ANTHROPOMETRIC CHARACTERISTICS AND SOMATOTYPE OF YOUNG GREEK ROWERS

S. Kaloupsis[1], G.C. Bogdanis[2], E. Dimakopoulou[1], M. Maridaki[2]
Depts. of [1]Aquatic Sports and of [2]Sports Medicine and Biology of Physical Activity, Faculty of Physical Education and Sports Science, University of Athens, Greece

Abstract. This study examined selected anthropometric characteristics of young rowers and compared them with those of senior national level athletes and untrained children, in order to establish a rowing specific anthropometric profile for young athletes. Anthropometric characteristics were measured in 509 club-level rowers aged 11-16 years and 29 male senior national level rowers. Club-level athletes were categorized in 6 age groups (11-16 y), while the senior national level rowers were divided into heavyweight (H-W) and lightweight (L-W). Rowers aged 15 and 16 y had similar height, body weight, arm length and leg length, but lower lean body mass (5 to 8.3 Kg less) compared with senior L-W rowers. Comparison of the young rowers with a reference group of untrained Greek children by means of percentiles (P) revealed that rowers in all age groups were heavier (P63 to P75), taller (P82 to P90) but had a lower body mass index than the mean values (P50) of the reference group after the age of 14 (P48 to P43). Skinfold thicknesses and body fat decreased from the 11 y through to the 16 y group (from 22.9% to 17.8%), and were lower in the two senior groups (9.6% for the L-W and 12.3% for the H-W). Endomorphy ratings decreased with age from 11 to 14 y, but there was no difference between the 14 to 16 y old groups. Mesomorphy was similar across all groups examined and ectomorphy did not show large fluctuations from the 13 y old group onwards. Somatotype of the 15 y old group was 2.4-4.4-3.4 (endo-meso-ectomorphy) and was identical to that of the 16 y group and the lightweight senior rowers. The results of this study showed that the club level rowers aged 15 and 16 yrs have similar body structure but different body composition compared with the senior L-W rowers. Anthropometric characteristics can be used as a criterion for selection of rowers by the coaches from an early age.

(Biol.Sport 25:57-69, 2008)

Keywords: Body lengths - Lean body mass - Body fat - Growth

Introduction

Physical structure is an important factor that contributes to success in rowing [20]. Data from elite adult rowers have shown that lean body mass and body dimensions are related to performance because they are significant determinants of muscle strength and range of motion during rowing [18,19,22,23,24]. Thus, the elite rowers are usually taller and heavier [2,18] than their less successful peers and also taller and heavier than athletes of other sports [3,7,17,16,20]. It has also been noted that elite rowers have long limbs, not only in absolute terms, but also in proportion to their height [17].

The important role of physique on success in rowing has led many coaches to select young rowers based on certain anthropometric characteristics such as height, lean body weight and limb lengths [16]. However, there is only limited information on anthropometric characteristics of young rowers, and most data are from either junior [3,16,21] or senior athletes [8]. Therefore, the purpose of the present study was to examine selected

Reprint request to: Dr. G.C. Bogdanis, Dept. of Sports Medicine and Biology of Physical Activity, Faculty of Physical Education and Sports Science, 41 Ethnikis Antistasis Street, Dafni, 172 37, Athens, Greece; Tel.: +30210 7276 043; Fax: +30210 9027840
E-mail: gbogdanis@phed.uoa.gr

anthropometric characteristics of rowers aged 11-16 (divided in six age groups) and to compare them with those of national level athletes (light and heavy category) and untrained Greek children. Furthermore, in order to provide a description of physique independent of body size, the Heath and Carter somatotype was calculated and compared between groups. These normative data for young Greek rowers can be used to establish a rowing specific anthropometric profile for young athletes that may help coaches and sport scientists in the process of talent identification.

Materials and Methods

Subjects: The sample consisted of 509 male club-level rowers aged 11-16 years and 29 male senior national level rowers (age: 22.7±0.7 yrs, mean ±standard error) of which 17 were heavyweight 12 were lightweight with 8 to 10 years training experience. The sample of the young athletes was representative of the 85% of the existing rowing clubs in Greece. All young athletes participated in regular training (at least 1 year training experience, 3-6 sessions per week). Senior athletes had 10-12 training sessions per week.

Data collection: The study had the approval of Athens University Ethics Committee. The athletes and/or their parents gave their informed consent before a complete anthropometric profile was taken. The following anthropometric variables were measured: body mass, height, sitting height, arm length (acromial height minus dactylion height), leg length (height minus sitting height), biacromial diameter, bicristal diameter, humerus and femur widths, biceps, thigh and calf girths. Also, measurements of six skinfolds (triceps, biceps, subscapular, supraspinal, front thigh and medial calf) were performed on the right side of the body using a Harpenden skinfold caliper (read to the nearest 0.01mm). All anthropometric measurements were taken by the same experienced investigator who was assisted by a recorder. The three somatotype ratings (ectomorphy, mesomorphy and endomorphy) were then calculated according to Heath and Carter [4]. From the skinfold data the percent body fat, fat mass and lean body mass were calculated according to Durnin and Rahaman [9]. Body mass index (BMI) was calculated as body mass divided by the height squared.

Data analysis: The results for the young club-level athletes were categorized by age, while the senior national level rowers were divided into two groups according to their weight category (lightweight: L-W and heavyweight: H-W). Comparisons between the groups were performed using one-way Analysis of Variance and a Tukey's post-hoc test for unequal sample sizes (Spjotvoll/Stoline test), using the STATISTICA V.5 software package. All data are presented as mean±standard error (SE). Furthermore, for some selected anthropometric variables (body mass, height and BMI) the mean of each group was compared with reference data from a representative sample of the Greek population (Unpublished Growth charts for the Greek population aged 0-18 years [6]). More specifically, for each group of young rowers, we calculated the percentiles (P) of the reference data to which the mean body mass, height and BMI of the rowers corresponded.

Results

The anthropometric profile of the six groups of club level rowers (aged 11-16 yrs) and the national level senior L-W and H-W groups are shown in Table 1. As expected, most anthropometric variables increased with age and the values were higher in the senior H-W rowers. Exceptions from this were the skinfold thicknesses and body fat that decreased from the group of the 11 year old rowers to the group of 16 year old rowers (Table 1, Fig. 1). Also, BMI was similar in all age groups but was higher only in the H-W group. Comparison of the young rowers with the reference group of Greek children by means of percentiles (P) revealed that rowers in all age groups were heavier (P63 to P75), taller (P82 to P90) but had a lower

BMI than the mean values (P50) of the reference group after the age of 14 (P48 to P43, see Table 1).

Table 1

Anthropometric profile of the six groups of young rowers (11-16 yrs) and the national level L-W and H-W groups. The percentiles (P) of the reference data [6] to which means of rowers correspond are presented for Body mass (Body $mass_{REF}$), Height ($Height_{REF}$) and BMI (BMI_{REF})

	Group							
Dimension	11	12	13	14	15	16	L-W	H-W
	n=31	n=102	n=102	n=109	n=100	n=65	n=12	n=17
Age (years)	11.4 ±0.1	12.4 ±0.0	13.4 ±0.0	14.5 ±0.0	15.5 ±0.0	16.3 ±0.0	23.1 ±1.4	22.4 ±0.8
Body mass (Kg)	48.4 ±1.6	53.8 ±1.0	58.2 ±1.0	64.3 ±0.9	68.2 ±0.8	72.4 ±0.9	71.2 ±0.3	87.4 ±1.6
Body $mass_{REF}$ (percentile)	P75	P75	P70	P70	P63	P63	-	-
Height (cm)	151.7 ±1.0	159.0 ±0.7	166.0 ±0.8	173.9 ±0.7	178.2 ±0.5	179.5 ±0.8	179.8 ±1.1	188.1 ±1.4
$Height_{REF}$ (percentile)	P82	P83	P83	P90	P88	P83	-	-
BMI ($kg \cdot m^{-2}$)	21.0 ±0.7	21.2 ±0.3	21.1 ±0.3	21.2 ±0.2	21.5 ±0.2	22.5 ±0.2	22.1 ±0.3	24.7 ±0.3
BMI_{REF} (percentile)	P63	P58	P52	P48	P42	P43	-	-
Sitting Height (cm)	78.0 ±0.6	80.8 ±0.4	84.7 ±0.4	89.2 ±0.4	91.3 ±0.3	92.7 ±0.4	93.7 ±0.6	97.5 ±0.8
Upper arm girth (cm)[a]	25.9 ±0.5	26.3 ±0.3	28.1 ±0.3	29.0 ±0.3	29.9 ±0.2	31.3 ±0.3	31.3 ±0.3	35.8 ±0.5
Thigh girth (cm)	47.3 ±1.1	48.4 ±0.5	50.2 ±0.4	51.0 ±0.4	52.8 ±0.4	54.7 ±0.5	54.0 ±0.5	58.6 ±0.6
Biacromial diameter (cm)	33.1 ±0.4	33.8 ±0.2	36 ±0.3	37.9 ±0.4	39.8 ±0.2	40.6 ±0.3	42.9 ±0.4	45.2 ±0.5
Bicristal Diameter (cm)	24.2 ±0.3	26.0 ±0.2	26.8 ±0.3	27.3 ±0.2	28.0 ±0.3	28.4 ±0.4	28.5 ±0.4	30.8 ±0.4
Biceps skinfold (mm)	8.6 ±0.6	7.5 ±0.3	6.0 ±0.3	5.3 ±0.2	4.5 ±0.1	4.4 ±0.1	3.3 ±0.1	3.6 ±0.2
Triceps skinfold (mm)	15.3 ±1.0	13.5 ±0.4	11.6 ±0.4	10.4 ±0.4	9.2 ±0.3	9.3 ±0.3	6.6 ±0.5	7.6 ±0.5
Subscapular skinfold (mm)	12.7 ±1.1	11.0 ±0.5	9.4 ±0.4	9.2 ±0.4	8.6 ±0.3	9.1 ±0.3	6.9 ±0.3	8.9 ±0.5
Suprailiac skinfold (mm)	12.3 ±1.0	11.5 ±0.6	9.5 ±0.5	8.8 ±0.4	8.0 ±0.3	8.3 ±0.3	4.8 ±0.2	7.3 ±0.7
Thigh skinfold (mm)	23.1 ±1.5	20.4 ±0.6	17.1 ±0.6	14.9 ±0.6	13.6 ±0.4	14.1 ±0.5	9.4 ±0.8	11.8 ±0.6
Calf skinfold (mm)	18.4 ±1.2	16. 5±0.5	14.6 ±0.5	12.5 ±0.5	10.4 ±0.3	10.7 ±0.4	6.4 ±0.8	8.0 ±0.7
Humerus width (cm)	5.9 ±0.1	6.3 ±0.1	6.8 ±0.1	6.7 ±0.0	7.0 ±0.0	7.0 ±0.1	6.9 ±0.2	7.2 ±0.1
Femur width (cm)	9.5 ±0.1	9.5 ±0.1	9.9 ±0.1	10 ±0.1	10.2 ±0.1	10 ±0.1	10.3 ±0.2	10.8 ±0.1

Data are mean±SE; BMI: body mass index; L-W: Lightweight national level rowers, H-W: Heavyweight national level rowers; a: maximum girth of flexed upper arm

Club level rowers aged 15 and 16 yrs had similar height, body mass, arm length and leg length compared with the senior L-W rowers (Fig. 1, Fig. 2). However, senior L-W rowers had a lower percentage of body fat ($p<0.01$) and therefore, higher lean body mass compared to the 15 and 16 yrs age groups (Fig. 1). Mean somatoplots for each group and somatotype distribution all groups are shown in Fig. 3. Mean endomorphy, mesomorphy and ectomorphy ratings for each group are shown in Fig. 4. Endomorphy ratings showed a decreasing pattern with age from 11 to 14 yrs but were similar in the 14 yrs, 15 yrs, 16 yrs, L-W and H-W groups. Mesomorphy ratings were not different between any group of the rowers examined. Ectomorphy ratings were only higher in the 14 yrs and 15 yrs groups compared with the 11 yrs and 12 yrs groups (Fig. 4).

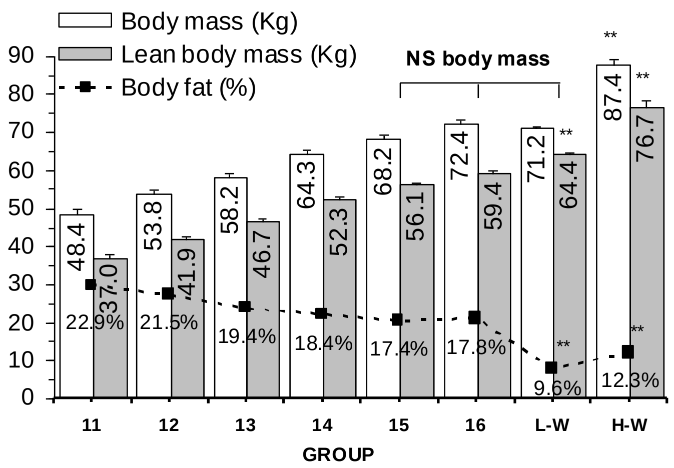


Fig. 1
Body mass, lean body mass and percent body fat for young and national level rowers (11-16: age groups for young rowers, L-W: light weight, H-W: heavy weight). **: $P<0.01$ from groups 11 to 16 yrs

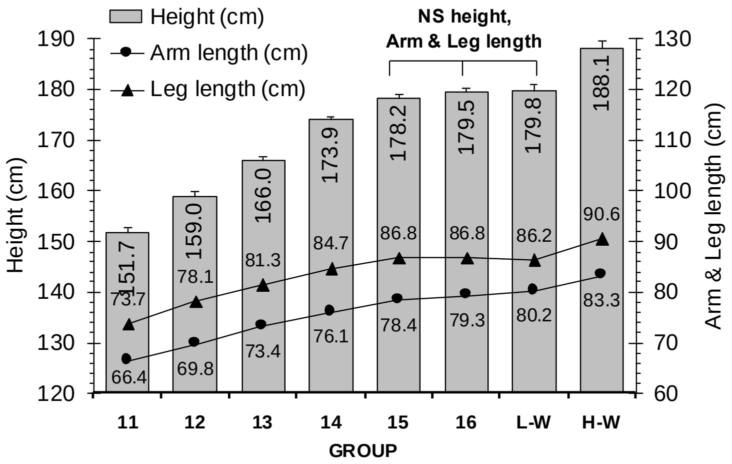


Fig. 2
Body height and arm and leg lengths for young and national level rowers (11-16: age groups for young rowers, L-W: light weight, H-W: heavy weight)

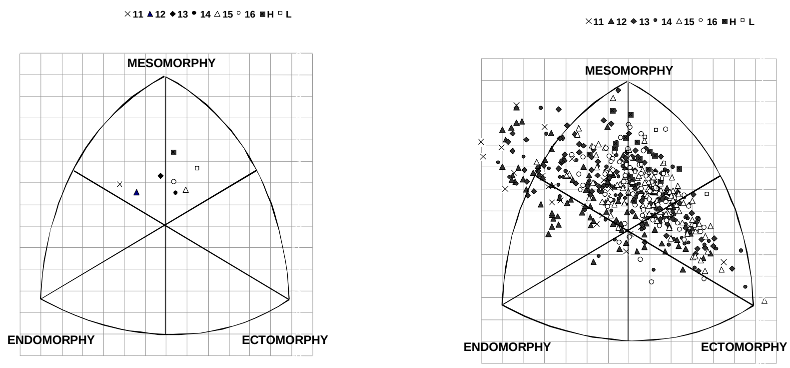


Fig. 3
Mean somatoplots for each group (left) and somatotype distribution for 509 male club-level rowers aged 11-16 yrs and 29 male national level rowers (H-W: heavyweight, L-W: lightweight)

Discussion

One main finding of the present study was that Club level rowers aged 15 and 16 yrs had similar height, body weight, arm length and leg length, but lower lean body mass compared with the senior L-W rowers (Fig. 1, Fig. 2). The height and weight of the senior L-W rowers were similar with the values reported in the literature for this category [1,17]. It is interesting to note that the difference in lean body mass between the 15 y old group and the L-W rowers was 8.3 kg and the difference between the 16 y old group and the L-W rowers was 5 kg, while height and body mass were similar in all 3 groups (Fig. 1 and 2). Thus, the main change in anthropometric characteristics with training from the age of 15 onwards seems to be an increase in muscle mass with a parallel decrease in body fat. This increase in muscle mass will contribute to the increase in muscle strength which is important for rowing success [19,23]. As proposed by Piotrowski *et al.* [16], the most able young rowers can be distinguished by their stature, skeletal robustness and muscular development.

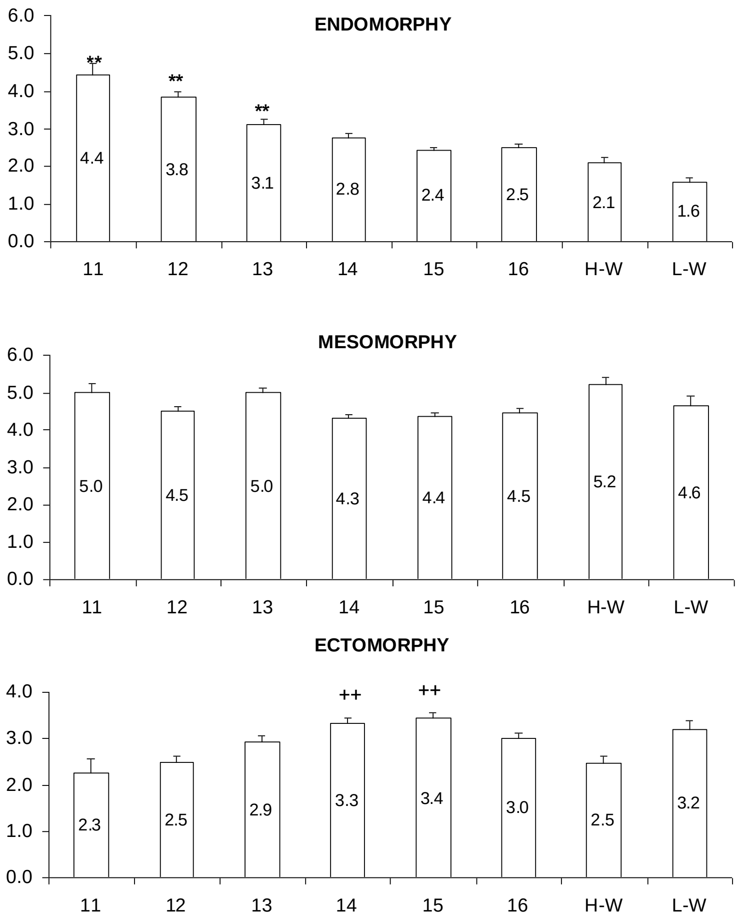
Additional support for the importance of height and body mass for rowing success even from an early age, is given by the fact that young rowers in all age groups are heavier (P63 to

P75) and much taller (P82 to P90) compared to the reference group of Greek children (Table 1). Similar results have been reported by Bourgois *et al.* [3] for female junior rowers aged 17.5±0.8 years, who were compared to a representative sample of Belgian non-athlete girls of the same chronological age. Also, finalists can be distinguished from non-finalists during by anthropometric characteristics such as height, weight and circumferences [2]. This shows that anthropometric characteristics can be an important criterion for selection of rowers by the coaches from an early age. In the present study, young rowers in all age groups were taller and heavier compared to the reference group (Table 1), and this shows that coaches select children with the appropriate body characteristics for the sport from a very early age. Alternatively, the fact that in the present study rowers are taller and heavier compared to the general population from the age of 11, may indicate “natural selection”, i.e. children with the appropriate anthropometric characteristics are attracted by the sport and continue to train, while the others, who do not comply with the “anthropometric model” of the sport, drop-out. Malina [14] 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.

The greater body weight of the rowers compared to the reference group of children may be due to an increased lean body mass as a result of training, especially at the older groups. Unfortunately, there are no normative data for lean body mass of untrained Greek children. However, it can be argued that rowing training may result in an increase of lean body mass, and thus young rowers may have greater muscle mass compared to their untrained peers. This notion is supported by the data of Sklad *et al.* [21] who found that a year of training increased arm and chest circumferences and lean body mass in junior rowers aged 17-18 years.

Further support for the suggestion that the higher body weight or rowers is due to an increase in lean mass and not fat, is lend by the skinfold thickness and body fat data. Skinfold thickness and percentage of body fat in the 15 y and the 16 y groups (Table 1 and Fig. 1) were very similar to those reported for junior rowers competing at the World Championships [2]. Furthermore, skinfold thicknesses and body fat decreased with age from the 11 y through to the 16 y group (Table 1 and Fig. 1). The decrease of body fat with age in athletes has also been reported for other sports [11] and may indicate the influence of training on body composition and the importance of low body fat for success in rowing [13]. The greatest decreases in skinfolds across the age groups, were observed for the thigh and the triceps sites (Table 1). The lowest skinfold thicknesses and percent body fat was found in both senior groups (L-W and H-W) compared with the younger rowers. The percent fat values of the senior rowers were comparable to those reported in the literature for high level athletes [19,10,12].

Fig. 4



Mean endomorphy, mesomorphy and ectomorphy ratings for young and national level rowers (11-16: age groups for young rowers, L-W: lightweight, H-W: heavyweight)
**p<0.01 from all other groups; ++p<0.01 from age groups of 11 and 12 yrs.

The somatotype ratings of the L-W and the H-W rowers were very similar to those reported for high level rowers and Olympic Games competitors [1,5,8]. For example, the somatotype of lightweight rowers (1.4-4.4-3.4) and heavyweight rowers (1.9-5.0-2.5) competing at the Sydney 2000 Olympic games [1] were almost identical with the H-W and L-W rowers of the present study (Fig. 4). Comparison of the somatotype ratings across age groups showed that endomorphy ratings were decreasing with age from 11 to 14 y, but there was no difference between the 14 to 16 y old groups and the senior groups. This reflects the decrease of body fat with age, which is also shown in Fig. 1. Furthermore, endomorphy is the component of somatotype that can be most influenced by training. On the other hand, mesomorphy was similar across all groups examined and ectomorphy did not show large fluctuations from the 13 y old group onwards (Fig. 4). Thus, muscularity, as indicated by mesomorphy ratings, seems to be similar across all groups examined. These findings may indicate that individuals with the appropriate somatotypes for rowing are selected from an early age. Although the present study was cross-sectional, the results may reflect the relative stability of ectomorphy and mesomorphy during growth, as has been suggested by Malina and Bouchard [15].

In conclusion, Club level rowers aged 15 and 16 yrs had similar height, body weight, arm length and leg length, but lower lean body mass compared with senior L-W rowers. Young rowers in all age groups were heavier and much taller compared to a reference group of Greek children. The greater body weight of the rowers compared to the reference group of children may be due to an increased lean body mass as a result of rowing training, especially at the older groups. Endomorphy ratings decreased with age from 11 to 14 y, but there was no difference between the 14 to 16 y old groups. However, mesomorphy was similar across all groups examined and ectomorphy did not show large fluctuations from the 13 y old group onwards. These results would suggest that anthropometric characteristics can be used as a criterion for selection of rowers by the coaches from an early age.

References

1. Ackland T., D.Kerr, P.Hume, B.Ridge, S.Clark, E.Broad, W.Ross (2001) Anthropometric normative data for Olympic rowers and paddlers, 2001: A Sports Medicine Odyssey: Challenges, Controversies & Change, ACT, Australia, Sports Medicine Australia, Stand alone: pp. CD Rom (2001)

2. Bourgois J., A.L.Claessens, H.Vrijens, R.Philippaerts, B.Van Renterghem, M.Thomis, M.Janssens, R.Loos, J.Lefevre (2000) Anthropometric characteristics of elite male junior rowers. *Br.J.Sports Med.* 34:213-217

3. Bourgois J., A.L.Claessens, M.Janssens, B.Van Renterghem, R.Loos, M.Thomis, R.Philippaerts, J.Lefevre, J.Vrijens (2001) Anthropometric characteristics of elite female junior rowers. *J.Sports Sci.* 19:195-202

4. Carter J.E.L. (1980) The Heath-Carter Somatotype Method. 3rd Ed. San Diego State, University Syllabus Service, San Diego

5. Carter J.E.L. (1984) Somatotypes of Olympic Athletes from 1948 to 1976. *Med.Sport Sci.* 18:80-109

6. Chiotis D., G.Tsiftis, M.Chatzisymeon, M.Maniati, X.Krikos, ADakou-Voutetaki (2002) Growth charts for the Greek population: boys aged 0-18 years. A΄ Paediatric Clinic, Medical School, University of Athens, Greece

7. Claessens A.L., J.Bourgois, G.Beunen, R.Philippaerts, M.Thomis, J.Lefevre, R.J.Loos, J.Vrijens (2003) Age at menarche in relation to anthropometric characteristics, competition level and boat category in elite junior rowers. *Ann.Hum.Biol.* 30:148-159

8. DeRose E.H., S.M.Crawford, D.A.Kerr, R.Ward, W.D.Ross (1989) Physique characteristics of Pan American Games lightweight rowers. *Int.J.Sports Med.* 10:292-297

9. Durnin J.V.G.A., M.M.Rahaman (1967) The assessment of the amount of fat in the human body from measurements of skinfold thickness. *Br.J.Nutr.* 21:681-689

10. Gualdi Russo E., G.Gruppioni, P.Gueresi, M.G.Belcastro, V.Marchesini (1992) Skinfold and body composition of sports participants. *J.Sports Med.Phys.Fitness* 32:303-313

11. Ibnziaten A., M.S.Poblador, A.Leiva, J.R.Gomez, B.Viana, F.G.Nogueras, J.L.Lancho (2002) Body composition in 10 to 14 year old handball players. *Eur.J.Anat.* 6:153-160

12. Krawczyk B., M.Sklad, A.Jackiewicz (1997) Heath-Carter somatotypes of athletes representing various sports. *Biol.Sport* 14:305-310

13. Maestu J., J.Jurimae (2000) Anthropometrical and physiological factors of rowing performance: a review. *Acta Kinesiol.Univ.Tartuensis* 5:130-150

14. Malina R.M. (1994) Physical activity and training: effects on stature and the adolescent growth spurt. *Med.Sci.Sports Exerc.* 26:759-766

15. Malina R.M., C.Bouchard (1991) Growth, Maturation and Physical activity. Human Kinetics, Champaign, IL, pp. 65-86

16. Piotrowski J., M.Sklad, B.Krawczyk, B.Majle (1992) Somatic indices of junior rowers as related to their athletic experience. *Biol.Sport* 9:117-124

17. Rodriguez F.A. (1986) Physical structure of international lightweight rowers. In: T.Reilly, J.Watkins, J. Borms (eds.). Kinanthropometry II. E. & F.N. Spon, London, pp. 255-261

18. Secher N.H., O.Vaage (1983) Rowing performance, a mathematical model based on analysis of body dimensions as exemplified by body weight. *Eur.J.Appl.Physiol.* 52:88-93

19. Secher N.H. (1990) Rowing. In: T.Reilly, N.Secher, P.Snell, C.Williams (eds.) Physiology of Sports. E. & F.N. Spon, London, pp. 259-286

20. Shephard R.J. (1998) Science and medicine of rowing: a review. *J.Sports Sci.* 16:603-620

21. Sklad M., B.Krawczyk, B.Majle (1993) Effects of intense annual training on body components and other somatic traits in young male and female rowers. *Biol.Sport* 10:239-243

22. Sklad M., B.Krawczyk, B.Majle (1994) Body build profiles of male and female rowers and kayakers. *Biol.Sport* 11:249-256

23. Tittel K., Wutscherk (1992) Anthropometric Factors. In: P.V. Komi (ed). Strength and Power in Sport. Blackwell Scientific Publications, London, pp. 180-196

24. Yoshiga. C.C., M.Higuchi (2003) Rowing performance of female and male rowers. *Scand.J.Med.Sci. Sports* 13:317-321

Accepted for publication 17.11.2005