientists and coaches to construct anthropometric profiles easily for individual rowers against templates.

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Take home message

The study of the body size of elite male junior rowers is very useful in view of the rapid evolution of sports and sportspeople, and against the background of secular trends in body size of the general population. This study will provide a better understanding of the relations between physical structure and performance in young rowers. The anthropometric profile chart is a useful instrument for coaching and advising.

Commentary

When researching athletic populations, it is seldom practical or possible to collect extensive data on well trained subjects. This is primarily due to limited access to such subjects and also because of the finite nature of the population. In this context, the current study provides a unique and extensive profile of the anthropometric characteristics of well trained Junior male rowers, who comprised 89% of rowers competing in the 1997 World Championships.