Journal of Physical Education and Sport ® (JPES), 16(1), Art 20, pp. 118 - 124, 2016
online ISSN: 2247 - 806X; p-ISSN: 2247 – 8051; ISSN - L = 2247 - 8051 © JPES

Original Article

Influence of one-year sport activities on the changes in morphological parameters and somatotypes in the current junior members of the Czech national whitewater slalom team

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Published online: March 25, 2016
(Accepted for publication February 23, 2016)
DOI:10.7752/jpes.2016.01020

Abstract:

Achieving the highest performance level in the area of top level sport is associated with optimum development of somatic parameters, which represent a significant part of the structure of sports performance. The development of somatic and functional parameters in a young athlete is determined by endogenous influences and at the same time is influenced by intensive sports preparation in a specific area of sport. The objective of the present study is to capture the dynamics of changes in morphological parameters and somatotypes in current junior members of the Czech national team in whitewater slalom in relation to the annual cycle. The survey included a total of 14 junior members of the Czech national team (absolute sample) in whitewater slalom aged 16-17 years. We used anthropometric methods in accordance with the international standards of the International Society for the Advancement of Kinanthropometry (ISAK) and the bioelectrical impedance analysis (BIA) using the InBody 230 instrument. The research data were processed by means of appropriate procedures in the Antropo programme, vers. 2000.1. Statistical analysis was performed using the Statistica programme v 10.0. The level of statistical significance was tested at $p \leq 0.05$; $p \leq 0.01$. The statistical significance is expressed in common p values as well as in d values, where d is Cohen's coefficient for effect size. The research study assessed the changes in the monitored parameters with regard to the preparatory period and the competition period in the context of the annual training cycle. The changes in the monitored morphological parameters and somatotypes in junior whitewater slalom racers suggest an appropriately selected training programme with a possibility of an effective transfer into the competition season. The assessed parameters represent a part of the nomination criteria of the Czech national whitewater slalom team for the Junior World Championships.
Keywords: exercise, morphological characteristics, body composition, adolescence, elite sport

Introduction

To achieve the highest performance level in sport requires a significant development of motor abilities and skills with an overall high level of development of physical fitness. This is associated with optimum development of somatic parameters, which represent a significant part of the structure of top level sports performance (Pavlík, 1999; Perič & Dovalil, 2010). Numerous studies by sports anthropologists result in definitions of specific somatic parameters and in determination of a specific morphological type relating to a particular sport sector (Blanchard, 1995; Bolin & Granskog, 2003; Malina, Bouchard, & Bar-Or, 2004). Accordingly, domestic experts emphasise morphological differences that are related to sports specializations (Bílý, Süss, & Buchtel, 2011; Grasgruber & Cacek, 2008; Pavlík, 1999; Sigmund, Dostálová, & Brychta, 2013).
Our survey focuses on top level athletes specialized in whitewater slalom. Whitewater slalom is one of our successful sports disciplines. Since 1959, World Championships have been regularly held; since 1972 it has been an Olympic discipline.

The first Olympic year was especially significant for the development of Czech whitewater slalom, although the Czech national team did not succeed at the first Olympic Games. An analysis of the failure suggested a need for systematic and scientific work with a transfer of knowledge into the area of whitewater slalom training. Since that period, training of young talented athletes has been based on modern scientific and research-based findings and their practical application in the area of whitewater slalom. From a physiological perspective, whitewater slalom represents a continuous type of load of moderate to vigorous intensity with an average duration of 90 to 120 seconds (Bernaciková et al., 2010; Kratochvíl & Bílý, 1997).

This is a technical discipline with a predominance of strength and endurance. The actual development of the skills and abilities of whitewater slalom racers focuses primarily on the development of technical aspects

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(50–70%) and strength (5–20%). A smaller proportion is represented by endurance and maximum speed training. The overall distance of a whitewater slalom race is 300 to 600 meters. The metabolic coverage is mixed using the ATP-CP system, anaerobic glycolysis and aerobic phosphorylation. Energy expenditure is 1.500 to 1.900% of basal metabolism (70–85 kJ/min); the total energy demand depends on the length of the race and its difficulty, water flows and weather conditions (Bernaciková et al.,2010; Kratochvíl & Bílý, 1997; Nolte, 2005).

From a kinesiological perspective, the locomotion is of an artificial nature with acyclic movements of various body segments. The overall load of an annual training cycle in top junior whitewater slalom racers represents over 400 training units, which is more than 600 hours of load on water. The competition period is between May and September with an average of twenty races (Sigmund et al., 2014). Regarding basic morphological parameters (body height, body weight, BMI, body fat percentage) in contemporary top level whitewater slalom there are no optimum values.

Successful athletes are tall individuals as well as those with lower values of body height. This also applies to body weight. What appears to be influential in relation to biomechanical aspects of this specific type of movement on whitewater is the length of the upper segment and arm span. Whitewater slalom racers usually have longer upper extremities and shorter lower extremities. They usually have wider shoulders and narrow pelvis. Kayakers tend to be higher than canoeists, but with lower body weight.

The aim of this paper is to identify the changes in selected morphological parameters and somatotypes in junior members of the Czech national team in whitewater slalom with regard to the annual sport cycle.

Material & methods

Subjects

The survey included a total of 14 Czech junior members of the national team in whitewater slalom aged 16-17 years. The survey took place during the national training camp in Prague in October 2014, March 2015 and October 2015. As far as the representativeness of the selection of the target group is concerned, our method was absolute collection. In terms of ethical aspects, all participants in the survey were fully informed of its purpose and of a possibility to terminate their participation at any time without giving a reason. The participants were informed of further data processing and ensuring anonymity. Each individual was involved on a voluntary basis and consented to data processing and publication.

Morphological assessment

Body height was measured by the Tanita HR-001 anthropometer (Tanita, Japan) with a permissible error of measurement of 5 mm. Body weight was measured using the InBody 230 instrument (Biospace, South Korea). Measurement accuracy for the determination of body weight was 100g. To determine the proportion of body fat (kg; %), fat free mass (FFM) and to perform a segmental analysis we used a non-invasive method of multifrequency tetrapolar bioelectrical impedance (BIA) using the InBody 230 instrument (Biospace, South Korea). During the BIA examination we adhered to the conditions of the recommended measurement procedure (Heymsfield, Lohman, Wang, & Going, 2005; Heyward & Wagner, 2004). To determine circumferential characteristics we used a medical tape measure (Holtain, Great Britain), width and bone diameters were determined by means of a calliper with adjustable tips – Pelvimetr P-216 (Trystom, Czech Republic). To assess the values of subcutaneous proportion of body fat and skinfolds, we used a calliper type Best II K-501 (Trystom, Czech Republic), contact surface 3 mm, pressing force 2N. Body composition expressed by means of somatotypes was assessed by the Heath-Carter methodology (in Riegerová, Přidalová & Ulbrichová, 2006). The anthropometric measurements were made in accordance with international standards (Marfell-Jones, Olds, Stewart, & Carter, 2006).

Statistical analysis

Statistical result processing was conducted using the Statistica programme v. 10.0 (Statistica, Tulsa, USA). For each variable, basic statistical quantities were calculated and distribution normality verified. Result processing was made using parametric as well as non-parametric statistical methods. Normality was assessed using the Shapiro-Wilk normality test. Multiple value comparison was made using the Kruskal-Wallis test. The level of statistical significance was tested at $p \leq 0.05$; $p \leq 0.01$. The statistical significance is expressed in common p values as well as in d values, where d is Cohen's coefficient for effect size defined as a difference between two means divided by a standard deviation for the data. The most frequent assessment of effect size d is 0.2 – small effect, 0.5 – moderate effect and 0.8 – large effect (Thomas, Nelson, & Silverman, 2011).

Training programme

The training programme is shown in Table 1. The quantification represents an estimate of the exercise during the monitored annual cycle. This is a qualified expert estimate by head coaches and coaches who performed the entire fitness training with the athletes. All coaches have top coaching licences in their sports specializations.

Table 1. Indicators of training load during the annual cycle in the observed junior members of the Czech national team in whitewater slalom

Type of training (man; 16.00–16.99 yrs.)	Preparatory period (5 months)		Main season (7 months)		Annual cycle (12 months)	
Fitness training	Σ (min.)	Proportion (%)	Σ (min.)	Proportion (%)	Σ (min.)	Proportion (%)
Power training	3 804	22.2	2 543	9.6	6 347	14.5
Anaerobic training	2 128	12.4	3 999	15.0	6 127	14.0
Aerobic training	1 005	5.9	2 507	9.5	3 512	8.0
Skill-oriented training	(min.)	(%)	(min.)	(%)	(min.)	(%)
Training on water	6 829	39.8	12 565	47.3	19 394	44.4
Sports games	1 173	6.8	1 822	6.8	2 995	6.9
Other	1 783	10.4	1 754	6.6	3 537	8.1
Regeneration	427	2.5	1 376	5.2	1 803	4.1
Total (minutes)	17 149	100	26 566	100	43 715	100
Total (hours)	Σ = 286 hours		Σ = 442 hours		Σ = 728 hours	

Results

The comparison of the monitored morphological parameters in junior whitewater slalom racers with reference values of the Czech population shows values in the interval of average values of a population of the same age in most categories. In the monitored sample we observed a trend of higher skeletal robusticity in the area of the biepicondylar distance of the humerus and in the development of maximum circumference of contracted arm. With regard to the changes in morphological parameters in relation to the annual cycle, which includes the preparatory and competition season, in some categories we observed significant differences with a low to medium level of material significance (Table 2).

During the year, the athletes increased in body height by 2.4 cm. However, in this category it is impossible to associate the increase and the period of preparation. The overall increase in body weight in whitewater slalom racers was 4.2 kg. This value can be regarded significant with respect to the identified decrease in fat mass, increase in muscle mass by 2.5 kg and overall increase in fat free mass by 4.0 kg (Table 2). The level of development of bone diameters shows a gradual increase throughout the annual cycle. A significant difference was observed in the circumference of contracted arm, a positive insignificant difference in maximum calf circumference.

We observed a general decrease in skinfold values in the area of subscapularis, triceps and calf. The only increase was observed in the suprailiac area. In terms of body composition, the average value of body fat proportion in the monitored slalom racers was around 10%. During the first examination, the overall body fat proportion was assessed as optimum regarding this sports specialization.

The changes observed in fat mass proportion can be assessed as insignificant; throughout the annual cycle their values move between 9.5 to 10.1% (Table 2). Among the monitored junior members of the national team in whitewater slalom, the body constitution expressed by means of somatotypes shows average medium values 2–5–3. Individual somatotypes are mainly located in the area of ectomorphic mesomorph (57%). Individual somatotypes are also located in the area of balanced mesomorph (21%) and mesomorph-ectomorph (14%) (Figure 1).

Table 2. Changes in morphological parameters in junior members of the Czech national team in whitewater slalom

Selected morphological parameters	**I.**		**II.**		**III.**	
	M	**SD**	**M**	**SD**	**M**	**SD**
Body height (cm)	178.4	5.46	180.5	5.38	180.8	4.89
Body weight (kg)	69.6	6.55	71.6	6.45	73.8	8.40
BMI (kg/m^2)	21.8	1.35	21.9	1.30	22.5	1.62
Biepicondylar width of humerus (cm)	7.3	0.40	7.4	0.36	7.5	0.71
Biepicondylar width of femur (cm)	9.9	0.37	10.0	0.29	10.2	0.37
Arm circumference contr. dx. (cm)	31.2	1.99	32.8	1.53	33.2	1.70
Calf circumference max. dx. (cm)	35.5	2.55	36.4	2.35	36.1	2.57

Suprailiac skinfold (mm)	7.9	3.34	6.5	2.18	11.9	4.00
Triceps skinfold (mm)	4.8	1.95	6.5	1.38	3.4	1.20
Subscapular skinfold (mm)	6.3	2.05	5.4	0.87	5.9	1.56
Calf skinfold (mm)	7.0	1.46	4.9	1.34	5.0	2.19
Body fat (kg)	7.0	2.17	6.7	2.09	7.2	1.17
Body fat (%)	10.1	3.31	9.5	3.29	9.9	1.80
Muscle mass (kg)	35.6	4.13	37.0	4.40	38.1	5.04
FFM (kg)	62.6	6.80	64.9	7.25	66.6	8.31
TBW (kg)	46.0	4.97	47.6	5.32	48.8	6.07
BMR (kcal)	1723	147	1771	157	1808	179

Change	**I.–II.**			**II.–III.**			**I–III.**		
	Δ	*p*	*d*	Δ	*p*	*d*	Δ	*p*	*d*
Body height (cm)	2.1	0.001	0.38	0.3	ns	0.06	2.4	0.034	0.46
Body weight (kg)	2.0	0.004	0.31	2.2	0.041	0.30	4.2	0.041	0.56
BMI (kg/m^2)	0.1	ns	0.08	0.6	0.011	0.41	0.7	0.008	0.47
Biepicondylar width of humerus (cm)	0.1	ns	0.26	0.1	ns	0.35	0.2	ns	0.18
Biepicondylar width of femur (cm)	0.1	ns	0.30	0.2	ns	0.81	0.3	ns	0.60
Arm circumference contr. dx. (cm)	1.6	0.001	0.90	0.4	ns	1.08	2.0	0.013	0.25
Calf circumference max. dx. (cm)	0.9	ns	0.38	0.3	ns	0.23	0.6	ns	0.12
Suprailiac skinfold (mm)	1.4	ns	0.50	5.4	0.001	1.09	4	0.012	1.70
Triceps skinfold (mm)	1.7	0.017	1.01	3.1	0.001	0.86	1.4	0.043	2.39
Subscapular skinfold (mm)	0.9	ns	0.57	0.5	ns	0.22	0.4	ns	0.40
Calf skinfold (mm)	2.1	0.001	1.50	0.1	ns	1.08	2.0	0.013	0.06
Body fat (kg)	0.3	ns	0.14	0.5	ns	0.29	0.2	ns	0.11
Body fat (%)	0.6	ns	0.18	0.4	NS	0.15	0.2	ns	0.07
Muscle mass (kg)	1.4	0.001	0.33	1.1	0.034	0.23	2.5	0.034	0.55
FFM (kg)	2.3	0.001	0.33	1.7	0.028	0.22	4.0	0.028	0.53
TBW (kg)	1.6	0.001	0.31	1.2	0.034	0.21	2.8	0.034	0.51
BMR (kcal)	48	0.001	0.32	37	0.034	0.22	85	0.034	0.52

Legend: I. – first measurement; II. – second measurement; III. – third measurement; M – mean; SD – standard deviation; BMI – body mass index; contr. – contraction; dx. – dexter; FFM – fat free mass; TBW – total body water; BMR – basal metabolic rate; Δ – difference; *p* – statistical significance; ns – non significant; *d* – effect size (Cohen), 0.20-0.49 – small effect, 0.50-0.79 – moderate effect and ≥ 0.80 – large effect

Table 3. Changes in somatotypes in junior members of the Czech national team in whitewater slalom

Somatotype	**I.**		**II.**		**III.**	
	M	**SD**	**M**	**SD**	**M**	**SD**
Endomorph	2.1	0.63	2.0	0.32	2.3	0.57
Mesomorph	5.0	0.67	5.0	0.70	5.2	0.89
Ectomorph	3.2	0.71	3.3	0.63	3.1	0.59

Change	**I.–II.**			**II.–III.**			**I–III.**		
	Δ	*p*	*d*	Δ	*p*	*d*	Δ	*p*	*d*
Endomorph	0.1	ns	0.20	0.3	0.033	0.66	0.2	ns	0.33
Mesomorph	0.0	ns	0.0	0.2	ns	0.25	0.2	0.041	0.26
Ectomorph	0.1	ns	0.15	0.2	0.009	0.33	0.1	ns	0.15

Legend: M – mean; SD – standard deviation; Δ – difference; *p* – statistical significance; ns – non significant; *d* – effect size (Cohen), 0.20-0.49 – small effect, 0.50-0.79 – moderate effect and ≥ 0.80 – large effect

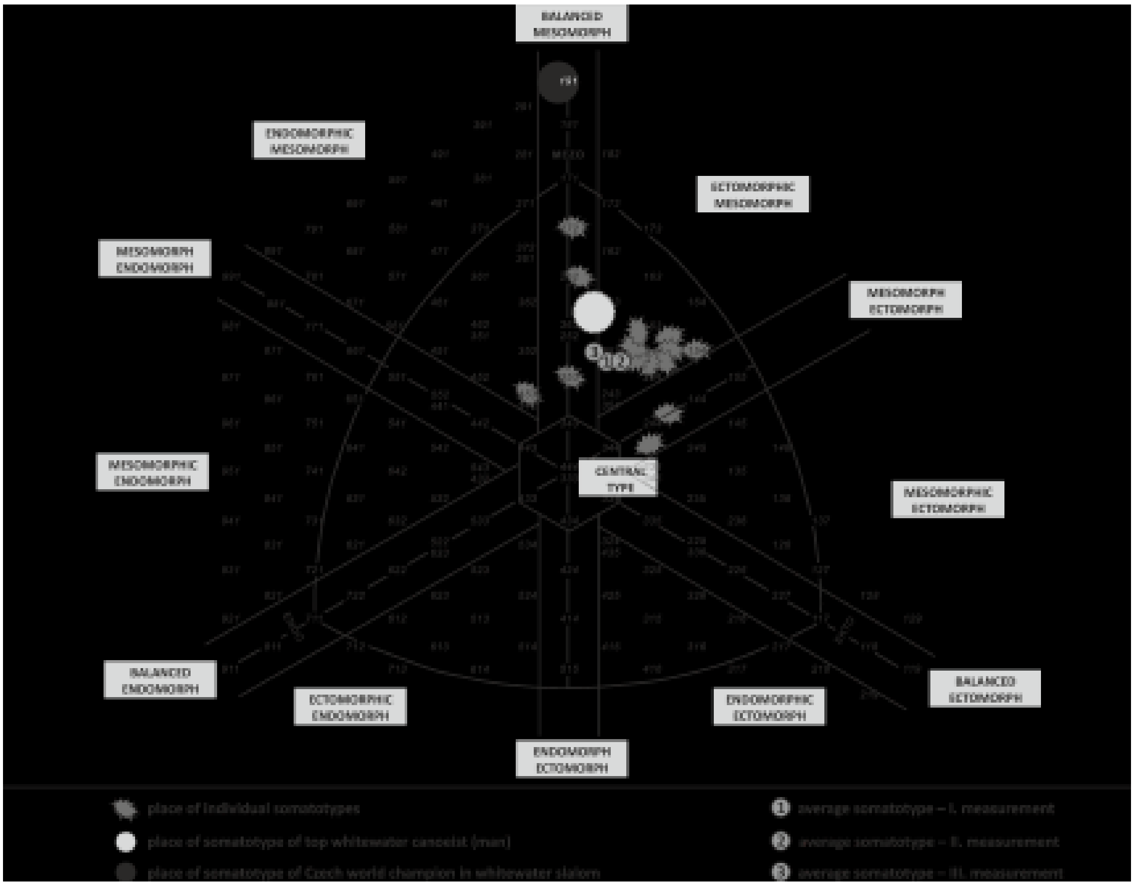

Fig. 1. Influence of one year sport period on changes of somatotypes of junior members of the Czech national team in whitewater slalom

Discussion

The complex of somatic parameters represents an important factor that influences sports performance. In water sports, the analysis of morphological dispositions has been included in the test battery since early 1970s. The original somatic typology top slalom races of K1 category pointed to individuals with body height of 177–185 cm and body weight of 68–77 kg. Typologically, these were individuals from the ectomorphic mesomorph area or endomorphic mesomorph area. The development of the mesomorph component was always frequently represented; there were more than 17% of strong mesomorph types (Sigmund et al., 2014). Similar values of morphological parameters were later also published by other authors (Sklad, Krawczyk, & Majle, 1994). At present, the optimum location of a whitewater slalom racer somatotype appears the transition between ectomorphic mesomorph and balanced mesomorph (Figure 1).

The whitewater slalom racers in our sample currently represent the top performance level in the junior category. The top performance achieved by the athletes monitored in the study is the result of individual dispositions and long-term systematic training in a well-organized system of whitewater slalom training. In our sample of junior members of the Czech national team, this fact is evidenced by a large number of medals won at top international events. Regarding the basic morphological parameters and their changes during the monitored period, we observed changes caused by the effect of the load exercised. This is not the case of changes in body height, which are mainly affected by endogenous influences with regard to the stage of ontogenesis. As far as changes in body weight and various body fractions are concerned, these are influenced by the load exercised. In the monitored sample of whitewater slalom racers we observed an increase in body weight and a decrease in fat mass (Table 2). We observed an increase in muscle mass, which eventually resulted in a general increase in fat free mass. The differences are significant with a medium level of material significance. With regard to the transfer into the area of practical sport and further work with the monitored group, these findings can be considered positive. This confirms an appropriately selected strategy of controlling the load of the monitored racers in the preparatory period. In relation to the development of muscle mass, some authors point to a possibility of muscle asymmetry, especially in sports activities that cause systematic overloading of certain muscle groups and body segments (Bílý et al., 2013). The authors suggest possible associations between muscle asymmetry and risk of injury. In this context we consider it appropriate to monitor morphological changes in the training process as a basis for further work of coaches and physiotherapists with an emphasis on health aspects. If we focus on the development of basic morphological characteristics in adult racers, it must be noted that for example body height in current top-level world whitewater slalom racers may be above average, average or below average. It is therefore impossible to clearly define the value of optimum development of this feature, which would clearly predict possible success in the discipline. For example the world champion in whitewater slalom has below-average body height and average body weight with extraordinary development of fat free mass (Sigmund, Rozsypal, & Kratochvíl, 2014). On the contrary, some top-level whitewater slalom racers e.g. from France or Germany, show above-average levels of body height (Sigmund et al., 2014). The development of body weight in top-level slalom racers corresponds with the degree of development of the skeletal muscle fraction, especially in the area of the upper extremities and trunk. The proportion of body fat should be maintained at a level of 8–10% (Sigmund et al., 2014). In terms of morphological differences among athletes in a water environment, the differences observed are interindividual, gender and those relating to water sport specialization (Ridge, Broad, Kerr, & Ackland, 2007; Sklad, Krawczyk, & Majle, 1994).

With respect to the criteria mentioned above, the current development of the muscle fraction and body fat proportion in our male sample can be considered ideal. Whitewater slalom racers report values of body fat proportion around 10%, which, regarding this age category, represents a good potential for further athletic development. In terms of body constitution the average somatotype of the monitored sample of junior whitewater slalom racers is in the area of ectomorphic mesomorph (Figure 1). At the same time, the highest number of somatotypes are also located in this area. In our sample of whitewater slalom racers, the changes in the somatotype as a result of the five-month fitness training and the following competition period are at a minimum level. Both the average somatotype and most individual somatotypes are placed in the same locations of the spherical triangle throughout the annual cycle. With regard to the sports specialization and the location of an optimum somatotype of a male whitewater slalom racer, we can conclude that in terms of typology, the monitored whitewater slalom racers develop in the desired direction. The current mean values of our whitewater slalom racers are represented by the following three digits: 2–5–3.

Akca & Muniroglu (2008) report the following somatotype values in adult elite kayakers: 2.9–5.2–2.2. Hagner-Derengowska et al. (2014) report the following average somatotype values in junior canoeists: 2.7–4.7–2.2, where the highest value of mesomorphic development was observed in racers specialized in short distance and sprints and was 5.7 points. We assume that after a longer period also in our racers the mesomorph component will increase to values around 5.5 and higher. This will result in the final shift of the somatotype into the area of optimum location. On the other hand, practice shows that the area of optimum somatotype location as one of the indicators of possible sports performance might be somewhat broader. Figure 1 shows the somatotype of the Czech world champion and Olympic medallist from London 2012 in whitewater slalom. Its location is completely outside the spherical triangle. This is an individual with an extremely developed mesomorph component and suppressed ectomorph component and overall component ratio of 1.2–9–0.2. These values can be considered rare. The mesomorph value of the Czech world champion is largely influenced by the extraordinary development of muscle mass (> 60%), while bone diameters (biepicondylar distance of the humerus and femur) show rather average values (Sigmund et al., 2014). In our sample we also found significant changes associated with the development of strength abilities. This corresponds with the significant proportion of strength training during the preparatory period, in addition to the proportion of training on water (Table 1). The proportion of load devoted to the development of strength abilities during the preparatory period in junior whitewater slalom racers is similar to that of junior ice hockey players of the same age (Sigmund, Dostálová, & Brychta, 2013). The development of aerobic abilities is represented by a lower proportion. This corresponds with the results indicating a minimum development of aerobic performance among our whitewater slalom racers. The proportion of aerobic training in junior whitewater slalom racers is almost half the value of the proportion of aerobic training of football players of the same age. In young football players, the proportion devoted to the development of aerobic abilities exceeds 22% of the total training time during the preparatory period (Sigmund, Lehnert, & Kudláček, 2015). Taking into account the limitations of the study, the authors are aware of possible overlaps of the effect of training and the effect of ontogenetic development with respect to the findings presented. We believe that the present study of junior members of the Czech national team in whitewater slalom is beneficial both in terms of expertise, i.e. to enrich the body of findings and database of current top-level athletes in the Czech Republic, and practice. With a minimum time lag, the findings were used in practice and further work with individual athletes. In this case, the findings became a part of nomination criteria for the upcoming Junior World Championships. The purpose of monitoring a wide range of factors influencing sports performance is to facilitate further sports development respecting a healthy development of the organism.

Conclusions

During the annual cycle we observed an increase in body height by 2.4 cm and body weight by 4.2 kg in junior members of the Czech national team in whitewater slalom. We also observed changes in other morphological parameters, especially in relation to the preparatory and the competition season. Other changes related to the composition of the body and individual body parts. The proportion of fat fraction is relatively stable and is around 7 kg, which represents a relative proportion of 10% of body fat. Throughout the year, the proportion of muscle mass has an increasing tendency; the total increase in muscle mass is on average 2.5 kg. The average somatotype of junior members of the national team is located in the area of ectomorphic mesomorph and its mean value is 2–5–3. Individual somatotypes of young elite whitewater slalom racers are distributed primarily in the area of ectomorphic mesomorph (57%), followed by balanced mesomorph (21%) and mesomorph-ectomorph (14%). Throughout the annual cycle there are no significant changes in the location of the average somatotype or individual somatotypes in the categories of the somatograph. The present findings are well applicable in practice as they represent a significant part of nomination criteria of the Czech national team for the Junior World Championships, and are also used to promote sports development of the monitored individuals and successful representation of the Czech Republic.

Conflicts of interest

None

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