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DISCRIMINATORY ANALYSIS OF ANTHROPOMETRIC CHARACTERISTICS IN YOUNG SWIMMERS

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ABSTRACT

The aim of this study was to describe the set of somatic characteristics, which significantly discriminate young swimmers.

Methods: 160 pupils (11 and 12-year-old) from primary schools in Wrocław were recruited for the study. The research group (Group I) consisted of swimmers and the comparative group (Group II), the non-swimmers. The participants selected for the study had been involved in swimming for 2 - 3 years. On average their training time per week was 12 to 18 hours. The following parameters were established: body height and weight, upper and lower extremities length, circumferences of: thighs, shanks, arms, forearms, chest at rest, chest after inspiration, chest after expiration, waist, hips, shoulder width, hip width, chest width, chest depth, and Rohrer index. In order to accomplish the aim of the study, a discrimination analysis method was employed.

Results: Analysis of the results indicated that the model for boys significantly appeared to discriminate the studied groups. The parameters, which distinguish the groups to the largest degree, include circumferences of the body, length parameters, and hip width. Those parameters indicate formation of the body figure typical for swimmers, characterized by specific proportions of the chest and hips, and usually by longer limbs. The difference in muscles circumferences is a direct result of training. This diversity between the groups of girls is less significant. This indicates that physical training influences the female body figure to a smaller degree than that of males. The parameters which discriminate girls the most, are the circumference of the thigh and shank, the hip width and the chest depth.

Conclusion: Sport training decreases dysmorphic differences and increases similarities in the constitution of boys and girls.

Key words: young swimmers, somatic features

Introduction

Biological development of the body, determined by the genotype, is influenced by the modifying environmental factors, such as bio-geographical and socio-economic living conditions. External modifiers may positively and negatively influence formation of biological features/characteristics. Researchers are particularly interested in the impact of increased physical activity on the human body, especially in terms of functional and structural changes. This impact is very pronounced when systematic physical activity is performed and when the loads are significant, like in the case of sports training (1,2,3).

Based on the observation of the influence of sport training on a child's body one can notice the many changes that occur in the children's body (4,5,6). Biological consequences of overtraining, such as ossification of epiphysial cartilage, which hinders the body's growth, are widely known.

Sports training is a very strong factor influencing the body condition. Therefore, all sport activities that children engage in should be carefully monitored as they affect the biological aspects of child development. Intensity of physical activities and their form are extremely important. A limited choice of exercises and work overload may negatively influence the child's development by slowing his or her body growth and retarding the sexual maturation. Additionally, static disorders may occur, which may become chronic and progress due to the lack of exercise diversification.

The most significant changes resulting from physical activity occur in the body build and in the muscular system (7,8,9,10). Sometimes development of muscles takes place at the cost of development of other features, such as body height and its functions.

Determination of the influence of physical training on the development of somatic features has been widely published. While single features were often compared, the parameters defining the features, which differ in examined and control groups, were given less attention. It may be assumed that not single fe-

atures but their mutual coexistence significantly influences high efficiency of a swimmer.

The aim of this study was to describe the set of somatic characteristics, which discriminate young swimmers in the strongest way.

Material and Methods

160 pupils (11 and 12 years old) from Wroclaw primary schools participated in the study. The research group (Group I) consisted of 40 girls and 40 boys attending the athletic profile classes. This population of swimmers had been practicing swimming for 2 to 3 years and were members of sports clubs Śląsk Wrocław and Juwenia Wrocław. The children spent, on average, from 12 to 18 hours a week in the swimming pool. The children were chosen by means of a selection procedure after three years of training from the first to the third class. The basic criterion used to qualify a child for the sports class was mastering of varied swimming styles, present and expected physical conditions of the children (i.e., height of their parents) determining their success in this sport discipline.

The control group (40 girls and 40 boys) consisted of randomly chosen children from parallel, non-athletic classes. The examined children did not practice swimming or other sports discipline in the high-performance manner. Physical education lessons at the swimming pool took place once or twice a week.

In order to determine the differences among the children in terms of somatic features, 18 features of the body constitution were examined. They were as follows:

– body height,
– body mass,
– length of the upper limb,
– length of the lower limb,
– thigh circumference
– shank circumference,
– arm circumference,
– forearm circumference,
– chest circumference – at rest,
– chest circumference – inspiration,
– chest circumference – expiration,
– waist circumference,
– hips circumference,
– shoulders width,
– pelvis width,
– chest width,
– chest depth,
– Rohrer index.

The measurements were performed according to commonly accepted standards of anthropometric examinations and were based on Martin's technique. Age and sex of the children were taken into consideration in both groups.

Statistical analysis

Statistical analysis of the collected data was performed. Age groups of the children were taken into account to increase the number of observations, which made it possible to use proper statistical methods. According to the standards, the data was previously converted into the mean value and the standard deviation for particular age group. Thus, the influence of age on the diversification of the body composition values was determined, which enabled joining of the groups of younger and older children.

The following formula was applied:

$$Z = \frac{X_i - \overline{X}}{SD}$$

Z – normalized value,
X_i – value of the measured parameter,
$\overline{X}$ – mean value of the parameter,
SD – standard deviation.

The discriminatory analysis method applied in this research was used to determine which variables discriminate one or more naturally emerging groups. The use of discriminatory function analysis consisted of including in the research various measures to separate those that discriminate both groups. A step-by-step proceeding method was applied. The variables were included into the model in consecutive steps. At each step, a variable of the largest introduction value (F) was chosen. The analysis was carried out separately for boys and girls.

Additionally, in statistical calculations the researchers used the multi-feature analysis of concentration, based on all the measured parameters. The single bonds method was used and the distance measure was Euclid's Distance.

Results

Among models developed for both genders, the model for boys – allowing stronger discrimination between the swimmers and non-swimmers in the boys group – proved to be a better one (Table 1). The Wilks' lambda value was 0,23, which indicates that the model was a good match.

The set of features, which appeared in the discriminatory model for girls, shows moderate discrimination between swimmers and non-swimmers in the girls group, which was proved by 0,45 Wilks' lambda value (Table 2).

Among all measured parameters, there are 13 discriminating features for boys and 5 for girls. In the group of 13 discriminating features for boys, eight are statistically significant and should be taken into account. These are the circumferences of arms, thighs, shanks, waist and the chest at rest, upper and lower limbs length, and the pelvis width. These para-

Table 1. *Analysis of the discriminating function in boys*

number of variables in the model: 13 Lambda Wilksa: 0,23, F =16,745 p< 0,00 *Wilks' lambda: 0,23, F =16,745 p< 0,00*						
	Wilks' Lambda	*Wilks' fraction*	*F-elimination* (1,66)	*p*	*Tolerance*	*1-Toler. R^2*
Rohrer index	0,23	1,00	0,16	0,69	0,03	0,97
arm circumference	0,26	0,88	9,01	0,00	0,06	0,94
shank circumference	0,38	0,62	41,22	0,00	0,19	0,81
pelvis width	0,29	0,80	16,48	0,00	0,42	0,58
chest depth	0,24	0,95	3,46	0,07	0,54	0,46
waist circumference	0,26	0,89	8,37	0,01	0,13	0,87
chest circumference at rest	0,25	0,93	4,62	0,04	0,07	0,93
lower limbs length	0,26	0,89	8,12	0,01	0,23	0,77
upper limbs length	0,26	0,90	7,65	0,01	0,18	0,82
thigh circumference	0,25	0,92	6,04	0,02	0,16	0,84
shoulders width	0,24	0,97	2,20	0,14	0,24	0,76
weight	0,24	0,96	2,93	0,09	0,01	0,99
height	0,24	0,97	1,76	0,19	0,02	0,98

Table 2. *Analysis of the discriminating function in girls*

number of variables in the model: 5 Lambda Wilksa: 0,45, F =17,91 p< 0,00 *Wilks' lambda: 0,45, F =17,91 p< 0,00*						
	Wilks' Lambda	*Wilks' fraction*	*F-elimination* (1,66)	*p*	*Tolerance*	*1-Toler. R^2*
chest depth	0,56	0,81	17,06	0,00	0,70	0,30
thigh circumference	0,67	0,68	35,55	0,00	0,31	0,69
shank circumference	0,55	0,83	15,38	0,00	0,28	0,72
shoulder width	0,55	0,82	16,11	0,00	0,57	0,43
chest circumference at rest	0,47	0,97	2,22	0,14	0,37	0,63

meters show developing of chest-hips proportion that is characteristic for swimmers, whose chest is much wider than hips. In addition, the length of the limbs, which conditions higher efficiency in swimming, is a feature characteristic for swimmers. These parameters were taken into account in the selection process. Differences of limbs' circumferences are a result of higher muscle mass.

The girls' model included 5 features, which appeared in the boys model. Interestingly enough, the girls differed significantly in terms of the thigh and shank circumference and the pelvis width as much as the boys did. In addition, they significantly differed in terms of the chest depth. This parameter did not differ statistically among the boys. In the group of girls, it has a higher diagnostic value than the resting chest circumference, which has an insignificant discriminating power.

The highest similarity of somatic features was observed in the swimmers groups. Non-swimmers show no such similarity of somatic features. (Fig. 1)

Swimming training is a factor that blurs dimorphic differences of the body build in swimmers. Observations made by the authors in the population of

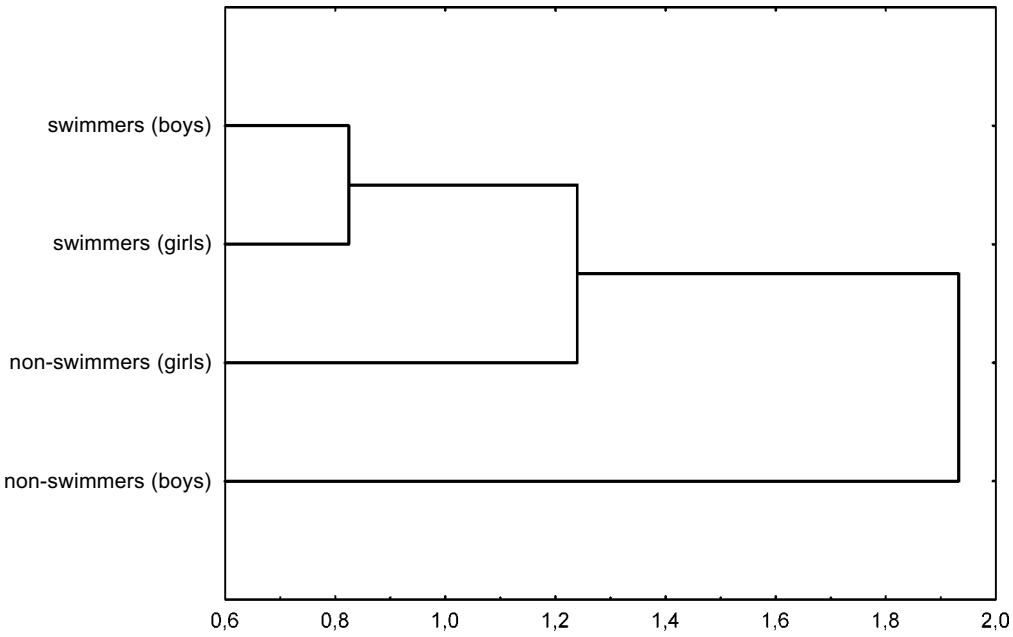

Fig. 1. *Similarities of the training and non-training groups in boys and girls expressed in Euclid's distances*

swimming children indicate that the development of certain somatic features is most probably an effect of the swimming training initiated in the early period of specialization and the selection process as well. Due to specific conditions of the swimming training, it may be assumed that its influence on a child's developing body is visible already in the early training period.

Discussion

Beneficial effects of intense physical activity have been described by many authors who emphasize that swimming is a form of a physical activity having a positive influence on the cardiovascular and respiratory systems (11,12,13). A young body is flexible and susceptible to various stimuli, which exceed the limits of biological tolerance of the body and are inadequate for the level of development of somatic and motor capacities of a child, and may affect the processes of body growth and maturation. Numerous studies carried out on groups of young sportsmen engaged in various sport disciplines (swimming, gymnastics, team games, tennis etc.) show divergent views concerning the impact of high-performance sports on physical development and the age, when the body becomes mature (14). It has been proved that among sportsmen, who began training in the pre-puberty period, swimmers show the most rapid development of sex characters. It applies to both boys and girls (15,16). However, the majority of authors report that swimming training does not disturb the puberty period (17) and does not inhibit physical development (18), including the height growth, which, to a large degree, is dependent on the genetic traits inherited from their parents (15).

The issue of a proper selection of children and youth for high-performance sports training has been studied by many authors (19,20,21). The main point here is the age at which the training has begun and defining the criteria, which allow to confirm suitability of candidates for a specific sport discipline based on their individual somatic features, motor skills, physical fitness, and other characteristics (22).

Somatic features are an important factor conditioning an achievement in sports (23) and are one of the elements taken into consideration during the candidate selection process. The method of group discrimination used in our studies allowed, selecting from a large set of somatic features only several features demonstrating the most significant discriminating power for swimmers and non-training children (2,3). Although changing of these parameters may be an effect of training changes, the selection effect cannot be excluded.

In general, the results obtained by many authors show higher values of height and weight of children training swimming in comparison to their non-training peers (11,16,24,25). The results of our studies only partially confirmed these observations. The observed differences were not statistically significant, thus this parameter was omitted in further analysis. The authors focused on the features that had the highest discriminating power between the groups.

Characteristics of the thigh, shank, arm circumferences, the pelvis width and the chest parameters were convergent with observations made by other authors. These features are more discriminating for males (both swimmers and non-swimmers). Our studies confirmed that the silhouette of the swimmers boys population shows certain qualities and proportions that are characteristic for adult swimmers. However, it is difficult to say to what extent it is an effect of sports training or of the selection process, which ta-

kes into consideration physical predispositions for training for this type of sport. Yet, it seems that larger development of muscles of the upper parts of the body (arm, trunk) in male swimmers and of the lower parts in female swimmers is a result of morphological changes caused by training and also by specific distribution of fatty tissue, which is dependent upon gender (26,27).

Conclusions

1. Method discriminating analysis is an efficient tool for characterizing somatic differences among swimmers and non-training children.
2. Higher differentiation of somatic features was observed in the boys group. The body circumferences (arms, thighs, shanks, chest at rest and waist), length parameters (length of the upper and lower limbs) and the pelvis width have the highest discriminating power. These parameters show the shaping of a silhouette typical for swimmers, which is characterized by defined chest-hips proportions and usually by longer limbs. Differences of the limbs' circumferences may result from swimming training character.
3. Fewer somatic features proved to have high discriminating power in the girls group. The most powerfully discriminating parameters were the thigh and shank circumferences, the pelvis width and the chest depth. The last parameter has higher diagnostic value than the chest circumference value.
4. Sports training blurs the dimorphic differences and increases similarity of the body build in boys and girls.
5. The observed changes of somatic characteristics of young swimmers may be an effect of sports training on their body starting as early as in the initial period of training, as well as an effect of the selection process, which aims at finding youth with specific body build features.

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