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Body physique and dominant somatotype in elite and low-profile athletes with different specializations

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ABSTRACT

Background and objective: Somatotyping is helpful in sports in which the body shape could influence the resulting performance. The purpose of this study was to determine the somatotype of high profile Lithuanian athletes in kayaking, basketball and football and to compare between disciplines and with low level sportsmen of the same age.

Materials and methods: A total of 72 young male sportsmen aged from 18 to 24 years were divided into three groups (kayakers, basketball and football players). Each group contained almost equal numbers of low level and elite, international level sportsmen. Anthropometric measurements of the players were used to establish somatotypes.

Results: The greatest difference was observed in the mesomorphic component of elite kayakers compared to the low profile sportsmen. Mesomorphy could also be used to predict sport ability. The range of mesomorphy for elite footballers was from 0 to 4.6, for basketball players from 4.6 to 5.9, and for kayaking, from 5.9 and higher. Individual groups of elite sportsmen displayed different modes of somatotype. The kayakers were predominantly endomorphic; the basketball players mostly endomorphic and the footballers most often ectomorphic. No distinguishable patterns of somatotype were displayed by the low level sportsmen.

Conclusions: Morphometric characteristics of the athlete's body and the fractional somatotype can be used as guiders and markers of the chosen sport and method of training.

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The results emphasize the necessity for a specific somatotype to reach a high profile in the selected area of sport and thus support morphometric oriented studies. Further studies could elucidate differentiation by age and sex.

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1. Introduction

Anthropometry has been shown to play an important role in athlete selection and performance criteria in sports. It is obvious that determination of the somatotype is especially supportive in sports in which the body may impact on the biomechanics of movement and the resulting performance [1,2]. Investigations of somatotypes in elite sportsmen play an important role in the study of the dynamics of development of a specific shape of the human body under the influence of various intensive purposeful training processes and competitive periods. It is well known that the anthropometric profile may indicate whether a player would be suitable to participate at the highest level in a specific sport [3–7]. Analysis of the literature has shown that there is a lack of information explaining the developmental pattern of high profile athletes in relation to different expressions of the human somatotype.

It is obvious that the structural appearance of a person, or body shape, is determined by his or her genotype as influenced by their environment [8–12]. The quantification of morphological characteristics of high profile athletes can be a key aspect of relating body structure to sports performance [13].

On the other side the quantified body physique of elite sportsmen has been shown to alter over time [14]. Analysis of the latest literature comparing anthropometric variables and somatotypes clearly illustrates that specific functional requirements produce differences in the anthropometric variables of the human body [15]. Another study showed the essential difference in the anthropometrical portrait between highly qualified, intermediate and junior surfers; however, it is difficult to compare their somatotypes because of the large age difference between groups [16]. It is also difficult to make accurate conclusions on the morphometric and somatotypic characteristics of elite athletes due to a lack of consistency between different studies, based on data received from different national groups of athletes and obtained during differing periods. Therefore, there is a gap in the literature in terms of determination of body physique and anthropometrical differences of contemporary elite Lithuanian sportsmen as well as between elite and low profile athletes of the same age.

The first objective of the study was to describe the body physique of modern elite sportsmen involved in kayaking, basketball and football. A further objective was to study differences in somatotypes between elite and low profile athletes involved in these sports.

2. Materials and methods

Anthropometry and somatotype data were collected from 72 young male sportsmen aged 18–24 years, who were divided

into three groups (kayakers, basketball and football players). Each group included lower ranked sportsmen, 11 people, and 13 elite, highly experienced athletes performing at international level. The low profile sportsmen who had no exceptional motor skills were students of the Lithuanian Sports University. They were selected in a randomized way.

The mean age of the elite sportsmen were 20.9 ± 0.9 years (kayakers), 24.0 ± 1.1 (basketball players), and 18.8 ± 0.6 (football players). The elite kayakers and basketball players were participants of united Lithuanian teams, trained for the World Cup in 2010; the elite football players were participants of the FIFA U-20 World Cup in 2011. All participating sportsmen had been training for at least 16 h per week for more than 6 years. There were clear differences between the best and the lower ranked sportsmen in number of training hours per week or number of competitions completed.

The research was approved by the Local Research Committee of the Lithuanian Sports University, Kaunas. Education was provided to and informed consent was obtained from each participant before their entry into the study. Participants were naive to the purpose of the experiment, and none of them reported any sensory or motor deficits.

The assessment of somatotype involved the measurement of 16 somatotype parameters using standard methods and licensed anthropometric instruments [17]. Anthropometric measurements of the athletes were performed according to techniques suggested by the Anthropometric Standardization Reference Manual [18] using the Heath-Carter protocol [19]. Somatotypes were calculated using the Heath-Carter decimal equations [19].

In somatotype calculations, triceps, subscapular, supraspinale and calf skinfold thickness, humerus bicondylar, femur bicondylar, biceps circumference, calf circumference, and body weight and height were used. For a quantitative description of each somatotype the endometric, mesometric, and ectometric indices were calculated. Basic statistics used the Student t test with two independent samples. Additionally, discriminant analysis was performed using SPSS 10. This analysis is useful in interpreting the potential discrepancies in morphometric measures [20]. A *P* value of <0.05 was considered as significant.

3. Results

All athletes demonstrated a monomorphic somatotype, independently of sports qualification. Elite athletes, representatives of all three kinds of sport, showed partial changes in their somatotype in comparison to beginners (Table 1).

The greatest changes were observed in the mesomorphic indices with the largest change observed in elite kayakers compared to the low profile sportsmen. All sportsmen of the

Table 1 – Morphometric indices by different groups of athletes.

Indices	Low-profile sportsmen			Elite sportsmen		
	Kayaking	Basketball	Football	Kayaking	Basketball	Football
Endomorphic	3.38 ± 0.63	2.77 ± 0.61	2.64 ± 1.04	3.52 ± 0.99	3.14 ± 1.03	2.41 ± 0.77
Mesomorphic	3.82 ± 0.77	4.09 ± 1.06	3.57 ± 0.47	6.20 ± 0.90**	5.60 ± 0.89	3.55 ± 0.70
Ectomorphic	3.87 ± 0.55	3.00 ± 1.14	3.00 ± 1.05	2.79 ± 0.85*	3.09 ± 0.83	3.33 ± 1.30

Level of significance of the difference between high and low profile sportsmen:
 * P < 0.05.
 ** P < 0.01.

Table 2 – Coefficients of variation for different morphometric indices by different groups of sportsmen.

Indices	Low profile			Elite		
	Kayaking	Basketball	Football	Kayaking	Basketball	Football
Endomorphic	18.6	22.0	39.4	28.1	33.1	31.9
Mesomorphic	20.1	25.9	13.2	14.5	15.9	19.7
Ectomorphic	14.2	38	35	30.5	26.9	39.0

Table 3 – Discriminant analyses for elite sportsmen.

Sport	Endomorphic type	Mesomorphic type	Ectomorphic type	Total
Kayaking	7	4	0	11
Basketball	4	6	1	11
Football	0	2	10	12
Kayaking (%)	63.6	36.4	0	100
Basketball (%)	36.4	54.5	9.1	100
Football (%)	0	16.7	83.3	100

elite groups, unlike the groups of low profile sportsmen, demonstrated a greater variability of endomorphic and ectomorphic indices. The smallest spread of data was recorded for mesomorphic indices in the group of low profile football players (Table 2).

The results of discriminant analysis showed that the successful prediction of a sportsman's ability to belong to the elite group may only be achieved using the index of mesomorphy. The range of mesomorphy for football players was from 0 to 4.6, for basketball players from 4.6 to 5.9, and for kayaking 5.9 and higher. It was also found that for high profile kayakers the most significant index was endomorphic, for the high profile basketball players it was mesomorphic and for high profile football players it was ectomorphic (Table 3). For the low-level sportsmen, this method did not reveal any patterns for any of the groups.

4. Discussion

The objective of the research was to study trends of the individual somatotype from the level of low profile to elite sportsmen. It was assumed that different functional requirements in different sports would produce differences in the anthropometric variables among the three groups. The chosen sports were selected according to the criteria of high levels of physical activity and strong power of performance. It is well known that somatotyping methods are especially helpful in

sports in which the body could directly influence the biomechanics of movements and thus the resulting performance [2]. There is also the suggestion of various athletes involved in these sports altering their body constitutional characteristics; height, weight, segmental proportions, particularly for the upper and lower limbs, and the appearance of the optimal ratio in human physique. Any dissimilarity in kinanthropometric values between elite and low profile sportsmen of the same age were noted.

Human somatotypes may be treated as very important health-related anthropometric indicators [21]. The latest references support the view that favorable somatotypical characteristics lead to exceptional biomechanical and metabolic efficiency in the selected sport [9]. According to the theoretical background proposed by Heath and Carter [19] the anthropometrical pattern or body physique of each individual cannot be totally committed to a certain somatotype; each individual has a specific ratio of the three somatotypes and this ratio is mediated by both genetic and environmental factors [9,11,12,22,23].

The mesomorphic index reflects the skeletal muscle mass in the human body. In many kinds of sport the mesomorphic index is dominant [22–25]. According to the latest results of Turkish researchers [13] the average somatotype in trained elite sportsmen was balanced mesomorph, as occurred in this current study. The same results have been demonstrated by other authors [26] who have confirmed that the somatotype of both elite and less trained football players was dominated by

the mesomorphic category. The considerable increase of the mesomorphic index for kayakers and basketball players can be explained by the necessity of strong power contraction of many synergetic skeletal muscles [27,28]. The same tendency has been illustrated in other studies [25,29]. Also it has been shown that highly trained kayakers demonstrate significantly greater measures of mesomorphy [30]. The training process of kayakers includes strong contractions of muscles of the shoulder, girth and other muscles of the body that lead to increased muscle mass [31]. In this case hypertrophy of muscle fibers develops caused by the increasing masses of contractile proteins and connective tissue elements [32].

It was interesting that the discriminant analyses for elite kayakers showed the endomorphic profile to have the most predictive value. This fact is in contradiction to the findings of some other authors who found that highly trained kayakers had a more lean body portrait in comparison to the general population [14]. However, their observed contingent was specifically trained sprint paddlers, while kayakers in this study were mostly trained for longer distances. For this reason, a greater amount of adipose tissue is probably required to provide fuel for extensive periods of aerobic energy expenditure.

Basketball also requires the development of jumping abilities, which are associated with the expansion of large muscles of the lower extremities, pelvis and lumbar segments [33]. It has been clearly shown that the mesomorphic component increased the height of the vertical jump [20].

As follows from the results of discriminant analysis, for a group of high profile football players the ectomorphic index is very important. Nikolaidis and coworkers [34], studying the body composition in young football players, demonstrated that in comparison with the age-matched general population, participants exhibited higher stature and lower body mass index that suggest development of ectomorphy, and this pattern has also been illustrated in the current study. It can be speculated that modern football requires the development of a stronger skeletal apparatus of the lower extremities. Each soccer game provides a number of small and moderate strikes and strains of the bony segments of the lower extremities of the player. In other words this situation is described by Wolff's law that is interpreted as; a bone becomes stronger and more massive at optimal loading rates [35,36].

Testing volleyball players, Buško and coworkers [25] also demonstrated that the ectomorphic and mesomorphic components of body physique correlated significantly with values of maximal power measured during counter movement jumps.

It was interesting that the athletes of the elite groups, unlike the groups of low profile sportsmen, demonstrated a greater variability of endomorphic and ectomorphic indices. It is difficult to explain this phenomenon. Probably it may be due to the large variety of individual somatotype ratios of high profile athletes who belong to the same kind of sport. Hazir [26] supported this point of view, testing elite football players. He supposed that highly trained athletes in modern sport vary more widely in terms of different anthropometrical values and explained this variation by the influence of the different sport requirements of the game.

Thus, this study, as well as those of other authors has found different somatotype ratios at which sportsmen excel in

different sports. The morphometric differences obtained in the experiments suggest the probable observation of a modification in morphometric phenotype of athletes as a result of intense workouts. This observation gives reason to believe that morphometric characteristics of the athlete's body and fundamental values of the fractional somatotype characteristics can be used as markers for the chosen method of training.

The results emphasize the necessity for a specific somatotype to reach a high profile in the selected area of sport as has also been stressed by other authors [2,9,37]. Furthermore, the results show the needs and requirements for such morphometric oriented studies in these and other sports with an importance of differentiation by age and sex. Thus it is probably determinative of an individual somatotype for kayaking, basketball and soccer.

While the classic Heath Carter protocol is widely used nowadays in elite and mass sports [38,39], future experimental work in this area is desirable to enrich data from other kinanthropometric approaches. For instance body size measurements may be advantageous to calculate vertical and circumferential proportionality (shapes) of the body which ought to be specific to some sports. Additional information about arm lengths and arm and hand span as well as leg lengths would be furthermore useful for a large variety of sport and athletic pursuits including; basketball, volleyball, soccer, and kayaking. Also the Androgyny Index [40] which illustrates the relative widths of the shoulders and pelvis may be valuable as an additional correlator of the level of masculinity and probably mesomorphy. It may prove useful to use bioelectric impedance examination that indirectly demonstrates the amount of fat-free mass within the body [41] or the measurement of the hydrostatic weight [42] for the same purpose. It is also possible to indirectly calculate body muscle mass using the simply attained girth and skinfold measurements [43].

Strengths of this study include anthropometric measurements of elite sportsmen in different sports codes that have not previously been performed on this scale. The design of the study allowed comparison between the different codes.

The study also has some limitations. There has been no opportunity to gather longitudinal data. The generalizability of the results is only likely to apply to Eastern European sportsmen. It is anticipated that sportsmen in other areas of the world may use different training regimes that will potentially alter their body physique. Future investigations could extend the breadth of the study to include lower profile sportsmen in different countries and thus increase the generalizability of the results. All participants were males and so the data does not apply to females. Both of these last limitations point to avenues of future research that could be explored.

5. Conclusions

These results suggest with high probability that there is a developmental tendency of change in different aspects of morphometric phenotypes of selected kinds of sport athletes. These phenomena may be explained by the effects of

continuous intensive training and achievement of highly sport-defined shapes.

The results can serve as a basis for more accurate and purposely focused management of the training process. Morphometric parameters of the body and the athlete's core values of the partial somatotype indices can be useful markers of the correctness of the chosen coaching techniques.

The results obtained show the need for similar studies in other sports with a greater differentiation of athletes in terms of age, sex, and initial individual morphometric indices.

Conflict of interest

The authors state no conflict of interest.

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