Original Paper DOI: 10.5604/20831862.1133937 Biol. Sport 2014;31:323-326

BODY STRUCTURE AND COMPOSITION OF CANOEISTS AND KAYAKERS: ANALYSIS OF JUNIOR AND TEENAGE POLISH NATIONAL CANOEING TEAM

Accepted for publication 09.09.2013

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ABSTRACT: The somatic build, biological age, general state of health, mental predisposition and physical fitness are the criteria for selection of individuals in competitive sport. The present study aims to analys the differences in body structure and composition of canoeists and kayakers and derive conclusions regarding the criteria for selection of individuals incompetitive sport. The research was conducted on a group of 32 men aged between 17 and 22: 16 kayakers and 16 Canadian canoeists of the junior and teenage Polish national canoeing team. Body composition was examined by means of bioelectrical segmental impedance. Body build type was determined using the anthropometric Heath-Carter method. Statistical analysis was performed using the Welch t-test. The examination of morphological features reveals significant differences in the studied parameters between the canoeists and kayakers. There are also significant differences between competitors of the Sydney 2000 Olympic Games and the studied group. We found that competitive kayakers should be taller than canoeists. The lower part of the body in kayakers is more developed than in canoeists and canoeists are more dehydrated than kayakers.

KEY WORDS: somatotype, body composition, kayakers, canoeists,

INTRODUCTION

Humans have been using boats since time immemorial. They were used for travelling, hunting and fighting. Depending on the actual conditions of living, various types of boats were built, including canoes, used until today by Native Americans from the Iroquois, Sioux and Apache tribes, and kayaks (qayaqs), used by the Eskimos [1]. In fact, the boat is an example of how humans have adapted to the surrounding conditions. The difference between canoes and kayaks is that the former are intended for relatively placid waters of rivers and lakes, while kayaks are intended for sea waters (hence their plating, manoeuvrability and speed).

Canoeing became an Olympic discipline only during the Olympics in Berlin in 1936 and the first world championships took place in 1938 in Sweden. Canoeing is divided into flat-water (classical) and white-water canoeing. Classical canoeing consists of kayaking and Canadian canoeing. Kayaking and canoeing are technical sports. In order to do such sports, special equipment apart from human strength is required: kayaks, Canadian canoes and paddles. Flat-water canoeing races involve single seat kayaks (K-1), double seated kayaks (K-2), four seated kayaks (K-4) as well as single kneeling Canadian canoes (C-1), double kneeling canoes (C-2) and four person kneeling canoes (C-4) [2]. The kayak is a covered-deck boat equipped with a cockpit where the competitor sits facing forward. The Canadian canoe, on the other hand, is an open boat where, in contrast to the kayak, no steering devices are allowed. In a canoe, the competitor is in a kneeling position and uses a single bladed paddle, whereas in the case of a kayak, a double bladed paddles is used [3].

Physiologically, canoeing may be characterised as follows: (1) the canoeist's work has the same movement pattern independent of the external conditions, (2) the movement is rhythmical, systematic and cyclic, (3) the pulse during a rest in canoeists is 55 beats per minute. The cardiac ejection volume is around 90 ml and the vital capacity of lungs is about 5400 ml [4,5],- (4). Alternating contraction and relaxation phases occur, determining the dynamic nature of muscular work, causing a substantial increase in metabolism which leads, in consequence, to using up a considerable amount of energy and utilising a maximal amount of oxygen [6,7]. (5) Canoeing is a sport which involves endurance and strength. (6) Work intensity is varied, mostly high, sub-maximal and maximal [8]. The specific physiolog-

ical requirements determine the somatic type of a competitor which could be further used as an indicator of the selection process by coaches. The aim of the present study is to create a scientific basis for finding individuals who are likely to achieve good results in the future in a given sport discipline. In our opinion the somatic build together with the current age of the competitor, his/her state of health, mental predisposition and physical fitness are the criteria for selection of individuals. Therefore in the study we characterise the body structure and body composition according to Sheldon somatic types [9] in canoeists and Canadian canoeists, and compare the somatic types with those reported previously for competitors of the Sydney 2000 Olympic Games.

MATERIALS AND METHODS

The research was conducted on a group of 32 men aged between 17 and 22: 16 canoeists (age mean 18.687 +/- SD 1.401) and 16 Canadian canoeists (age mean 18.250 +/- SD 1.528) from the junior and teenager Polish national team. Only volunteers who provided informed consent in accordance with the procedures approved by the Bioethics Commission of Collegium Medicum, University of Nicolas Copernicus, Poland, were included in the study. The research was carried out at the Department of Anthropology, Collegium Medicum, Nicolaus Copernicus University. Body composition was examined by means of a bioelectrical segmental impedance method using the "In Body 3.0" equipment (Biospace Co. Ltd.). On the basis of the amount of water within a human body, the device calculates body mass without fat, fat mass and mass of proteins and minerals. It also allows one to examine examine lean body mass (LBM) in body segments [10]. Body build type was determined by means of anthropometric methods according to the Heath-Carter method [11]. This method uses the measurements of body height, body mass, width of elbow and knee epiphysis (using a bow compass), arm and calf circumference (using a measuring tape) and four skin folds: on the arm, underneath the shoulder blade, above the iliac ala, and on the calf, by means of a fat calliper.

Statistical analysis

The statistical analysis of the data was performed by means of appropriate t-statistics derived under the assumption that the data presented in the literature followed the normal distribution. We also evaluated the distribution of our data by means of the Shapiro-Wilk test and quantile-quantile plot. For the data analysis we applied the Welch t-test. We are also aware that for studies involving more than two groups the one-way ANOVA is the appropriate approach. However, we decided to use the t-test. For the ease of reading and writing we refer to data gathered from the literature [12], -as sprint paddlers. The original data presented in this study are referred to as canoeists and kayakers

RESULTS

The statistical analysis of the basic morphological features (Table 1) such as body height (BH), body mass (BM), and body mass index (BMI) reveals the following results. There are statistically significant differences between C and K and C and SP with respect to BH. The analysis of BM shows statistically significant differences between C and SP and K and SP. No statistical difference is observed between C and K. Statistically significant differences are observed between C and K and K and SP, when analysing BMI.

The analysis of Table 1 makes it clear that kayakers in the Polish national team and participants of the Olympic Games are on average 8 centimetres taller than canoeists. It also shows that BM of junior competitors is significantly lower than observed for Olympic paddlers and that BMI of canoeists is of the same order as SP. The results of biotype analysis (Table 2) exhibit the following statistical differences. There is a clear statistical difference in the endomorph component between C and SP as well as K and SP. In the mesomorph component statistically significant differences are visible between all the studied groups, and in the ectomorph component statistically significant differences are observable between C and K and K and SP. Compared with K, the amount of mesomorphic element in C is higher. However, the mesomorphic element in SP is significantly higher than that observed for both C and K. The analysis of differences in the endomorphic element shows the lack of statistically significant differences between C and SP and significant differences between C and K and K and SP. It is striking that endomorphy is the lowest in the group taking part in the Olympic Games. We also observed specific differences between body composition of C and K (Table 3). There are statistical differences in LBM values of lower

TABLE 1. STATISTICAL CHARACTERISTICS OF BASIC TRAITS IN STUDIED SPORTSMEN

Feature	Canoeists (C) (n=16)	Kayakers (K) (n=16)	Sprint paddlers* (SP) (n=50)	Welch t-test result		
	mean ± SD	mean ± SD	mean ± SD	C/K	C/SP	K/SP
Body height (cm)	176.9 ± 6.9	184.9 ± 5.8	184.9 ± 6.0	*	*	*
Body mass (kg)	75.5 ± 8.0	78.1 ± 4.9	84.8 ± 6.2	x	*	*
Body mass index ($kg \cdot m^{-2}$)	24.1 ± 1.2	22.8 ± 0.9	24.9 ± 2.4	*	x	*

Note: x refers to $p < 0.05$ for the t test.

TABLE 2. BODY BUILD TYPES IN THE STUDIED SPORTSMEN ACCORDING TO HEATH-CARTER METHOD

Feature	Canoeists (C) (n=16)	Kayakers (K) (n=16)	Sprint paddlers* (SP) (n=50)	Welch t-test result		
	mean ± SD	mean ± SD	mean ± SD	C/K	C/SP	K/SP
Endomorphy	2.7 ± 0.6	2.3 ± 0.6	1.6 ± 0.5	x	*	*
Mesomorphy	4.7 ± 0.5	3.7 ± 0.5	5.7 ± 0.8	*	*	*
Ectomorphy	2.2 ± 0.5	3.1 ± 0.7	2.2 ± 0.7	*	x	*

Note: *- refers to literature derived data, x refers to $p < 0.05$ for the Welch t test

limbs, both right and left, LBM of the trunk, percentage fat, extracellular fluid and oedema index. The relative level of fat in both cases was similar, ranging between 8.5 and 10.7 kg. The protein mass in both groups was similar. The difference in the oedema index between both groups was 0.11, which points to higher dehydration in C compared with K.

TABLE 3. BODY COMPOSITION IN CANOEISTS AND KAYAKERS

Feature	Canoeists (n=16)	Kayakers (n=16)	Welch t test
	M±SD	M±SD	
Lean body mass [kg]	69.04 ± 8.67	71.54 ± 5.39	x
LBM_{pkg}	4.10 ± 0.68	4.36 ± 0.35	x
LBM_{lkg}	30.50 ± 3.88	32.30 ± 2.13	x
LBM_{t}	9.95 ± 1.30	10.95 ± 1.13	*
LBM_{pkd}	9.93 ± 1.29	10.96 ± 1.13	*
LBM_{lkd}	7.98 ± 2.46	6.59 ± 1.80	x
Fat [kg]	10.69 ± 3.47	8.51 ± 2.41	x
Fat [%]	0.81 ± 0.02	0.78 ± 0.02	*
WHR index	46.92 ± 5.90	49.73 ± 3.78	x
Total body water [l]	32.27 ± 4,01	33.68 ± 2.53	x
Intracellular fluid	14.67 ± 1.97	16.05 ± 1.40	x
Extracellular fluid	0.312 ± 0.007	0.323 ± 0.010	*
Oedema index	17.08 ± 2.15	18.12 ± 1.37	*
Protein mass [kg]	3.52 ± 0.37	3.70 ± 0.23	x

Note: LBM pkg right upper limb; LBM lkg left upper limb; LBM t trunk; LBM pkd right lower limb; LBM lkd left lower limb

DISCUSSION

The national team requires from sportsmen a high level of professionalism in respect of a given discipline. Satisfactory results in the international arena can be achieved only by individuals with a specific somatic and mental model. The fact that somatic structure is genetically conditioned can be used as a prognostic parameter [13, 14], indicating the chance for the desired further development of a subject. Research conducted on canoeists [15] and kayakers [12,16] contributed to the scientific definition of the required somatic model. The previous studies showed that canoeists are characterised by very strong skeletal build, tallness, large body mass, long upper limbs, muscularity of the chest and upper limbs and athletic build [17,18], having at the same time narrow hips and slim lower limbs [19]. Other experimental data [19,20] indicate that the best results are achieved by individuals who are 180-190 cm tall. The subjects analysed in the present study fulfil the desired characteristics. The mesomorphic element in both C and K of the Polish junior national team is significantly lower and the endomorphic element is significantly higher than that observed for competitors of the Sydney 2002 Olympic Games. The data indicate that both K and C are inferior to the Sydney competitors. The presented study also indicates that with a small percentage of fatty tissue, both kayakers and canoeists are characterised by high values of LBM and protein mass. This phenomenon is caused by the fact that training in both groups is aimed at improving strength and speed, which favours hypertrophy of muscle tissue [21]. A segmental analysis of body composition enables us to observe the differences between the upper and the lower parts of the body. With similar musculature of the upper limbs and trunk, kayakers are characterised by larger lean body mass in the lower limbs. This can be explained by the fact that there is a dependency between muscular work of the lower limbs and the frequency of paddle strikes. The present study also indicates adequacy of BMI and biotype for the prediction and analysis of fitness level prior to competition.

CONCLUSIONS

The study allowed us to draw the following conclusions: Competitive kayakers are and should be significantly taller than canoeists. Junior canoeists have a greater proportion of mesomorphic element and a smaller proportion of ectomorphic element than kayakers. Both groups are characterised by a similar proportion of endomorphic element. The lower part of the body in kayakers is more developed than in canoeists. The two groups differ in body composition. Canoeists were more dehydrated than kayakers. The differences between somatic parameters of juniors and Olympic Games competitors may be the result of age and fitness level.

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