BODY PROPORTIONS OF ELITE MALE JUNIOR ROWERS IN RELATION TO COMPETITION LEVEL, ROWING STYLE AND BOAT TYPE

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Abstract:

The performance of elite rowers is, beside others, determined by their physical characteristics. Anthropometric data for adult rowers emphasise the importance of body mass and body size for rowing performance. Little is known concerning the importance of proportional length development. At the 1997 World Junior Rowing Championships anthropometric measurements (body mass and 6 length dimensions) were performed on 383 elite male junior rowers. Based on these measurements several proportional length dimensions were calculated. Data on boat type were obtained by questionnaire and data on competition level were based on the results obtained during the championship. The results indicate that these rowers were heavier (Mean = 82.2±7.4 kg) and taller (Mean = 187.4±5.8 cm) and had a larger sitting height (Mean=96.8±3.2 cm) and longer legs (Mean= 90.7±3.8 cm) than a reference population. Finalists had significantly larger length dimensions than non-finalists and sweep rowers had in general larger length dimensions than scullers. No differences existed when the length dimensions were expressed proportional to the stature of the rowers. It can be concluded that elite junior rowers have larger length dimensions compared to less successful rowers, but these top athletes do not differentiate from the sub-elite athletes regarding proportional length development. Differences could be observed between sweep rowers and scullers with larger length dimensions in favour of sweep rowers.

Key words: *rowing, length development, proportionality, junior, males*

KÖRPERPROPORTIONEN DER LEISTUNGSSTÄRKSTEN JUNIORENRUDERER IM BEZUG AUF WETTKAMPFNIVEAU, DEN STIL DES RUDERNS UND DIE BOOTSGATTUNG

Zusammenfassung:

Die Leistung der leistungsstärksten Ruderer ist unter anderem von ihren körperlichen Eigenschaften bestimmt. Körperbaudaten für erwachsene Ruderer stellen den Nachdruck auf die Wichtigkeit des Körpergewichts und der Körperhöhe für das Rudern. Es bleibt noch unklar, wie wichtig die proportionale Längenzunahme ist. Während der Junioren Weltmeisterschaften im 1997 wurden die Körperbau-Messungen (Körpergewicht und 6 Extremitätenlängen) auf 383 leistungsstärksten Junioren-Ruderer vorgenommen. Auf Grund dieser Messungen einige proportionale Extremitätenlängen wurden berechnet. Die Angaben über die Bootsgattung wurden einem Fragebogen entnommen, während die Angaben über dem Wettkampf-Niveau auf den während der Meisterschaft gewonnenen Ergebnissen basierten.

Den Ergebnissen nach wogen diese Ruderer mehr (Mittelwert = 82,2±7,4 kg), sie waren größer (Mittelwert = 187,4±5,8 cm) und hatten eine größere Sitzhöhe (Mittelwert = 96,8±3,2 cm) und längere Beine (Mittelwert = 90,7±3,8 cm) als die Referenz-Grundgesamtheit. Die Finalisten hatten bedeutend größere Extremitätenlängenwerte als die Nicht-Finalisten, während die Riemenruderer im allgemeinen größere Extremitätenlängenwerte hatten als die Skuller. Keine Unterschiede waren zu merken, wenn die Extremitätenlängenwerte proportional der Körperhöhe der Ruderer dargestellt wurden. Daraus lässt sich schließen, dass die leistungsstärksten Junioren größere Extremitätenlängenwerte haben im Vergleich zu den weniger erfolgreichen Ruderern, aber diese Spitzensportler unterscheiden sich keineswegs von weniger erfolgreichen Sportlern im Bezug auf die proportionale Längenzunahme. Die Unterschiede sind bei den Riemenruderern und den Skullern zu merken, wobei die Skuller größere Extremitätenlängenwerte aufzeigen.

Schlüsselwörter: *Rudern, Proportionalität der Längenzunahme, Junioren*

Introduction

Elite athletes in different disciplines and events differ in physical and physiological characteristics. From the biological point of view, one would expect to find in the Olympic and world class athlete the optimal expression of the effects of heredity, training, nutrition and sociocultural factors. Examination of the characteristics of these athletes can help sport scientists and coaches to understand top-level performance by providing information useful in formulating strategies for the explanation and prediction of performance. 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. The relevance of kinanthropometry for talent detection (Claessens, 2001) and predicting outstanding athletic performances has been shown previously (Tittel, 1978; Ross, de Rose, & Ward, 1988; Russo, Gruppioni, Gueresi, Belcastro, & Marchesini, 1992). Different studies described the kinanthropometric characteristics of Olympic and elite athletes in which it has been shown that athletes of different disciplines have specific anthropometric profiles (Carter, 1984; Malina, Battista, & Siegel, 2002).

The performance of elite rowers is, in part, determined by their physical characteristics (Shephard, 1998; Maëstro & Jürimäe, 2000). In the past, anthropometric studies were mostly focused on the senior rower (Maëstro & Jürimäe, 2000) and to a lesser degree on the junior athletes (Steinacker et al., 1993; Stupnicki, Obminski, Klusiewicz, & Viru, 1995; Bourgois et al., 2000).

Anthropometric data for adult male and female rowers emphasise the importance of body mass (Secher & Vaage, 1983) and body size (Hebbelinck, Ross, Carter, & Borms, 1980; Rodriguez, 1986) for rowing performance. Especially the longer limbs, which accompany the larger body size, seem advantageous for the rower with respect to the larger leverage and power output. Long legs increase the drive phase of the rowing stroke. Moreover, the larger rowers have a greater cross-sectional area of muscle and a greater absolute metabolic capacity (de Rose, Crawford, Kerr, Ward, & Ross, 1989). Studying the length development of rowers has mostly been limited to the variable "height or stature". Only a few studies report proportional length dimensions in elite rowers (Ross, Ward, Leahy, & Day, 1982; Carter, Ross, Aubry, Hebbelinck, & Borms, 1982; Rodriguez, 1986; Norton, Olds, Scott, & Craig, 1996). It is obvious that there is lack of information concerning proportionality in junior rowers.

The aim of this study is threefold: (1) to describe the proportional length development in male junior rowers compared to Flemish boys, (2) to compare the rowers' body proportions at different levels of competition, rowing styles and boat categories and (3) to establish a rowing-specific anthropometric profile chart for male junior rowers.

Methods

Subjects

At the 1997 FISA World Junior Rowing Championships (Hazewinkel, Belgium, August 6-10, 1997), anthropometric measurements were performed on 383 male junior rowers. The study included competitors and reserves (4.4% of the sample). Coxswains were not included. The sample represented 90% of the participants. Most rowers were from Europe (83.8%) and were Caucasian (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. Mean chronological age of the subjects was 17.8 ± 0.7 years, varying from 15.1 to 18.6 years. They trained 7 to 10 times (10-15 hours) a week. A full description of the sample and detailed information about how the data were obtained have been reported earlier (Bourgois et al., 1998).

Anthropometry

Upon arrival at the laboratory, the participants provided informed consent. After the participants had been 'landmarked' by one of the authors (ALC) who served as the criterion (ISAK Level 4 Anthropometrist), they were directed to one of five stations. Out of the 22 measurements taken (body mass, 6 length dimensions, 4 width dimensions, 5 girth dimensions and 6 skinfolds), the following body dimensions were used in this report: *height, sitting height, acromion height, radial height, dactylion height* and *tibial height.* The variables were measured by trained anthropometrists. Each anthropometrist took the same measurements and was assisted by a recorder. Measurements were obtained under standard conditions following the procedures described by Claessens and associates (1998).

Body proportions

Different proportions and derived measurements were calculated to study the body proportions of the rowers. An overview of the variables is presented in Table 1.

Rowing data

Data on boat type were obtained using a standardised questionnaire. Data on competition level were based on the results obtained in the championship. The international male junior rowing competition is standardised at 2000 m and divided into sweep rowing and sculling. The techniques for these events differ significantly; sweep rowing requires each competitor to row with just a single oar on one side of the boat while scullers use two sculls of a shorter length and pull on them simultaneously. An overview of the different boat types is given in Table 2.

Statistical analysis

Descriptive statistics (mean, standard deviation and range) were calculated for all variables for the total sample of male rowers. In order to compare proportionality in scullers versus sweep rowers, and finalists versus non-finalists, Student's *t*-tests for independent samples were carried out. Analyses of variance (ANOVA) and post-hoc Tukey's tests were applied to detect differences between the proportionality in rowers of different boat types. All statistical analyses were performed using the Statistical Analysis System program (SAS Institute Inc., Cary, North Carolina, USA). All the tests were two-sided and differences were considered significant at $p < 0.05$.

Results

Descriptive statistics are presented in Table 3. Comparisons between male junior rowers and

Table 1. Overview of the variables used in this study of proportional length development in elite male rowers

Variable	Formula	Unit
Chronological age		year
Body mass		kg
Height		cm
Body mass index	Body mass/ height²	kg m⁻²
Sitting height		cm
Leg length	Height – sitting height	cm
Arm length	Acromion height – dactylion height	cm
Upper arm length	Acromion height – radial height	cm
Lower arm length	Radial height – dactylion height	cm
Upper leg length	Leg length – tibial height	cm
Lower leg length		cm
Trunk height	Acromion height – leg length	cm
% length lower limbs	Leg length * 100 / height	%
% arm length	Arm length * 100 / height	%
% upper arm length	Upper arm length * 100 / height	%
% lower arm length	Lower arm length * 100 / height	%
% upper leg length	Upper leg length * 100 / height	%
% lower leg length	Lower leg length * 100 / height	%
% trunk height	Trunk height * 100 / height	%
Index of Manouvrier	Leg length * 100 / sitting height	%
Index of Valois	Sitting height * 100 / height	%
Brachial index	Lower arm length * 100 / arm length	%
Crural index	Tibial height * 100 / leg length	%

Table 2. An overview of the different boat types

Type		Abbreviation
Sweeping		
	Coxed pair	2+
	Coxless pair	2-
	Coxed four	4+
	Coxless four	4-
	Eight (with coxswain)	8+
Sculling	Always without a coxswain	
	Single scull	1x
	Double scull	2x
	Quadruple scull	4x

a normative reference group (Ostyn, Simons, Beunen, Renson, & van Gerven, 1980) show that the rowers are heavier (+ 17.5 kg), taller (+ 12.0 cm), have a larger sitting height (+ 5.4 cm) and longer legs (+ 6.7 cm).

In Table 4, body proportions of scullers and sweep rowers are compared. Sweep rowers were significantly taller and heavier than scullers. The larger stature was accompanied by significantly greater values for the other length dimension, except for upper arm length and upper leg length. When the length dimensions were expressed proportional to stature, no significant differences were observed between the scullers and sweep rowers. Similar results were found when finalists were compared to non-finalists (Table 5). Finalists were significantly taller and heavier and had larger length dimensions as compared to non-finalists. Again no significant differences existed when the length dimension were expressed proportional to the stature.

Table 3. Descriptive statistics (mean, standard deviation and range) of elite male junior rowers (n=383)

Variable	Mean	SD	Range
Chronological age (year)	17.8	0.7	15.1 – 18.6
Body mass (kg)	82.2	7.4	60.0 – 108.1
Height (cm)	187.4	5.8	167.6 – 201.5
Body mass index (kg ·m^{-2})	23.4	1.7	19.1 – 31.1
Sitting height (cm)	96.8	3.2	87.5 – 106.7
Leg length (cm)	90.7	3.8	78.3 – 99.1
Arm length (cm)	82.9	3.3	71.6 – 92.6
Upper arm length (cm)	36.0	1.8	27.3 – 42.2
Lower arm length (cm)	47.0	2.3	38.3 – 59.4
Upper leg length (cm)	40.2	2.2	33.0 – 46.9
Lower leg length (cm)	50.4	2.3	41.8 – 59.8
Trunk height (cm)	63.0	2.8	55.0 – 69.7
% length lower limbs (%)	48.4	1.1	45.1 – 50.9
% arm length (%)	44.2	1.2	38.7 – 48.0
% upper arm length (%)	19.2	0.8	13.9 – 22.9
% lower arm length (%)	25.1	0.9	20.4 – 30.6
% upper leg length (%)	21.5	0.9	17.3 – 23.8
% lower leg length (%)	26.9	0.7	24.8 – 31.4
% trunk height (%)	33.6	1.1	28.7 – 37.8
Index of Manouvrier (%)	93.7	4.1	82.2 – 103.7
Index of Valois (%)	51.6	1.1	49.1 – 54.9
Brachial index (%)	56.6	1.5	51.2 – 68.5
Crural index (%)	55.6	1.3	52.0 – 64.4

Table 4. Descriptive statistics and t-test between elite junior scullers (n=161) and sweep (n=222) rowers

	Scullers		Sweep rowers		t- value
Variable	Mean	SD	Mean	SD	
Chronological age (year)	17.8	0.7	17.8	0.6	-0.61
Body mass (kg)	80.3	6.9	83.6	7.5	-4.31**
Height (cm)	186.4	6.4	188.2	5.3	-2.91**
Body mass index (kg ·m^{-2})	23.1	1.6	23.6	1.8	-2.67**
Sitting height (cm)	96.3	3.3	97.2	3.1	-2.75**
Leg length (cm)	90.2	4.1	91.0	3.6	-2.22*
Arm length (cm)	82.4	3.5	83.3	3.1	-2.82**
Upper arm length (cm)	35.8	1.8	36.1	1.8	-1.53
Lower arm length (cm)	46.6	2.4	47.2	2.3	-2.82**
Upper leg length (cm)	40.1	2.2	40.3	2.1	-0.72
Lower leg length (cm)	50.0	2.4	50.7	2.2	-3.04**
Trunk height (cm)	62.4	2.6	63.4	2.8	-3.33**
% length lower limbs (%)	48.4	1.1	48.4	1.1	-0.11
% arm length (%)	44.2	1.1	44.3	1.2	-0.75
% upper arm length (%)	19.2	0.8	19.2	0.8	-0.37
% lower arm length (%)	25.0	0.9	25.1	1.0	-1.25
% upper leg length (%)	21.5	0.8	21.4	0.9	1.27
% lower leg length (%)	26.8	0.7	27.0	0.7	-1.74
% trunk height (%)	33.5	1.0	33.7	1.2	-1.51
Index of Manouvrier (%)	93.7	4.0	93.8	4.1	-0.13
Index of Valois (%)	51.6	1.1	51.6	1.1	0.11
Brachial index (%)	56.5	1.4	56.7	1.5	-1.06
Crural index (%)	55.5	1.2	55.7	1.3	-1.94

* $p < 0.05$
** $p < 0.01$

As indicated by the ANOVA (Table 6) the differences between both rowing styles (scullers versus sweep rowers) are, in general, found between the coxed pair (2+) and the coxed four (4+) on the one hand, and the single scull (1x), quadruple scull (4x) and coxless pair (2-) on the other hand. Athletes who row in the (2+) and (4+) were, on average, heavier and taller as compared to the (1x), (4x) and (2-). No differences in proportional length development between boat types could be observed.

Table 5. Descriptive statistics and t-test between finalist (n=144) and non-finalist (n=222) elite junior rowers

	Finalists		Non-finalists		t- value
Variable	Mean	SD	Mean	SD	
Chronological age (year)	17.9	0.6	17.8	0.7	1.15
Body mass (kg)	84.8	7.1	80.6	7.0	5.67**
Height (cm)	189.3	5.0	186.3	6.1	5.14**
Body mass index ($kg \cdot m^{-2}$)	23.7	1.8	23.2	1.6	2.62**
Sitting height (cm)	97.6	2.9	96.2	3.3	4.24**
Leg length (cm)	91.6	3.5	90.1	4.0	3.85**
Arm length (cm)	83.7	3.0	82.4	3.4	3.73**
Upper arm length (cm)	36.3	1.7	35.8	1.9	2.84**
Lower arm length (cm)	47.4	2.3	46.7	2.3	3.06**
Upper leg length (cm)	40.5	2.2	40.1	2.2	2.10*
Lower leg length (cm)	51.1	2.1	50.0	2.4	4.46**
Trunk height (cm)	63.7	2.5	62.5	2.8	4.12**
% length lower limbs (%)	48.4	1.1	48.3	1.1	0.59
% arm length (%)	44.2	1.3	44.2	1.1	-0.03
% upper arm length (%)	19.2	0.8	19.2	0.8	-0.14
% lower arm length (%)	25.1	1.0	25.0	0.9	0.09
% upper leg length (%)	21.4	0.9	21.5	0.9	-0.84
% lower leg length (%)	27.0	0.7	26.8	0.7	1.93
% trunk height (%)	33.7	1.0	33.6	1.2	0.79
Index of Manouvrier (%)	93.9	4.0	93.6	4.1	0.58
Index of Valois (%)	51.6	1.1	51.7	1.1	-0.59
Brachial index (%)	56.6	1.5	56.6	1.5	0.11
Crural index (%)	55.8	1.3	55.5	1.2	1.71

* $p < 0.05$
** $p < 0.01$

Table 6. Analyses of variance of anthropometric differences between elite junior rowers of different boat types

Variable									F
Chronological age (year)	18.0 (2+)	17.9 (8+)	17.9 (2x)	17.8 (4+)	17.8 (4-)	17.8 (2-)	17.7 (4x)	17.7 (1x)	0.66
Body mass (kg)	87.6 (2+)	87.4 (4+)	83.5 (8+)	82.9 (4-)	80.8 (2x)	80.5 (4x)	80.5 (2-)	79.4 (1x)	5.56**
Height (cm)	190.8 (2+)	190.7 (4+)	188.5 (4-)	187.4 (2x)	187.2 (8+)	186.4 (2-)	186.2 (4x)	186.0 (1x)	3.41**
Body mass index ($kg \cdot m^{-2}$)	24.1 (2+)	24.0 (4+)	23.8 (8+)	23.3 (4-)	23.2 (4x)	23.1 (2-)	23.0 (2x)	22.9 (1x)	2.38
Sitting height (cm)	99.1 (4+)	98.7 (2+)	97.0 (4-)	96.8 (2x)	96.8 (8+)	96.2 (4x)	96.0 (1x)	95.9 (2-)	4.07**
Leg length (cm)	92.1 (2+)	91.6 (4+)	91.5 (4-)	90.6 (2x)	90.5 (2-)	90.4 (8+)	90.1 (1x)	90.0 (4x)	1.56
Arm length (cm)	84.2 (4+)	83.7 (4-)	83.3 (2+)	83.1 (2x)	83.0 (2-)	82.8 (8+)	82.6 (1x)	82.1 (4x)	2.11
Upper arm length (cm)	36.5 (4+)	36.2 (2-)	36.2 (4-)	36.1 (2+)	35.9 (2x)	35.8 (8+)	35.8 (1x)	35.8 (4x)	0.74
Lower arm length (cm)	47.7 (4+)	47.5 (4-)	47.2 (2+)	47.2 (2x)	47.0 (8+)	46.8 (1x)	46.8 (2-)	46.3 (4x)	2.29
Upper leg length (cm)	41.0 (2+)	40.4 (2-)	40.4 (2x)	40.4 (4-)	40.2 (8+)	40.2 (1x)	40.1 (4+)	40.0 (4x)	0.49
Lower leg length (cm)	51.5 (4+)	51.1 (4-)	51.1 (2+)	50.2 (8+)	50.2 (2x)	50.1 (2-)	50.0 (4x)	49.9 (1x)	3.13

(continued)

Table 6. Continuation

Trunk height (cm)	65.3 (4+)	64.8 (2+)	63.0 (4-)	63.0 (8+)	63.0 (2x)	62.6 (2-)	62.5 (4x)	61.6 (1x)	5.46**
% length lower limbs (%)	48.5 (2-)	48.5 (4-)	48.4 (1x)	48.3 (4x)	48.3 (2x)	48.3 (8+)	48.3 (2+)	48.1 (4+)	0.79
% arm length (%)	44.5 (2-)	44.4 (4-)	44.4 (1x)	44.4 (2x)	44.3 (8+)	44.1 (4+)	44.1 (4x)	43.6 (2+)	1.31
% upper arm length (%)	19.4 (2-)	19.2 (1x)	19.2 (4x)	19.2 (2x)	19.2 (4-)	19.1 (8+)	19.1 (4+)	18.9 (2+)	0.74
% lower arm length (%)	25.2 (4-)	25.2 (2x)	25.1 (1x)	25.1 (8+)	25.1 (2-)	25.0 (4+)	24.9 (4x)	24.7 (2+)	1.23
% upper leg length (%)	21.7 (2-)	21.6 (1x)	21.5 (2x)	21.5 (4x)	21.5 (2+)	21.4 (8+)	21.4 (4-)	21.0 (4+)	1.46*
% lower leg length (%)	27.1 (4-)	27.0 (4+)	26.9 (2-)	26.8 (4x)	26.8 (8+)	26.8 (1x)	26.8 (2x)	26.8 (2+)	1.61
% trunk height (%)	34.2 (4+)	33.9 (2+)	33.6 (8+)	33.6 (2x)	33.6 (2-)	33.6 (4x)	33.4 (4-)	33.1 (1x)	2.48**
Index of Manouvrier (%)	94.4 (2-)	94.4 (4-)	93.8 (1x)	93.7 (4x)	93.7 (2x)	93.4 (8+)	93.4 (2+)	92.6 (4+)	0.79
Index of Valois (%)	51.9 (4+)	51.7 (2+)	51.7 (8+)	51.7 (2x)	51.7 (4x)	51.6 (1x)	51.5 (4-)	51.5 (2-)	0.79
Brachial index (%)	56.8 (4-)	56.8 (8+)	56.8 (2x)	56.7 (2+)	56.7 (4+)	56.6 (1x)	56.4 (4x)	56.4 (2-)	0.71
Crural index (%)	56.3 (4+)	55.9 (4-)	55.6 (8+)	55.5 (4x)	55.5 (2+)	55.4 (2x)	55.4 (1x)	55.3 (2-)	2.10

* $p < 0.05$
** $p < 0.01$
Underlined values do not differ significantly

Table 7 represents the profile chart in proportional length development for male junior rowers of the FISA World Junior Rowing Championships.

Table 7. Profile chart for proportional length development in elite junior rowers (n = 383).

	Percentiles						
Variable	5	10	25	50	75	90	95
Chronological age (year)	16.5	16.9	17.4	18.0	18.3	18.5	18.5
Body mass (kg)	69.8	73.0	77.2	81.9	87.0	92.3	94.7
Height (cm)	177.3	179.2	183.6	187.6	191.4	195.2	196.6
Body mass index (kg·m^{-2})	20.5	21.1	22.2	23.5	24.5	25.5	26.1
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
Upper arm length (cm)	33.3	33.9	35.0	36.0	37.2	38.0	38.9
Lower arm length (cm)	43.5	44.2	45.4	47.0	48.5	49.5	50.3
Upper leg length (cm)	36.5	37.5	38.7	40.4	41.6	42.9	43.6
Lower leg length (cm)	46.6	47.5	48.9	50.4	51.9	53.4	54.2
Trunk height (cm)	58.6	59.4	61.2	63.1	64.8	66.7	67.4
% length lower limbs (%)	46.7	47.0	47.6	48.3	49.1	49.9	50.2
% arm length (%)	42.6	42.8	43.6	44.1	44.9	45.7	46.3
% upper arm length (%)	18.2	18.4	18.8	19.2	19.7	20.0	20.2
% lower arm length (%)	23.8	24.1	24.5	25.0	25.5	26.0	26.4
% upper leg length (%)	20.0	20.4	20.9	21.4	22.1	22.6	23.0
% lower leg length (%)	25.7	26.0	26.4	26.9	27.4	27.7	27.9
% trunk height (%)	31.9	32.2	32.8	33.7	34.4	34.9	35.3
Index of Manouvrier (%)	87.5	88.7	91.0	93.6	96.5	99.5	100.7
Index of Valois (%)	49.8	50.1	50.9	51.7	52.4	53.0	53.3
Brachial index (%)	54.9	55.3	55.9	56.6	57.2	57.7	58.3
Crural index (%)	53.7	54.1	54.8	55.6	56.5	57.1	57.6

Discussion and conclusions

This study shows that the male junior rowers were heavier and taller than a reference group (Ostyn et al., 1980). Finalists and sweep rowers were significantly taller and heavier as compared to non--finalists and scullers, respectively. Related to the larger stature, also the other length dimensions were larger in finalists and sweep rowers. However, body proportions did not differ according to competition level or boat type.

Rowing is a *strength endurance* type of sport, and as previously has been shown, length development is undoubtedly a performance related factor (Secher, 1983; Bourgois et al, 2000; Maëstro & Jürimäe, 2000; Claessens, 2001). Long legs increase the drive phase of the rowing stroke meaning that rowers with longer legs have a biomechanical advantage.

Since most studies only focused on stature (Carter et al., 1982; Koutedakis & Sharp, 1986; Steinacker et al., 1993), little is known concerning the body proportions in junior and senior rowers. Different studies used the Phantom-method (Ross et al., 1982), which is a 'unisex' reference model, based on a large amount of anthropometric data. According to this method, all dimensions are expressed relative to a fixed stature of 170.18 cm. Ross and co-workers (1982) have reported that male rowers have a larger proportional length of the tibia and the arm compared to the Phantom-model. However, concerns have risen about the use of this Phantom-method since no attention is given to biological variability (Shephard et al., 1985). Comparison of the body proportions of the junior rowers of this study with the values reported by others (Carter et al., 1982; Rodriguez, 1986) reveals that junior rowers have a shorter sitting height relative to stature (index of Valois) (51.6%) and a higher leg length relative to stature (48.4%) compared with the normative reference group (Ostyn et al., 1980) (52.1% and 47.9% respectively) and heavyweight Olympic rowers (Carter et al., 1982) (52.1% and 47.9% respectively). No differences were found between junior rowers and elite lightweight rowers (51.5% and 48.5% respectively) (Rodriguez, 1986). Norton and associates (1996) reported for both heavyweight and lightweight rowers a mean value of 44.5% for % arm length, which is comparable with the results of this study in junior male rowers (44.2%).

It can be concluded that the better rowers are mainly taller and, related to this difference, have larger length dimensions compared to the less successful rowers, but they do not differ when the dimensions are expressed against their body height. Differences can be observed between sweep rowers and scullers with larger stature and absolute length dimensions for the sweep rowers. The results of this study in addition to the profile chart will be helpful to coaches and sports scientists in a better understanding which morphological characteristics are related to the rowing performance. These results can also be used to determine the kinanthropometric profile of their male rowers and as an instrument for screening young talented boys for rowing performance.

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TJELESNE PROPORCIJE VRHUNSKIH VESLAČA JUNIORA U ODNOSU NA NATJECATELJSKU KVALITETU, NAČIN VESLANJA I VRSTU ČAMCA

Sažetak

Uvod

Natjecateljska uspješnost vrhunskih veslača određena je, između ostaloga, i njihovim tjelesnim karakteristikama. S biološkog stajališta možemo kod sportaša olimpijske i svjetske razine kvalitete očekivati optimalnu ekspresiju utjecaja nasljeđa, sportske pripreme, prehrane i socio-kulturnih faktora. Ispitivanje obilježja tih sportaša može pomoći kineziolozima, znanstvenicima i trenerima, u razumijevanju vrhunskog sportskog uspjeha time što im pruža informacije korisne za oblikovanje strategija za objašnjenje i predviđanje sportskih rezultata. U prošlosti su se antropometrijske studije bavile uglavnom veslačima seniorima, a manje juniorima. Te antropometrijske studije naglašavaju važnost tjelesne mase i veličine tijela za uspješnost u veslanju. Smatra se da osobitu prednost veslačima donose duži udovi zbog toga što su to duže poluge i što omogućuju veću radnu snagu. Duge noge pojačavaju potisnu fazu (provlak) veslačkog zaveslaja. Štoviše, veći veslači imaju veći presjek mišića i veći apsolutni energetski kapacitet. Proučavanje longitudinalnih dimenzija do sada je bilo uglavnom ograničeno na varijablu "visina tijela ili stas". Samo je nekoliko studija o proporcijama longitudinalnih dimenzija vrhunskih veslača, pa se malo zna o važnosti longitudinalnih proporcija tijela veslača.

Cilj je ove studije bio trostruk: (1) opisati razvojne proporcijske longitudinalne dimenzije juniora veslača u usporedbi s flamanskim mladićima, (2) usporediti tjelesne proporcije veslača prema različitim kvalitetnim natjecateljskim razinama, načinu veslanja i kategorijama čamca i (3) ustanoviti model antropometrijskog profila za veslače juniore.

Metode

Uzorak ispitanika činila su 383 veslača juniora, u dobi od 17,8 ± 0,7 godina, raspon godina od 15,1 do 18,6. Ispitanici su nastupili na FISA svjetskom juniorskom veslačkom prvenstvu 1997 godine. Istraživanjem je obuhvaćeno 90% sudionika (bez kormilara), od toga 83% pobjednika i osvajača medalja te 89% finalista. Svi su trenirali 7-10 puta tjedno (10-15 sat). Potpuni opis uzorka i mjerenja može se naći u članku Bourgois i suradnici (1998).

Za ovaj članak upotrijebljene su sljedeće tjelesne dimenzije: tjelesna visina, sjedeća visina, duljina nadlaktice, duljina podlaktice, duljina šake i duljina potkoljenice. Mjerenja su provedena u standardnim uvjetima prema postupcima koje su opisali Claessens i suradnici (1998). Na temelju tih mjera izračunate su proporcijske longitudinalne dimenzije. Pregled varijabli prikazan je u tablici 1.

Podaci o vrsti čamca prikupljeni su upitnikom, a podaci o kvalitetnoj razini temeljili su se na rezultatima postignutima na prvenstvu. Međunarodna juniorska veslačka natjecanja standardizirana su na stazi od 2 000 m i podijeljena su u discipline veslanja jednim veslom (rimen) i veslanja na pariće (skul). Te se veslačke tehnike međusobno dosta razlikuju – veslač u čamcu rimen, dakle, vesla samo jednim veslom, dok skuleri koriste dva kraća vesla koja povlače istodobno.

Izračunati su parametri deskriptivne statistike (aritmetička sredina, standardna devijacija i raspon) za sve varijable i za ukupni uzorak veslača. Za usporedbu proporcijskih odnosa između rimen veslača i skul veslača te finalista i onih koji se nisu plasirali u finale upotrijebljen je Studentov *t*-test za nezavisne uzorke. Analiza varijance (ANOVA) i post-hoc Tukeyjev test primijenjeni su da bi se otkrile razlike u proporcionalnosti među veslačima u raznim vrstama čamaca. Za statističke analize korišten je računalni program Statistical Analysis System. Svi su testovi bili dvostruki, a značajnom se smatrala razlika na razini od $p<0.05$.

Rezultati

Deskriptivna statistika prikazana je u tablici 3. U tablici su uspoređene proporcije veslača u rimenu i skulu. Rimen veslači bili su značajno viši i teži od skulera. Kada su se longitudinalne dimenzije dovele u proporcijski odnos prema tjelesnoj visini, nisu primijećene značajne razlike između te dvije vrste veslača. Slični su se rezultati dobili i u usporedbi finalista i ne-finalista (tablica 5). Prema rezultatima analize varijance (tablica 6) razlike između dva stila veslanja (rimen nasuprot skul) nađene su između dvojca sa (2+) i četverca sa (4+), s jedne strane, te samca (1x), četverca na pariće (4x) i dvojca bez (2-), s druge strane. Sportaši koji veslaju u dvojcu sa (2+) i četvercu sa (4+) bili su, u prosjeku, teži i viši od veslača u samcu (1x), četvercu na pariće (4x) i dvojcu bez (2-). Nisu dobivene razlike u proporcijskim odnosima longitudinalnih dimenzija prema vrsti čamaca. U tablici 7 predstavljen je model profila proporcijskih odnosa longitudinalnih dimenzija za veslače juniore koji su nastupili na FISA svjetskom juniorskom veslačkom prvenstvu.

Rasprava i zaključak

Rezultati pokazuju da su promatrani veslači teži i viši te da imaju veću sjedeću visinu i duže noge od opće populacije. Finalisti su imali značajno veće longitudinalne dimenzije od ne-finalista, a rimen veslači su općenito imali veće longitudinalne dimenzije

od skulera. Nisu, međutim, dobivene razlike kada su longitudinalne dimenzije postavljene u proporcijski odnos prema tjelesnoj visini.

Veslanje je sport izdržljivosti i longitudinalne dimenzije su nedvojbeno povezane s uspješnošću. Duge noge pojačavaju potisak u fazi provlaka tijekom veslačkog zaveslaja, što znači da su veslači s dugim nogama u biomehaničkoj prednosti.

Usporedba tjelesnih proporcija izmjerenih veslača juniora s vrijednostima o kojima su izvijestili drugi autori (Carter i dr., 1982; Rodriguez, 1986) otkriva da veslači juniori imaju manju sjedeću visinu u odnosu na ukupnu tjelesnu visinu ili stas (Valoisov indeks) (51,6%) i veću duljinu nogu u odnosu na stas (48,4%) od normativne usporedne skupine (Ostyn i dr., 1980) (52,1% i 47,9%) i od teških olimpijskih veslača (Carter i dr, 1982) (52,1% i 47,.9%). Nisu dobivene razlike između veslača juniora i vrhunskih lakih veslača (51,5% i 48,5%).

Može se zaključiti da su kvalitetniji veslači uglavnom viši i, povezano s tom razlikom, imaju veće longitudinalne dimenzije od manje uspješnih veslača, ali se oni ne razlikuju međusobno kada se te vrijednosti izraze proporcionalno u odnosu na njihovu tjelesnu visinu. Uočene su razlike između rimen veslača i skul veslača – rimen veslači su višega stasa i imaju veće apsolutne vrijednosti longitudinalnih dimenzija. Uz to što je izrađen profil veslača juniora, rezultati ove studije mogu pomoći trenerima i kineziolozima da steknu bolji uvid u to koje su morfološke karakteristike povezane s uspješnošću u veslanju. Rezultati se također mogu primijeniti za određenje antropometrijskog profila veslača i kao instrument za selekciju dječaka talentiranih za veslanje.