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DIFFERENTIATION AND SEXUAL DIMORPHISM OF CHILDREN'S MORPHOLOGICAL FEATURES AGAINST A BACKGROUND OF PRACTISING SWIMMING

DIFERENCIACIJA IN SPOLNI DIMORFIZEM V MORFOLOŠKIH ZNAČILNOSTIH OTROK V ODVISNOSTI OD TRENIRANJA PLAVANJA

Abstract

Sport training is one of factors which can cause changes in morphology of young people. The lack of uniform methods in the training of swimming in terms of organism and strength persuaded the authors to tackle this problem. The aim of the study was to assess whether an increase in the number of swimming hours affects the development of somatic and morphological parameters of the body. The second problem was to determine sexual dimorphism and its contribution to shaping of inter-group differences. The research was conducted on a sample of 160 pupils from primary school. Children participating in the research were divided into 4 groups ($n = 40$): swimming boys and swimming girls, non-swimming boys and non-swimming girls. Many somatic measurements were taken, such as: body mass and height, girths, depths and lengths of extremities and chest. Next, the groups were compared in order to establish the influence of swimming effort on biological growth of children. ANOVA and post-hoc Tukey tests were used to estimate differences between groups. The authors suppose that the researched factor affects some of the somatic measurements. The established differences between the groups of swimming and non-swimming children partially overlap with those observed by other authors. However, these observations do not concern the basic body measures such as height and body mass.

Key words: sport swimming, somatic parameters, physical effort, sexual dimorphism

Izvleček

Športno treniranje je eden od dejavnikov, ki lahko povzročijo spremembe v morfologiji mladega telesa. Pomanjkanje enotnih metod pri treniranju plavanja je avtorje spodbudilo k raziskovanju tega vprašanja. Namen študije je bil oceniti, ali večje število ur plavanja vpliva na razvoj somatskih in morfoloških telesnih parametrov. Drugi problem je predstavljala določitev spolnega dimorfizma in njegovega vpliva na nastanek razlik med skupinami. Raziskava je potekala na vzorcu 160 učencev osnovne šole. Otroci, ki so sodelovali v raziskavi, so bili razdeljeni v 4 skupine ($n = 40$): dečki plavalci, deklice plavalke, dečki neplavalci in deklice neplavalke. Opravljene so bile naslednje somatske meritve: telesna masa in višina ter obseg, širina in dolžina okončin ter prsnega koša. Nato smo skupine primerjali, da bi ugotovili vpliv napora med plavanjem na biološko rast otrok. Za ugotavljanje vpliva napora med plavanjem na biološko rast otrok smo uporabili ANOVO in post-hoc Tukeyeve teste. Avtorji domnevajo, da raziskovani dejavnik vpliva na nekatere somatske meritve. Ugotovljene razlike med skupinami plavalcev in neplavalcev so delno sovpadale z ugotovitvami drugih avtorjev, vendar pa se izsledki ne nanašajo na osnovne telesne meritve, kot sta višina in telesna masa.

Ključne besede: športno plavanje, somatski parametri, telesni napor, spolni dimorfizem

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Introduction

Somatic and functional development of children and youth is influenced by different factors, forming a human ecological niche. Analyses of environmental determinants most frequently cover the effects of "natural" factors in relation to bio-geographical and socio-economic conditions of living. Determined by genotype, development trends are under influence of the actions taken by humans. External modifiers may positively and negatively influence the formation of biological features/characteristics. Researchers are particularly interested in observing the phenomena that occur in organism during interaction with external factors.

One of the factors is practising sport. The motion is a basic attribute of life. Therefore, motion activity accompanies man from conception. As we are so strongly bound to motion activity during our life, we do not think about its essence. This cognition only appears in special situations, when a specific motion form becomes a desirable value e.g. during practising of sport (Szopa, Mleczko, & Žak, 1996). Monitoring how increased quantity of movement impacts on children's organism in progressive development phase reveals that multidirectional changes occur in a young organism (Benefice, Mercier, Guerin, & Prefaut, 1990; Courteix, Obert, Lecoq, Guenon, & Koch, 1997). Biological after-effects of over-training, such as ossification of epiphysial cartilage or hindering of body's growth, are widely known. On the other hand, some persons are more susceptible to the negative impacts of training. In the face of this fact, selection is very important (Leone, Lariviere, & Comtois, 2002).

All actions connected with sport of children and youth should take into account the aspects of biological development. Prognoses of development functional abilities should be made based on development parameters, depending on training only to a small extent. Foresight of development abilities and selection should be based on some stable features that are only to a limited extent influenced by training (Duche, Falgairette, Bedu, Lac, Robert, & Coudert, 1993). These features are determined by hereditary factors as well as innate abilities. At the beginning of training high levels of these factors predetermine mastery in the future. Among other things there are also height and maximal work capacity (MWC).

Training is a very strong stimulus affecting the organism status. It must be remembered that during the development phase, an organism develops under the influence of physical exercises. By crossing the limits of functional adaptation, one may upset the biological equilibrium and cause developmental irregularities or disproportions. The child's organism can develop in one direction e.g. excessive muscle mass at the expense of impairments such as low height or poor organism function. In extreme cases, excessive exploitation of biological force of children can bring about changes in their sexual maturation.

In sport practice various forms of selection for practising sport occur, such as natural selection, intuitive selection and guided selection. In historical terms, the oldest but still essential form of selection is spontaneous desire of the child to practice a specific sport. This kind of decision is triggered by own inclination, some great successes of the national team and results of competitions with schoolmates (Czabanski & Filon, 1991; Dziedziczak & Witkowski, 1998). Coaches have selected young athletes on the basis of recently taken measures of various quantities. In their opinion, this method is more objective than natural selection. The above case involves a guided selection which is substantiated by research. This method makes possible the evaluation of essential parameters for youth and enables drawing of conclusions about youth's predisposition to specific sport (Damsgaard, Bencke, Matthiesen, Petersen, & Muller, 2000; Malina, Meleski, & Shoup, 1982).

The longer the period of measurements and observations of individual training stages, the higher the effectiveness of selection (Baxter-Jones, Helms, Maffulli, & Baines-Preece, 1995; Chomiak, 1994; Saczuk, Poplawska, & Wilczewski, 1998). Having in mind that increased doses of training impact on children's morphological development, the aim of the research was to assess physical development of swimming children. We also wanted to establish whether an increase in the number of swimming hours affects the development of somatic and morphological body traits. The second problem is to determine a sexual dimorphism and its participation in shaping of inter-group differences. In an indirect way, we want to establish, if swimming training can reduce differences between genders.

METHOD

Participants

The research into some of the morphological traits of school children was carried out on a sample of 160 pupils from selected primary schools in Wroclaw, Poland. The children participating in the study were divided in the following two groups (80 pupils each): swimming children (experimental group) and non-swimming children (control group). Each group was further divided by age and gender.

The experimental group consisted of 11- and 12-year old pupils attending the 5th and 6th grades of the Primary School No. 72 in Wroclaw. The group of boys aged 11 consisted of children from 10.51 to 11.50 years old (M = 11.04 yrs, SD = 0.29 yrs) and the group of boys aged 12 consisted of children from 11.51 to 12.50 years old (M = 12.06 yrs, SD = 0.27 yrs). The same methodology applied to the groups of girls (11 years old: M = 11.11 yrs, SD = 0.22 yrs; 12 years old: M = 12.09 yrs, SD = 0.27yrs). All of the studied pupils had been members of the swimming clubs Šlask and Juwenia in Wroclaw for 2-3 years. The children spent, on average, from 12 to 18 hours a week in the swimming pool.

The control group consisted of 80 pupils. The same as in the experimental group, the control group consisted of 11- and 12-year old pupils attending 5th and 6th grades, except that their school was not a sports school. The group of boys aged 11 consisted of children from 10.51 to 11.50 years (M = 11.09 yrs, SD = 0.27 yrs). The group of boys aged 12 consisted of children from 11.51 to 12.50 years (M = 12.11 yrs, SD = 0.31yrs). The same methodology applied to the groups of girls (11 years old: M = 11.13 yrs, SD = 0.24 yrs; 12 years old: M = 12.05 yrs, SD = 0.22 yrs). The children in the control group had never practised sport professionally. The group consisted of pupils from the Primary School No. 113 in Wroclaw.

Instrument

The following 18 basic measurements were applied in the research, plus height and weight. In addition to skeletal and girth measurements (recorded in centimetres - cm) each subject had his/her age (years), weight (kg), height (cm) and gender recorded. Thus, 20 body dimensions were measured, namely:

- body height
- body mass
- upper extremity length (a-da_{III}) – average of right and left lengths)
- lower extremity length (B-sy) – from pubic symphysis to base

– thigh (maximum) circumference
– calf (maximum) circumference
– arm (maximum) circumference (biceps circumference, flexed)
– forearm (maximum) circumference (extended, palm up)
– chest circumference at rest – nipple line in males and just above breast tissue in females
– chest circumference after inspiration – nipple line in males and just above breast tissue in females
– chest circumference after expiration – nipple line in males and just above breast tissue in females
– waist circumference
– hip circumference
– shoulder width – diameter (a-a)
– hip width – biiliocristal diameter (ic-ic)
– chest width (thl-thl)
– chest depth – antero-posterior chest (xi-xi)

The obtained values were used to calculate anthropometric index, namely:

$$\text{Rohrer index} = \frac{\text{body mass (g)}}{(\text{body height})^3\ (\text{cm})} \times 100$$

$$\text{BMI index} = \frac{\text{body mass (kg)}}{(\text{body height})^2\ (\text{m})} \times 100$$

$$\text{Marty index} = \frac{\text{chest girth (cm)}}{(\text{body height})\ (\text{m})} \times 100$$

Procedure

The body parameters were measured by the method of Martin and Saller. A statistical analysis of the collected data was carried out. The age groups of children were merged so as to increase the number of observations, which enabled the use of proper statistical methods. According to the principles, data were normalised with respect to mean and standard deviation for the appropriate age group.

In this way, the influence of age on different body builds was ruled out and thus the older and the younger groups of children were merged.

The following formula was used (Stanisz, 1998):

$$Z = \frac{X_i - \bar{x}}{SD}$$

Z – normalised value;
X_i – value of measured parameter (for the child);
$\bar{x}$– mean value of parameter in the age group of child;
SD – standard deviation of parameter in the age group of child.

The basic statistical parameters such as arithmetic mean, standard deviation, minimal and maximal values of body dimensions were calculated. To assess statistical significance of the differences between the swimming and non-swimming pupils and to evaluate sexual dimorphism, ANOVA (one-way) was applied. The result of ANOVA was a significant value, therefore, F-test was used to estimate the differences compared to other values resulting from the tests used in post-hoc test groups. Of course, one could carry out a series of tests to compare all possible pairs of mean values, but such a procedure would be loaded with incidental effects (randomness). In most cases the number of significant differences would be overestimated. The t-test for independent samples is used to establish significance of the differences between two samples, while post-hoc comparisons include more than 2 samples.

RESULTS

Height and body mass are the basic and most representative somatic measures for assessing morphological development. Although the above parameters describe well body build, they do not give full information on somatic development. Hence, to complete the basic body dimensions of the population under research, other parameters connected with body build as width, height and girth were discussed. To determine the build proportions on the basis of height and body mass the Rohrer index was calculated, and on the basis of chest girth the Marty index was calculated.

Statistical characteristics of normalised measured parameters are shown in Table 1 and 2.

Table 1: Normalised values of somatic parameters of swimming boys (A) and non-swimming boys (B)

	A				B			
	M	SD	Min	Max	M	SD	Min	Max
body height	0.04	0.93	-1.68	2.30	-0.11	1.12	-2.04	1.94
body mass	-0.12	0.86	-1.57	1.94	0.41	1.28	-1.57	3.88
Rohrer index	-0.23	0.77	-2.03	1.27	0.74	1.16	-1.26	3.50
BMI index	-0.20	0.79	-1.64	1.24	0.65	1.22	-1.20	3.46
upper limb (arm) length	0.31	1.19	-1.59	4.05	-0.15	1.02	-2.04	2.02
lower limb (leg) length	-0.02	1.01	-1.98	2.69	-0.05	1.12	-2.17	2.99
thigh girth	0.01	0.85	-1.36	2.04	-0.05	1.19	-2.08	4.01
calf girth	-0.28	0.81	-3.10	1.22	0.58	1.29	-1.48	3.65
arm girth	0.21	0.98	-2.46	2.23	0.22	1.20	-2.12	3.10
forearm girth	0.22	1.03	-1.92	2.35	0.26	1.14	-1.92	2.59
chest girth at rest	0.04	0.82	-1.46	1.96	0.15	1.39	-1.85	2.88
chest girth after inspiration	0.03	0.81	-1.14	2.32	0.29	1.38	-1.81	2.71
chest girth after expiration	0.05	0.86	-1.63	2.10	0.14	1.35	-1.89	3.03
waist girth	0.04	0.70	-1.28	1.37	0.55	1.39	-1.16	3.65
hip girth	-0.21	0.71	-1.35	1.06	0.23	1.30	-1.66	3.66
shoulder width	0.18	1.14	-1.77	3.31	-0.10	0.98	-2.49	1.50
hip width	0.20	0.81	-1.24	2.20	-0.07	1.00	-1.67	3.06
chest width	0.08	1.20	-1.78	4.09	0.17	1.14	-1.33	2.96
chest depth	-0.38	1.13	-2.09	2.21	0.52	0.80	-0.44	2.04
Marty index	0.02	0.86	-1.63	1.64	0.23	1.29	-1.65	3.81

Table 2: Normalised values of the somatic parameters of swimming girls (A) and non-swimming girls (B)

	A				B			
	M	SD	Min	Max	M	SD	Min	Max
body height	0.07	0.97	-1.44	2.91	0.00	1.00	-2.04	2.42
body mass	-0.12	0.87	-1.62	1.84	-0.17	0.85	-1.57	2.10
Rohrer index	-0.25	0.84	-1.69	1.98	-0.26	0.84	-1.58	2.35
BMI index	-0.21	0.85	-1.54	2.13	-0.24	0.82	-1.47	2.49
upper extremity length	0.05	0.91	-1.59	2.02	-0.21	0.79	-2.04	1.79
lower extremity length l	0.01	1.01	-3.17	2.39	0.06	0.89	-1.98	2.19
thigh girth	0.34	0.92	-1.09	2.22	-0.31	0.94	-2.44	1.86
calf girth	-0.23	0.74	-1.61	1.49	-0.06	0.86	-1.48	1.49
arm girth	-0.13	0.89	-1.77	1.71	-0.30	0.83	-2.12	1.71
forearm girth	-0.12	0.89	-1.68	1.64	-0.36	0.81	-1.68	1.16
chest girth at rest	-0.14	0.75	-1.85	1.30	-0.05	0.93	-1.72	2.61
chest girth after inspiration	-0.21	0.71	-1.54	1.25	-0.11	0.94	-1.54	2.45
chest girth after expiration	-0.14	0.77	-1.76	1.56	-0.06	0.94	-1.63	2.76
waist girth	-0.19	0.61	-1.40	1.31	-0.40	0.87	-1.52	2.45
hip girth	0.00	0.90	-1.54	2.17	-0.02	0.98	-1.41	2.42
shoulder width	0.11	0.92	-1.40	2.22	-0.18	0.94	-1.77	2.22
hip width	0.17	1.11	-1.67	2.63	-0.30	1.00	-2.10	2.20
chest width	-0.12	0.76	-1.78	1.38	-0.14	0.83	-1.78	2.29
chest depth	-0.44	1.04	-1.76	1.22	0.30	0.61	-1.10	1.88
Marty index	-0.19	0.88	-2.32	2.14	-0.06	0.89	-1.48	2.69

Body mass, Rohrer index, extremities girths, waist girth and chest depth belong to the most diagnostic measures which differentiate between the test groups. This was confirmed by the results of the variance analysis, as shown in Table 3. However, in individual parameters, directions of the influence of swimming training differ by age.

Differences between the groups of children in terms of body mass and Rohrer index are similar in character. Non-swimming boys have the highest level of body mass development. They are the heaviest group in terms of Rohrer index, too (Figure 1). They differ statistically significantly from their swimming peers and both groups of girls (swimming and non-swimming) (NIR test; see Table 4). At the same time, normalised values of both parameters are above the mean value for age groups. Non-swimming girls have the lowest body mass and are also the slenderest. It is evident that girls without increased dose of movement should be heavier. We considered the fact that body mass is characterised by susceptibility to larger relative fluctuations in standard limits (Bogdanowicz, 1962). Body mass also tends to decrease or increase the development rate in individual phases of ontogenesis. Bochenska (1958) has observed the above phenomenon and named it "swinging" stage (body height increment) and "fulling" stage (compensate body mass increment). It is characterised by phasic changes in body mass and height increment rate (deceleration of mass body development accompany acceleration of value jump period and vice versa) in the puberty. Perhaps this can explain the observed facts. A lack of statistically significant differences between groups in terms of body height indicates that the girls enter the phase of puberty and become higher than 11-12 year old boys – their peers. This is confirmed by slightly higher values of normalised body height in both groups of girls compared to those of boys. At that period development of girls' body mass decelerates while that of boys' body mass still accelerates. It appears that greater doses of movement (i.e. in the form of systematic training) can make great differences in the basic somatic parameters and especially body mass. The peculiarity of the swimming training lies in the fact that aerobic metabolism is a source of energy for effort. Substratum is a fatty tissue that burns during longer efforts. One might say that training reduces boys' fatty tissue and closes-up training groups to both girl groups. Height and body mass proportions are reflected in Rohrer index.

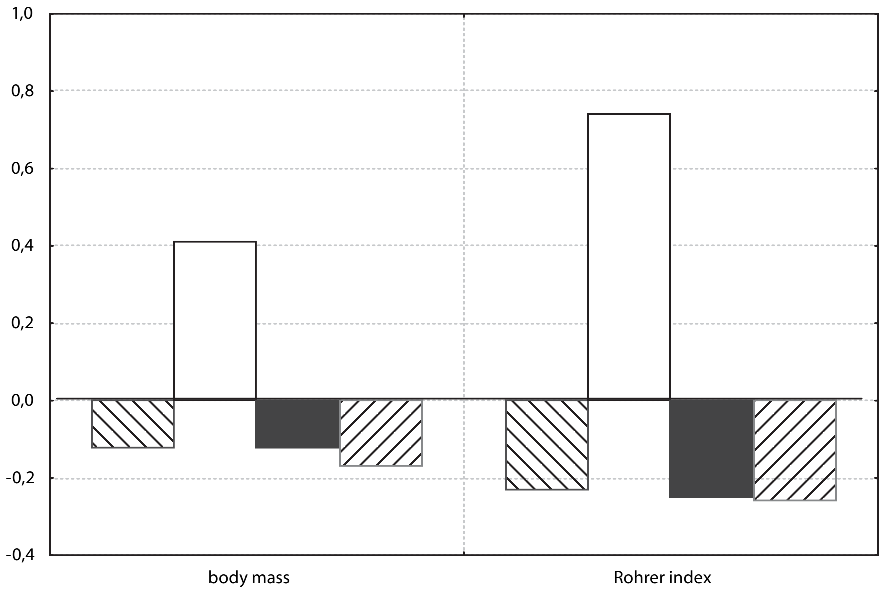


Figure 1. The mean values of normalised body mass and Rohrer index.

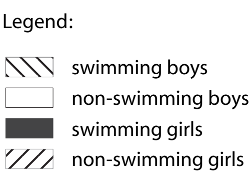


Table 3: ANOVA results (between all groups)

	F	p
body height	0.25	0.86
body mass	**3.18**	**0.03**
Rohrer index	**11.69**	**0.00**
BMI index	**8.69**	**0.00**
upper extremity length	2.21	0.09
lower extremity length	0.09	0.96
thigh girth	**2.97**	**0.03**
calf girth	**7.06**	**0.00**
arm girth	**2.77**	**0.04**
forearm girth	**3.67**	**0.01**
chest girth at rest	0.60	0.62
chest girth after inspiration	1.89	0.13
chest girth after expiration	0.60	0.61
waist girth	**7.56**	**0.00**
hip girth	1.30	0.28
shoulder width	1.18	0.32
hip width	2.21	0.09
chest width	0.91	0.44
chest depth	**11.06**	**0.00**
Marty index	1.28	0.28

Table 4: Post-hoc Tukey tests for body mass and Rohrer index

group	swimming boys	non-swimming boys	swimming girls
body mass			
non-swimming boys	**0.02**		
swimming girls	0.98	**0.02**	
non-swimming girls	0.81	**0.01**	0.79
Rohrer index			
non-swimming boys	**0.00**		
swimming girls	0.93	**0.00**	
non-swimming girls	0.89	**0.00**	0.96
BMI index			
non-swimming boys	**0.00**		
swimming girls	0.97	**0.00**	
non-swimming girls	0.83	**0.00**	0.87

The trends of differences between the groups in terms of extremities' girths are seen in shoulders and in legs (see Figure 2). Shoulders differ the same as in the case of arm and forearm girths. The group which significantly statistically differed from others was the group of non-swimming girls (see Table 5). They had smallest girths and their normalised values were below their age group's mean. Similarly, normalised values of the arm and forearm girths of the swimming girls were below the mean value of the groups of non-swimming and swimming boys. However, these differences had no statistical significance. In boys from both groups significant differences were found in shoulder girths. All of the above facts indicate sexual dimorphism of the above parameters which are higher in boys. A lack of significant diversity in the swimming girls indicates that swimming training stimulates a development of upper-extremity muscles, resulting in weakness of dimorphism, when the girl takes up increased motion activity. A lack of significant diversity among the boys indicates that the natural developmental processes of the boys at this age are so strong that an increase in the dose of movement does not cause an increase in muscle mass. Furthermore, it cannot preclude the unaided training of boys from the control group in disorganized way, which would annihilate the influence of swim trainings on a natural penchant for spontaneous motion activity.

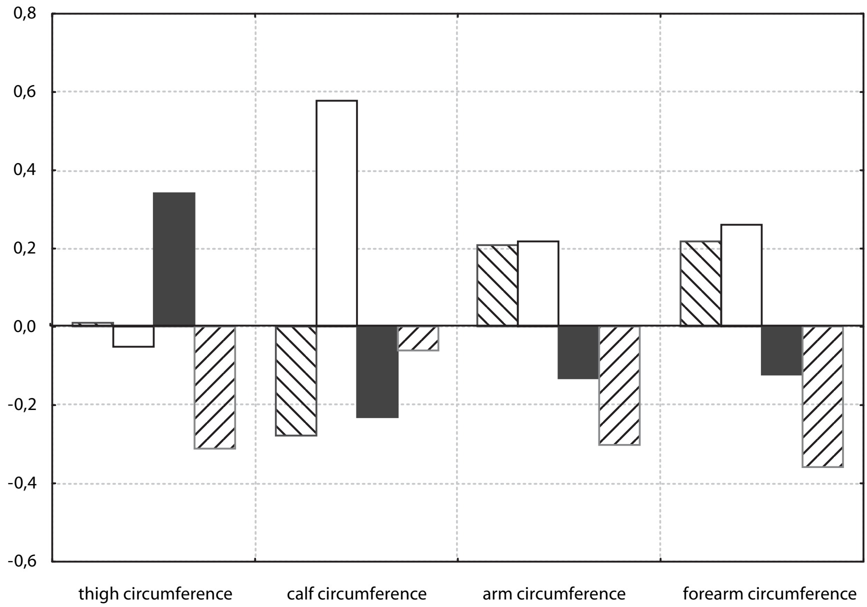
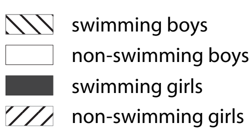


Figure 2. The mean values of normalised extremities' girths

Legend:



The diversity of thigh and calf circumferences proceeds quite differently. Maybe these body measures react differently during training. The swimming girls had the highest normalised mean value of thigh circumference, although the differences are not statistically significant compared to both groups of boys (see Table 5). This mean value is the lowest in the non-swimming girls. They differ statistically significantly only compared to swimming girls.

Table 5: Post-hoc Tukey tests for extremities girths

group	swimming boys	non-swimming boys	swimming girls
thigh girth			
non-swimming boys	0.81		
swimming girls	0.13	0.08	
non-swimming girls	0.15	0.24	**0.00**
calf girth			
non-swimming boys	**0.00**		
swimming girls	0.81	**0.00**	
non-swimming girls	0.29	**0.00**	0.42
arm girth			
non-swimming boys	0.94		
swimming girls	0.13	0.11	
non-swimming girls	**0.02**	**0.02**	0.44
forearm girth			
non-swimming boys	0.87		
swimming girls	0.12	0.09	
non-swimming girls	**0.01**	**0.00**	0.26

As regards calf girth, the group of non-swimming boys was the only group differing statistically significantly from others. Their calf circumference was higher. The above observations are quite interesting, although it is difficult to unambiguously explain the differences in both girths of lower legs.

Practising of swimming flattens sexual dimorphism of children's waist girth, but does not differentiate between the groups of girls. There are no statistically significant differences in terms of development level between the groups of swimming men and swimming women and neither between both groups of women (see Table 6). As regards age groups, the normalised parameters of both groups of boys lie above the mean value, while those of both groups of girls lie below the mean value (see Figure 3). Perhaps, age-dependent are decreasing of girls' waist girths (associated with body mass) and increasing of boys' waist girths unless they practice swimming, which makes them look slimmer and brings the swimming boys closer to girls.

Training of swimming has the most unidirectional influence on chest depth. This parameter is subject to training to a greater extent than others and shows low dimorphism, which was proven by the trends in inter-group differences (see Figure 3).

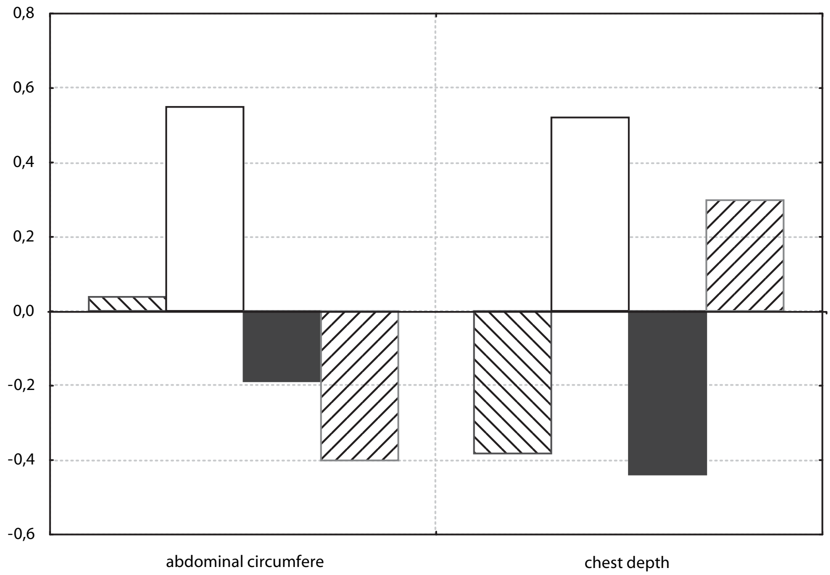


Figure 3. The mean values of normalised waist circumferences and chest depth

Legend:

swimming boys
non-swimming boys
swimming girls
non-swimming girls

Both swimming groups are marked by higher values of chest depth while both non-swimming groups have had lower values in this parameter. Moreover, differences between the swimming and the non-swimming groups were statistically significant. Differences between boys and girls within both groups were not noticed until the subjects took a swim (see Table 6). We may assume that chest depth is more environmentally (susceptible to training) than genotypically (lack of gender differences) conditioned.

Table 6: Post-hoc Tukey tests for waist girth and chest depth.

group	swimming boys	non-swimming boys	swimming girls
waist girth			
non-swimming boys	**0.02**		
swimming girls	0.29	**0.00**	
non-swimming girls	**0.04**	**0.00**	0.31
chest depth			
non-swimming boys	**0.00**		
swimming girls	0.76	**0.00**	
non-swimming girls	**0.00**	0.27	**0.00**

DISSCUSSION

The beneficial effect of increased dose of movement on physical development of children has already been discussed many times, especially highlighting swimming as an activity which is particularly stimulating (Dziedziczak & Witkowski, 1998; Leone, Lariviere, & Comtois, 2002). Nevertheless, if the movement dose is not suitable for a given level of development as well as somatic and motor abilities of the child, unfavourable reactions occur. At the same time the issue of how to correctly select children and youth for professional athletics is still dealt with by many researches (Bartkowiak, 1997; Laska-Mierzejewska, Piechaczek, & Skibinska, 1985; Piechaczek, Lewandowska, & Orlicz, 1995).

Body build features are important factors determining sport success and one of the elements to be taken into account in selection. Many authors point to generally higher values of height and body mass in swimming children compared to their non-swimming peers (Bartkowiak, 1978; Benefice, Mercier, Guerin, & Prefaut, 1990; Dziedziczak & Witkowski, 1998; Malina, Meleski, & Shoup, 1982; Piechaczek, Lewandowska, & Chorzweski, 2000; Skibinska, Laska-Mierzejewska, & Piechaczek, 1988; Thorland, Johnson, Housh, & Refsell, 1983). Our research results differ only slightly from the results of the cited authors. Although the mean values of the swimming children in terms of normalised body height (both girls and boys) are higher than those of the control group, the differences are not statistically significant. Hence, in our analysis we have omitted this parameter, concentrating only on those traits that have unambiguously differentiated between all of the researched groups. In the opinion of many authors, body height is a trait which is not useful for selection in the sport of swimming (Skibinska et al., 1988; Wieczorek & Witkowski, 1992). In view of the mark direction and the research results found in the literature, it may be assumed that a larger sample could deepen the observed phenomenon. A different observation from those of other authors is that, in terms of body mass trends, non-swimming boys have advantage over swimming-boys. They were statistically significantly heavier than all other groups. In the studies of other authors the contrary trend was observed, although Dziedziaczak and Witkowski (1998), in addition to age also point to equalising of body mass between boys doing sport and those not doing sport. This phenomenon has been explained by an increase in the training load and thereby higher movement activity of swimmers. Perhaps this fact has influenced proper study results. Rohrer index behaviour is similar to height and body mass. Although it was not possible to estimate differences in skin fold tissue between groups of children because no data are available, it is most probable that children practising swimming had less fatty tissue than non-swimming children. Reduction of fatty tissue during sport training is described in many articles (Lowensteyn, Signorile, & Giltz, 1994; Trappe & Pearson, 1994). We could only compare BMI. The differences between groups were similar to Rohrer index.

The trends in body girths – especially of the upper extremities – concurred with those observed by other authors. In own studies no statistically significant differences among the groups were observed, with the exception of swimming girls. It may be assumed that swimming can stimulate development of extremities' muscles in women, but it is not the prevailing development factor in boys. Hence, there is lack of significant differences between the swimming girls and both groups of boys.

According to the expectations and in the light of the study results of other authors, differences were seen in waist girth and chest depth (Benefice et al., 1990). In swimming children lower values of waist circumferences were observed, compared to their non-swimming peers. Their body shapes in a typical silhouette of a swimmer, which should be marked by streamline shapes. Baxter-Jones and colleagues (1995) observed development of the chest and muscles girths during swimming training.

There are several conclusions that can be drawn from the results:

1. The methodological approach to the subject of the study enables division of parameters which are affected by swimming training and depend on gender. Body mass, limb and waist girths and chest depth belong to the most diagnostic features.
2. The magnitude of the upper limb circumferences seems to be associated mainly with gender which is indicated by lack of significant differences between training and non-training groups but significant differences between boys and girls.
3. In contrast to the above, it seems that chest size more strongly depends on swimming practising.
4. The established differences between the groups of swimming and non-swimming children partially overlap with other authors' observations. However, this observation does not concern the basic somatic traits such as height and body mass.

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